
CONNECTIONS

The EERI Oral History Series

**William
W. Moore**

Stanley Scott
Interviewer

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Earthquake Engineering Research Institute

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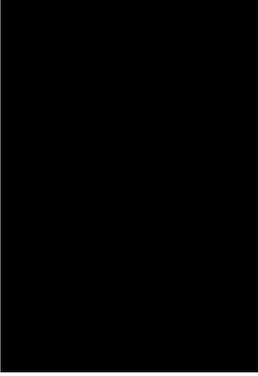
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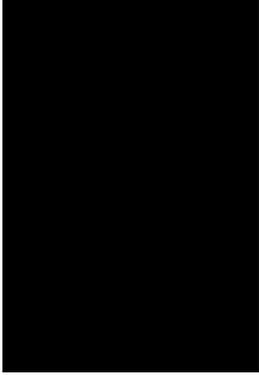
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The help, encouragement, and editorial feedback of EERI executive director Susan K. Tubbesing and the EERI Board of Directors were instrumental in both establishing *Connections: The EERI Oral History Series* and in bringing this volume to publication.

EERI also gratefully acknowledges partial funding of this project by the Federal Emergency Management Agency (FEMA).



The EERI Oral History Series

This is the fifth volume in *Connections: The EERI Oral History Series*. The Earthquake Engineering Research Institute initiated this series to preserve the recollections of some of those who have pioneered in earthquake engineering and seismic design. The field of earthquake engineering has undergone significant, even revolutionary, changes since individuals first began thinking about how to design structures that would survive earthquakes.

The engineers who led in making these changes and shaped seismic design theory and practice have fascinating stories. *Connections: The EERI Oral History Series* is a vehicle for transmitting their impressions and experiences, their reflections on the events and individuals that influenced their thinking, their ideas and theories, and their recollections of the ways in which they went about solving problems that advanced the practice of earthquake engineering. These reminiscences are themselves a vital contribution to our understanding of the development of seismic design and earthquake hazard reduction. The Earthquake Engineering Research Institute is proud to have part of that story be told in *Connections*.

The oral history interviews on which *Connections* is based were initiated and are being carried out by Stanley Scott, formerly a research political scientist at the Institute of Governmental Studies at the University of California at Berkeley, who has himself for many years been active in and written on seismic safety policy and earthquake engineering. A member of the Earthquake Engineering Research Institute since 1973, Scott was a commissioner on the California State Seismic Safety Commission for 18 years, from 1975 to 1993. In 1990, Scott received the Alfred E. Alquist Award from the Earthquake Safety Foundation.

Recognizing the historical importance of the work that earthquake engineers and others have been doing, Scott began recording interviews in 1984 with Henry Degenkolb. The wealth of information obtained from these interviews led him to consider initiating an oral history project on earthquake engineering and seismic safety policy, and in due course, the Regional Oral History Office of the Bancroft Library approved such an oral history project on a continuing, but unfunded, basis. First undertaken while Scott was employed by the Institute of Governmental Studies, University of California at Berkeley, the effort has continued following his retirement in 1989. For a time, modest funding for some expenses was provided by the National Science Foundation.

Scott's initial effort with Degenkolb was extended to a number of other earthquake engineers who have been particularly active in and close observers of seismic safety policy and

practice. Key members of the Earthquake Engineering Research Institute became interested in the project when asked to read and advise on the oral history transcripts. This led to EERI's decision to publish *Connections*.

The Earthquake Engineering Research Institute was established in 1949 as a membership organization to encourage research, investigate the effects of destructive earthquakes and the causes of building failures, and bring research scientists and practicing engineers together to solve challenging engineering problems through exchange of information, research results, and theories. In many ways, the development of seismic design is part of the history of EERI.

EERI Oral History Series

Henry J. Degenkolb	1994
John A. Blume	1994
Michael V. Pregnoff and John E. Rinne	1996
George W. Housner	1997
William W. Moore	1998

Interviews completed or nearing completion include:

Robert E. Wallace
LeRoy Crandall
Ralph McLean
George A. (Art) Sedgewick

Work on several other interviews is in progress.

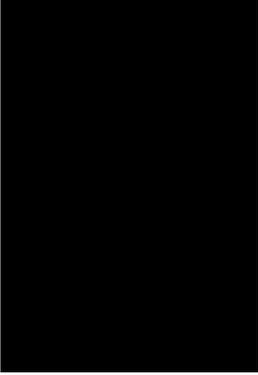
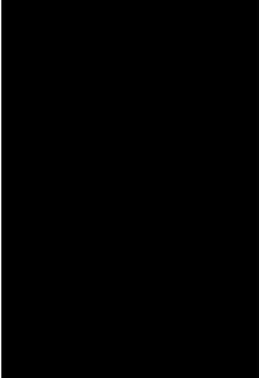


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Foreword

The interviews were conducted in the office of Dames & Moore in San Francisco, beginning in 1987 and ending in 1995. During the final editing and correcting process, however, one or two meetings were held in Moore's home in San Rafael. Through the sessions, Bill Moore seemed actively enthusiastic about the interviews and the subject matters discussed. His wide-ranging interests span the science and techniques of soil engineering to what he sees as important social and public policy issues affecting the engineering profession and society at large. His leadership role in many capacities also comes through clearly, although his modesty required some prodding and questioning to bring this out.

During the interview process, the following readers were asked to review and comment on the transcribed material: Wilson Binger, LeRoy Crandall, Trent Dames, Robert Darragh, Neville Donovan, I. M. Idriss, Joseph Lamont, Robert Lawson, George Leal, Joseph Nicoletti, Frank McClure, Ralph McLean, Robert Perry, Robert Pyke, Clarkson Pinkham, Robert Preece, Roland Sharpe, Stanley Teixeira, James Thompson, and Tom Wosser. They were asked to read the interviews particularly with a view to suggesting additions or corrections. Their guidance was much appreciated, and proved extremely helpful to both me and Bill Moore in completing the interviews published here.

I also wish to thank Willa Baum and others in the Regional Oral History Office at UC Berkeley's Bancroft Library for advice, encouragement, and moral support over the years.

Stanley Scott
Research Associate
Institute of Governmental Studies
University of California, Berkeley
May 1998



A Personal Introduction

As a young undergraduate engineering student in New Zealand, one of my lecturers made the comment that “You aren’t engineers. What we have given you is the technical education so that in time you should be able to become engineers.” That lecturer understood the difference between education and experience—a theme that runs throughout this oral history of Bill Moore.

When I joined Dames & Moore in 1963, the firm was already 25 years old. Their practice at the time was for all new employees, regardless of either their education or past experience, to spend some time in the laboratory and on field drilling jobs. This useful practice unfortunately had to be abandoned when the firm’s growth became more rapid.

Having spent graduate education summers working on field sites and in soil laboratories in the eastern United States I was impressed, probably more so than other new employees, by both the compactness of the Dames & Moore laboratory and the ability of the Dames & Moore field equipment to get samples from bore holes that were still relatively undisturbed. Consolidation testing, the results of which are used for estimating settlement behavior of soils, requires a laboratory test with continuous doubling of the applied load. With a lever arm and counterweight system this quickly leads to weightlifting practice, which should not be part of a job description. The pneumatic consolidometer designed by Dames & Moore avoided this. This is but one example of the innovation Bill Moore and Trent Dames showed in developing equipment for special needs at a time when there was none available. Bill Moore was primarily a soils engineer, albeit an excellent one, and it was as a soils engineer that I first learned to appreciate this excellence.

One day while riding to a meeting in San Francisco with Bill I asked him what analytical project we might try to provide some useful results for. We had both recently attended the seminal short course on earthquake engineering given at Berkeley in 1965 which was later published as *Earthquake Engineering*, edited by Robert L. Weigel,* perhaps the first English language book on the subject of earthquake engineering. Bill explained his visualization of both vertically propagating and reflected waves within the soil profile and how they might modify the site response during an earthquake. With the late R. B. (Fritz) Matthiesen, then a professor at UCLA, I was able to develop this idea and we were able to demonstrate results at the 1968 annual meeting of the EERI. We showed wave propagation in the soil profiles

*Weigel, Robert L., Ed., *Earthquake Engineering*. Prentice-Hall, Englewood Cliff, NJ.

of San Francisco could be used to partially explain the different records obtained at widely distributed sites during the 1957 San Francisco earthquake. Later work by graduate students at the University of California at Berkeley using this same wave propagation approach resulted in the now widely used computer program SHAKE.

In the summer of 1969, Dames & Moore was involved with site exploration and site geologic studies of the seismic hazard potential at the proposed oil terminal at Valdez for the TransAlaska Pipeline, later renamed the Alyeska project. This joint project of several oil companies was planned to be the terminal of a 750-mile-long pipeline to be built by long time pipeline contractors who planned to dig a ditch, bury the pipeline in it and after burial walk away. We cautiously suggested that perhaps the problem was not that simple. A rather perfunctory inspection identified possible scouring problems at river crossings, two active fault crossings, and potential severe landslide problems. Somewhat more ominous, we found that the proposed location for a pumping station, sited on the basis of pipeline hydraulic considerations, was planned to be located within the fault trace of the Denali Fault, Alaska's largest. Intervention by those more familiar with permafrost problems and other problems of cold regions forced the project owners to reconsider and a joint group of consultants was then gathered to study major problems in detail.

Dames & Moore was then assigned the development of seismic design criteria for both the pipeline route and the terminal. Following considerable effort in preparing the seismic input for the study—seismologists at the time had little interest in strong motion—a report was prepared using the probabilistic seismic hazard assessment (PSHA) approach to seismic hazard estimation that Allin Cornell had pioneered in his 1968 paper.[†] When the report using the PSHA approach was taken to Washington for presentation to USGS, however, it was considered not acceptable. I quote “It is a nice piece of work but we don't believe it.” Looking back 30 years later, this now seems almost incredible. The late Professor Harry B. Seed of UC Berkeley told me at the time that “If you aim to be a missionary you have to expect to be eaten by the cannibals!” The USGS has now completely adopted the probabilistic approach and used the method in their recent mammoth development of seismic hazard maps for the most recent publication of the NEHRP (National Earthquake Hazard Reduction Program) design guidelines.

[†]Cornell, C. Allin, “Engineering Seismic Risk Analysis,” *Bulletin of the Seismological Society of America*. Vol. 58, no. 5, 1968.

The first acceptance of our PSHA approach in evaluating seismic hazard came from a different quarter. We were approached in late 1972 by the Atomic Energy Commission (it later became the Nuclear Regulatory Commission), and asked if we did “seismic risk analyses.” When we gave an affirmative answer they requested that we ignore their own nuclear plant siting criteria and perform PSHA analyses for the three AEC uranium enrichment facilities in Oak Ridge, Tennessee, Paducah, Kentucky and Portsmouth, Ohio. These studies, our first involving midwestern seismic modeling, were completed in 1973.

The Applied Technology Council (ATC) was founded following the 1971 San Fernando Earthquake. Bill Moore’s ability to listen to all sides of technical subjects with divergent interpretations, combined with his ability to then bring a consensus viewpoint to the entire group, made him the obvious choice to be the first president of ATC. His ability to control meetings in a calm way without being a dictatorial meeting chairman is a rare quality. It also made him the obvious choice to be the first chairman of the Building Seismic Safety Council (BSSC), a group which started under very contentious circumstances.

By the end of the decade, however, growing stresses forced major changes in the firm’s organization and business practice. Bill has a thoughtful chapter on this trying time. The engineering profession was taking a major role in the development of the ATC design criteria projects. At Dames & Moore we were also working on major seismic studies and using new methods for projects in Europe, Asia and Africa, in addition to many sites in the U.S. The end of the decade forced major changes in the firm organization and business practices.

When I originally stepped off the ship from New Zealand in 1963, my intention was to get some years of practical experience before moving on to some teaching position. After several years with Dames & Moore I came to appreciate the hustle and time constraints of the commercial world, where you have to supply an answer now, with what information is available, rather than wait until a research project might provide a better answer. I also enjoyed the excitement of trying to apply in real projects the results of academic research. Bill’s encouragement and enthusiastic support provided me with a very rewarding career. He both understands and practices the value of a mentor.

Neville Donovan
Dames & Moore

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William W. Moore

Background and Early Interests

I have always wondered if some of my enthusiasm for professional activities and engineering societies is inherited from my dad's love of preaching and telling people what to do!

Scott: Why don't we start with your family and background?

Moore: My grandfather's name was Wallace Moore. I have no idea when he was born but I know that he lost an arm in the Civil War. I knew him, but only slightly, as I was pretty young when he was still around. He and his family lived in Iowa, and after the Civil War he worked as a postmaster in a post office in Iowa.

My father's name was Leon Wallace Moore, and I don't know when he was born, either. He went to Cornell College in Mt. Vernon, Iowa, and graduated in engineering. My mother also went to Cornell College. Later my father went to a Methodist seminary and was ordained as a minister. Then sometime after the Spanish-American War he worked in Mexico as an engineering surveyor on railroad locations. After that he came back to California, and he married my mother in 1907 or thereabouts. They had known each other back in Iowa.

My mother's name was Nellie Munson, and her father's name was William Munson. I don't think I have a family tree on her side of the family, although I do on my father's side, to some extent. My mother's parents were Iowa farmers who raised corn and hogs. I was back there in that area once and visited a relative's farm.

Sometime in the early 1900s—probably about 1905—my grandparents moved to Long Beach, and then to Pasadena. They wanted to buy a place to live, and looked at some lots on Signal Hill, but it seemed kind of desolate, so they bought a lot in Pasadena.

Scott: They bought in Pasadena, instead of on Signal Hill, where oil was discovered a little later?

Moore: Yes. I distinctly remember that on retiring in Pasadena and buying the little house there, they had \$8,000 that they put in the savings and loan, from which they got 6 percent interest, totaling nearly \$500 per year. They were able to live very nicely on that. The contrast with current living costs demonstrates the effects of inflation. I recall them saying that paying day labor to get painting or gardening and so forth done cost 50 cents a day. I was born in their home in Pasadena.

Scott: So they retired from farming in Iowa, moved to California with a nest egg, bought the house in Pasadena, put the \$8,000 in the savings bank at 6 percent interest, and lived on that.

Moore: Yes, that sums it up. They probably paid about \$2,000 for the house. I visited them later and stayed in their home. The last time I looked for it, the house was still there.

Shortly after my father and mother married, he decided he wanted to work as a minister, which he did for some years. The preaching business was a very difficult way to make a living, however, and my parents moved around quite a bit. He was first a Methodist and later a Presbyterian minister. He was a Methodist minister in Westminster when I was born in 1912, when my mother was about 34. When I was young they moved up to Estrella, near Paso Robles, where he had a little church. He also had a couple of other churches, and would ride a motorcycle with a leather belt on it to go to the other churches. Sometime in that sequence, he became a Presbyterian minister.

Scott: So he was a circuit-riding minister on a motorcycle?

Moore: Yes. He liked that—it made him happy—but it afforded a poor living, very difficult monetarily. About that time, while they were in Estrella, we got into World War I. That was about 1917. He decided he had to get involved in the war effort, so we moved to Seattle where he took a shipyard job at night, and taught mathematics to military officer candidates at the University of Washington. He held both jobs at the same time. That was where he got into the teaching business. I guess he had taken some pretty good courses in mathematics in college. He stayed there through the war. I took my first grade of school in Seattle.

Then after the war, he wanted to go back into preaching, and got an assignment in Kamiah, Idaho, on an Indian reservation. I don't remember the name of the Indian tribe. He ran the church there in the small town, and I went

to school there. But it was an extremely tough business. The winters were hard, and it was very difficult for both my mother and my father.

Scott: Was the church principally for the Indians, or did the congregation comprise mostly white or "Anglo" residents of the town and surrounding area?

Moore: Mostly the whites, although I suppose that some of them were half-Indian. About that time my brother was born, so they then had two kids and no money. Finally, my dad decided he had better do something to earn a little money, so he got a job teaching mathematics and engineering at Albany College in Albany, Oregon, near Salem. It is now Lewis and Clark College in Portland, and a good school. While this did not pay a lot it did bring him a regular salary, which is more than he got preaching. I continued there in grammar school and went on through junior high school, for a total of about five or six years.

About 1927 or 1928 they decided they were not getting enough money to put us kids through school, so they left Albany College. They moved back to Pasadena, and my father took a job in the Los Angeles County engineer's office. He did not like the county job very much, but it produced money and enabled them to put my brother and me through college at Caltech. That did not cost a lot, nothing like it does now. We could walk to high school and to Caltech. I finished high school in Pasadena, and then went to college at Caltech. My

brother also went to Caltech, and we both graduated and got master's degrees. We have since gone our separate ways.

I have always wondered if some of my enthusiasm for professional activities and engineering societies is inherited from my dad's love of preaching and telling people what to do!

Scott: And your father apparently had an interest in trying to help people.

Moore: Yes, helping people was a very deeply ingrained part of both my father and mother.

Scott: And of course there also was his interest in engineering and mathematics.

Moore: Yes, the tendency toward engineering and analytical, mathematical things.

Scott: When you were growing up, did you have a leaning toward mathematics or engineering?

Moore: Probably. I liked models, airplanes, and trains, and all that sort of thing. I actually wanted to be a radio engineer, but in the Depression days that was not a big career, so I went into civil engineering because I could get a job more easily. As to my early interests, I think I had been exposed to a bit of engineering perhaps through my father. I am sure this had a lot of influence on me, and my brother is also an engineer. Somebody once said, "You can't raise an engineer in one generation." I don't know if that is true, but I have two sons who are engineers.

At Caltech

The campus had an atmosphere that had an influence.

Scott: Talk about your college years at Caltech. I believe you started there in 1929, and graduated with a bachelors degree around 1933?

Moore: Yes, I graduated in 1933 and then in 1934 I went back and got the Master's in civil engineering. About that time the 1933 Long Beach earthquake occurred, and when I graduated in 1934 there was quite a lot of work going on in earthquake repair, particularly of school buildings.

Pear-Picking and Other Summer Work

Moore: Money was extremely scarce when I started at Caltech in 1929 at the onset of the Depression. My parents worked to help me get into Caltech and to pay the expenses. In fact, to get money for the first year's tuition—about \$500—the whole family went up and picked pears at Littlerock, which is southeast of Lancaster and Palmdale. We worked with the immigrant pear-pickers. My mother, father, and I all picked pears, and my brother, who was four years younger, was also probably old enough to pick.

My friends and I got into the business of peddling oranges to get money for school. We would go to the packing house, buy reject oranges, put them in the back of an old car, and drive around selling bags of oranges for 15 or 20 cents a bag. We did

this mostly during the summer. I really did not work during the school year, although I did work every summer.

One summer I worked for a sash and door mill in Pasadena, cutting up material for making window sashes. I managed to get a job there and learned something more about working with wood, having already had some manual training in high school. Some have asked how I could get a job when there were no jobs. Well, I did not demand a lot of money, but it was enough to help pay expenses.

Another summer I was on a survey party at a dam up near San Gabriel, working as rodman and stake punching and so forth. During two summers I worked for the California Highway Department, cutting brush and punching stakes. The summer I graduated, at an ASCE meeting I met R.R. Proctor, chief engineer of the Los Angeles city Bureau of Water and Power. Proctor had invented the Proctor Compaction Method and the Proctor Compaction Test. The compaction test is basically very simple, based on the concept that the more dirt you pound into a given hole, the stronger it would be. The test is a system of figuring out the strength—the bearing strength produced by a given amount of soil compaction.

Under Proctor's direction the bureau was building Bouquet Dam, one of the early compacted earth fill dams, located out near Saugus [California]. I told Proctor I would like a job that would provide some experience useful for doing a master's thesis. He arranged for me to get a job with the department that summer—1933—at Bouquet Dam, where I became an assistant soil inspector for putting in earth fills. That is where I first got started in soil mechan-

ics. I made friends in the Bureau of Water and Power, and even now still have some friends there. Then I went back and took a Master's degree, along with my later partner, Trent Dames. The experience of that summer of 1933 provided the basis for the research that both Trent Dames and I did for our Master's theses, and also provided some money to go on to Caltech.

Those summer jobs when I was going to Caltech gave me the experience I needed to get started. When I finally got out of school in 1934, I got a job testing the soil on the streets of Pasadena. Nobody there knew how to test the soil themselves, whereas I had taken soil mechanics at Caltech, and had worked as an inspector on Bouquet Dam. Anyhow, that is how I got interested in the soil engineering business.

Schooling at Caltech

Scott: What about your schooling at Caltech? What about the faculty? Do you particularly remember some of them?

Moore: The professors were mostly excellent. Franklin Thomas, chairman of the civil engineering department, was very much involved in what you might call public affairs. He was part of the organization that developed the plans and put over the program of the Metropolitan Water District of Southern California to build the Colorado River Aqueduct. I worked some of my summers with him. He was a great character, and I am sure provided a lot of stimulus to become interested in the engineering profession.

Professor R. R. Martel was one of the structural engineering professors, and a leading light in some of the early developments of earthquake design. I took some of his classes, and he influenced my interest in earthquakes. We also got acquainted with people at Caltech's seismological lab, such as Charles Richter and Hugo Benioff—I forget some of the other names.

Carl Anderson was my physics professor. I think he was a Nobel prize winner, and developed one of the first cyclotrons. He had to wind it from wire that he got from the electrical contractors' junk pile. I took his courses in physics and particle physics, and when I got done I understood the theory of relativity and could even explain it. But a year later I could not remember it. I saw Albert Einstein around campus a lot, but did not get to know him particularly. The campus had an atmosphere that had an influence.

Scott: I take it that fairly complex mathematics did not bother you too much? An engineer needs some proficiency in mathematics.

Moore: No, mathematics did not bother me, and in fact I enjoyed it. You are of course right that an engineer needs some ability in mathematics. Incidentally, my granddaughter is now working for a graduate degree at the University of Washington in the mathematics of economics. She and I have some interesting discussions.

I was also active in sports at Caltech. I played on their basketball and football teams for at least three years. I was not very good in football, but got a letter three times in basketball. I also got interested in sailing while I was at

Caltech. I started sailing at a summer camp in South Balboa Beach, run by the Pasadena Presbyterian Church.

A Note on Caltech's History

Scott: Before you go on, do you have any observations about the creation of Caltech as one of the nation's premier research universities in engineering and technology.

Moore: Caltech or its predecessor had started as a trade school, maybe around 1910. It was transformed into a major research university, and I think the change took place mostly under Robert A. Millikan. Others no doubt helped him, such as Arthur Fleming, who was a trustee and contributor, along with four or five other people who put up money for it. Millikan looked way ahead, saw what he thought should be done, and made it happen.¹

Millikan thought it would be extremely important to our country to be in the lead in the development of knowledge. At Caltech they did some of the work on high-tension electrical energy, and also more recently, earthquake studies, aerospace, and biology, for example. The work done at Caltech—and other institutions, of course—on two things, radar and the development of nuclear energy, probably helped determine the outcome of World War II. The Germans were not far behind. Moreover, a lot of the people who worked on those things, especially nuclear, came from Germany.

1. See Goodstein, Judith R., *Millikan's School: A History of the California Institute of Technology*. 1st ed. New York, W.W. Norton, 1991.

Starting Out

I suppose we in soil engineering were trying to do what the designer did not do.

Working for the Coast and Geodetic Survey

Moore: When I got out of school with my Master's degree, one of my first jobs was with the U.S. Coast and Geodetic Survey, in 1934-1935. We were measuring the wiggles of the ground and of the buildings after the Long Beach earthquake. I worked for what they called the "earthquake research program." Franklin Ulrich was head of the program, and I worked under Ralph McLean, who is a structural engineer in Fullerton, down near Santa Ana.

At that point we were mostly measuring the normal vibrations of buildings and grounds. We thought that if we had measurements made before the earthquake, and could measure the same building afterwards, we probably would find the building had become a little bit "looser." In other words, after going through an earthquake, a building would have a longer period of vibration. In the process, we went into some of the buildings that had been closed after the earthquake. It was spooky to go up in 10-story or 12-story buildings that had been empty ever since the earthquake—but that was our job.

Scott: Were those buildings being vibrated at the time when you took the readings?

Moore: No, except of course for traffic and wind vibrations—natural vibration. Any building vibrates. (This building

we are in here is shaking a little bit right now.) We just measured the normal movements with the wind, and from that we could tell the period of the building. Later another study was done trying to measure some buildings both before and after an earthquake, I forgot which earthquake it was—was it San Fernando or another one? Anyway, in some cases they have been able to detect some change in period as a consequence of an earthquake's effects on a building.

Scott: You started with the Coast and Geodetic Survey pretty early. That was the beginning of your career?

Moore: Yes, that was 1934, and I think it was the first job I had after I got my Master's degree. I was working for the Coast and Geodetic Survey, for Frank Ulrich. Part of our business was to go around pulling and shaking elevated, steel-supported water tanks, and measuring the vibration. We developed some methods for calculating the period of vibration of the water tanks. The article, published in 1936, was about the vibration periods of elevated water tanks.²

Shaking Machine Studies

Moore: At about that same time John Blume started working at Stanford with Lydik Jacobsen. Jacobsen was a mechanical engineer who got interested in the mechanics of the movement of buildings under vibratory loads. John Blume was working with Jacobsen. Ralph McLean and I got together with John Blume,

2. McLean, R. S. and W. W. Moore, "Computation of the Vibration Period of Steel Tank Towers," *Bulletin of the Seismological Society of America*. Vol. 25, no. 1, 1936.

and set out to force vibration of some structures, including the Colorado Street Bridge and the Los Angeles City Hall, and measured the wiggle of the buildings and their periods of vibration.

Scott: When you say "force," you are referring to use of a shaking machine?

Moore: That's right. Ralph McLean and I had worked on measuring the vibrations of buildings, and another part of that program involved the development of instrumentation. I believe Dean Carder was in charge of instrument development.

Under the same program with Franklin Ulrich, Blume was developing some machinery to produce artificial shaking of buildings. He built a shaking machine that produced an oscillatory force that would get a building to shaking. They shook quite a few buildings. On some occasions, I handled some of the instrumentation set up to measure responses, where John Blume was causing the wiggles with his shaking machine, and was also involved in analyzing the kind of shaking that occurred.

While I was with the Coast and Geodetic Survey I got involved with the Colorado Street Bridge, where John Blume had set up a shaking experiment. I operated the instruments to measure the shaking, while my wife drove a car across the bridge to create the shaking.

Corps of Engineers: Hansen and Sepulveda Dams

Scott: You also worked with the Corps of Engineers for a time—when was that?

Moore: Yes, I believe it was in 1936, when jobs were pretty scarce, that I got a job as an engineer on the building of channels for the Los Angeles River, and Hansen Dam and Sepulveda Dam. I was a geotechnical engineer working in the design department of the Los Angeles office of the Corps of Engineers. My job was to figure out the supporting capacity of the foundations of the retaining walls for the river. They had an idea of driving steel piles into the sands and gravels down there, or in some cases driving down to rock. I did calculations and we did dozens of loading tests on steel piles. That was all done to show that the capacity of the piles really was adequate, although the driving resistance was not considered adequate under the *EN* formula (the *Engineering News* formula).

Hansen Dam is a flood control dam with a slot in it. There was a slot in the dam, a concrete abutment on each side, and then earth fill behind that. My work there was investigation of one of the abutments. There were some shale layers in the sandstones, and those layers dipped down under the concrete abutment of the dam. The argument was that the shaley layers that sloped were likely to be slippery, and might slide.

We took samples and I devised some schemes for making shear tests of the shale layers to measure the sliding resistance. We correlated that with some field tests by taking samples in the field, cutting a steel cylinder over an area of two feet in diameter. Then we made one that was ten feet square and shoved it with hydraulic jacks to make a block of the sandstone move. We demonstrated that the shale layer had pretty significant shear resistance. That finding

enabled them to reduce the amount of the shale layer that they had proposed to remove. The Army guys had said, "We'll have to follow that shale layer down and take it out as far as it goes." They might have had to go 50 feet below the dam. It was unnecessary.

We also did some studies of the lateral resistance of steel piles for Sepulveda Dam. You can still see Sepulveda Dam as you drive by just north of the intersection of I-405 and 101 [in southern California]. It was another spillway dam with a slot in the middle. The concrete spillway is in the middle, and the earth dam is at the sides at a higher elevation. The spillway was put on fairly soft ground, so it was placed on steel piles. I made a lot of field tests and calculations of the lateral deflections of steel piles under lateral loads, whether water load or earthquake load.

Irrelevant Tests and Unusable Data

Moore: At the beginning of our work on the Sepulveda Dam, the head of the design section put me to work looking after his foundation design. So I went down to the soil lab there. They had boxes of dirt all over, and stacks and stacks of paper, compaction curves, plasticity indexes, and all that. They had a big one-square-foot shear box that they put dirt in, and sheared it.

In talking to the fellow in the soil lab, referring to the first 50 or 100 feet of soil under the dam, I asked him what he thought the average shear strength of that soil would be? What was its shear strength—was it 100 pounds per square foot or 1000 pounds per square foot, or what? What did he think? He said, "I have no idea." I said, "That won't do me any good. I have to

guess, and you're going to have to help me guess." He gave me a stack of data—sieve data, plasticity tests, particle size, and all that. There was all of this information, but they had made only one shear test. They put loads on it and they sheared it. I asked, "Can I say it is representative of the whole 100 feet?" He said, "No, it is only for that one foot."

Well, the soil lab sent up this pile of data. My boss at the design section looked at it, and didn't know what it was. He handed it to his secretary to file, and pulled a handbook by Hool and Kinne³ off the shelf. He looked at the handbook and said, "Well, we'll use four tons." That was the allowable bearing pressure, which came out of the handbook—none of the soil test data the soil lab had collected had one thing to do with the design of what was built. That really made an impression on me that I think has lasted all my life.

Scott: In all of the soil sampling they had been getting data without first considering how the data would be used?

Moore: That is right—they had no concept of how the data was to be used, and had no contact with the people who were supposed to use it. They were simply doing soil tests. They took a sample every five feet and ran a sieve test, a plastic index test, a particle size test, and so on.

Scott: They only knew how to take the samples, did not understand how the data collected would be used? Was no one responsible for

making sure that the samples they collected and tested would yield results that would then be usable?

Moore: No one was responsible, and that's right, all they knew how to do was make the tests.

Scott: You say that made a lifelong impression on you. As a young and perhaps a bit idealistic beginning engineer who wanted to do things right, how did it all strike you?

Moore: Really, I thought it was pretty horrible. It was sad.

Data That Users Can Understand

Moore: Anyway what we did was to settle down to go about our business. We talked to the people who were doing the design, finding out what final decisions they were going to make, and trying to put the data that we had in a form they could use easily.

After we got data, we did the calculations for them. We would give them curves showing what settlement should be expected—say if they put 1000 pounds per square foot on a footing, or 2000 pounds on it, and so on. We told them, "You don't have to calculate it, we make these graphs for you." They could use the information without calculating all of the soil mechanics, which they did not understand. We wanted to give them something they could understand and would use. We worked mostly with the structural engineers, because that's where we started. We talked with the design engineers about what they were trying to design, and mostly it was buildings or bridges. We would find out what was the problem. For example, they may have certain loads to sup-

3. Hool, George A. and W. S. Kinne, eds., *Foundations, Abutments and Footings, Compiled by a Staff of Specialists*. New York: McGraw-Hill, 1st edition, 1923.

port, or they may worry about lateral pressures on retaining walls, etc.

So we would take our soil data, shear strength, and compressibility and so on and try to give them a choice in how to deal with their problem. We'd give them a set of graphs of column loads versus settlements, for example. Column loads may be 200, 300, 400 kips⁴ and so forth, and we would make a graph for 1000 per square foot bearing pressure, and 2000 per square foot bearing pressure so they could compare the expected settlement. If you want equal settlement you use different pressures for different sizes of the footing.

Then we turned those graphs around. For one inch of settlement, you would use certain size footings; you worked with the data either way. We worked with the structural engineers doing that. We did the same thing with pilings. We developed some methods for calculating the skin friction capacity, and then bearing capacities for piling. We used the lab data and then we checked it in the field by driving piles and making pile load tests, and so on.

We would give them data for different kinds of piles, different lengths of concrete piles, steel piles and so forth. We would give capacities for different lengths, then they would try to figure out what would be economical for their particular structure. We were being interpreters. I suppose we in soil engineering were trying to do what the designer did not do. The designers did not interpret the different choices. That's what I see as an opportunity for the consulting engineers.

Friction Testing Steel Piles

Moore: We also tested the skin friction of steel piles for the Los Angeles River channel work. The design manual for the job said that the bearing pressure of the soil was to be 4000 pounds per square foot. If it won't take 4000 pounds per square foot, we will use wood piles to carry 20 tons, or concrete piles to carry 30 tons, or steel piles to carry 40 tons. Wood piles are to be 20 feet long, concrete piles are to be 30 feet long, and steel piles are to be 40 feet long.

The 40-foot steel piles would be cheaper than 20-foot wood piles. And that's the way it was designed. I worked up a scheme with my boss to go out and test the piles. They were finding that the driving resistance in sand and gravel was pretty easy. They would get down to 40 feet and did not get a high blow count for the steel piles. I said, "Let's set up a load test program," and we tested the piles. We proved that they had skin friction and could support the load.

At that time they were using a driving formula. The EN formula, which was probably developed in the early 1930s, related the blow counts per inch of pile driving to the presumed capacity of piles to carry a load. There were some fundamental flaws in it, and everybody realizes that now. The resistance to driving impacts and the resistance to static loads, or even to earthquakes, are not directly related. We developed some methods of making friction tests between the soil and the piles, whether steel or concrete, and calculating the supporting capacity of the piles. Then we compared that with the driving resistance. That was published in ASCE, probably in 1947 or 1948.⁵

4. A kip equals 1000 pounds.

We tried to do mathematical studies in each of these investigations. Also, however, we checked the results with field tests and observations of field behavior—settlements of structures and so on. That part is too often missing in computer studies. Many just do the computer study, and then say, "That's the answer." That can be a major source of disagreement between practicing structural engineers and university researchers.

It is now a lot easier to set up computer studies, which are run out by the gross. But it is still pretty difficult and expensive to make field observations of real structures, although that is a very important part of the picture. The only real proof of the calculations is how they relate to actual structures and their behavior. Nowadays, however, most researchers do try to correlate analysis with performance or with model tests before saying, "This is the answer."

Labarre and Converse

Moore: In 1936-1938, following my employment with the Coast and Geodetic Survey, I worked for Cap Labarre, a foundation engineering consultant in Los Angeles, who worked with structural engineers in southern and northern California to try to promote better earthquake-resistant engineering. Labarre's firm was Labarre and Converse. Robert V. "Cap" Labarre was probably the first foundation engineering consultant in the Pacific Coast area. Fred Converse was one of our professors at Caltech.

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5. Moore, William W., "Experiences With Predetermining Pile Lengths," *Transactions*, ASCE, 1947.

Anyway in 1936 I went to work for Labarre, although I don't remember what month I started. Labarre was actually not an educated engineer, he was just a good construction man. He had worked for the Foundation Company in New York. He had a fantastic intuition about foundation matters. Working with him was a heck of an education too.

Scott: He did not have an engineering education, as such?

Moore: That's right, what he knew was just based on experience.

Scott: So this was the first engineering firm you were associated with? How long did that last?

Moore: I guess about three years. Then in 1938, we started Dames & Moore, I guess in about August of 1938.

Scott: In the period of about three years or so before you fellows set up Dames & Moore, is there anything else that you would like to talk about?

Learning From the Old-Timers

Moore: Yes. We learned a lot from some of those old-timers like Labarre and Gus Saph. "Old Man" Labarre, as I called him, or "Cap" Labarre, had a tremendous intuition. When we had a problem, we would make studies for certain structures, a retaining wall, or something like that. We would make our calculations of the pressure and so forth and so on, and he would look at it and say: "No, this isn't right." So then we would tell him how we calculated it all, and he would point out that our calculations were not right.

What we had to do then was to sit him down and get him to tell us what he remembered, because he had a picture in his mind of some job or some project, something that he'd seen somewhere, and it didn't work that way. And nine times out of ten, after we talked it over and began to find out what he had on his mind, we would find that we had not put one of the factors in our calculations. He didn't know what the factor was either, but this exercise was an interface, if you will, between an old experienced construction guy and the young guys who know all the equations and calculations for earth pressure and all that sort of thing. By the time we resolved it, we of course found out what was the difference between what he was remembering and what we were talking about. Nine out of ten times we had to revise some of our assumptions.

Scott: So his experience and intuition enabled him to identify assumptions that your theory did not?

Moore: Once in a while we could show him why this job was different, or why it really would work in this case. But first we had to find out what was his understanding of the situation, and this made us look at the assumptions we had made. And all of the analyses engineers make are loaded with assumptions. Some of the assumptions are not bad, but they are assumptions.

Scott: So I guess some of them can be pretty fictional.

Moore: They are. Anyway, that is one thing I think we learned from Labarre.

Scott: You got excellent early experience working with Labarre, Saph and other old-timers?

Moore: Yes, we did, working with other people like Clarence Derrick, and Mark Falk, and so on. Gus Saph was one of the greatest engineers in San Francisco. I did a lot of work with Gus Saph up here. I used to think he was pretty tough on me, because when we made a report, or made a recommendation on something, he would start questioning and questioning. He questioned this and questioned that. I thought he was being nasty, but I finally found out that he wanted to find out what we knew, what we *thought* we knew, and when we were guessing.

When we were guessing, he wanted to guess along with us, but on what we really knew, okay, that was all right. When we were extrapolating from what we knew, that was okay, too. When we were guessing, that was also all right, but if we were guessing, he wanted to know it. He liked to talk about the consequences of guessing. That taught me a lot about dealing with people. It's related to the attitude of so many engineers who do their calculations, and tell their clients, "This is the answer."

Birth of the Strong Motion Program

Moore: Meanwhile a couple of things were going on relating to earthquakes. One was the development of better guidelines or codes for seismic design, and the other one was a gathering of information on what happens during earthquakes. That was the real birth of the strong motion program. I think John R. Freeman proposed or advocated it,⁶ but I don't think much happened until after the 1933

Long Beach earthquake. About the mid-30s, the Coast and Geodetic Survey got enough money to build some instruments to record what happens in an earthquake.

My old boss Cap Labarre would get on the train, go back to Washington, D. C., and stamp his feet and pound on the table and demand some money for strong motion instrumentation, because the engineers out here couldn't design seismically resistant buildings if they didn't know what forces they had to design for. So this was a combination of technical needs and the political inclination, I suppose, of people like Labarre.

It was not only Labarre, but also there were other engineers all over the state who were joined together to demand, or ask for, if you will, some money for the strong motion program, to build instruments to be put in buildings and on the ground, to record what goes on during earthquakes. That is now being done by the U.S. Geological Survey. That work in the 1930s was just the beginning of it. The person in Washington D.C. in charge of this program was Capt. N. H. Heck of the U.S. Coast and Geodetic Survey.

Scott: You got deeply involved in seismic and earthquake-related matters at the very beginning of your career.

Moore: Yes. I think we wrote one of the first differential equations for describing the motion of a structure when the bottom moves. Around 1936, I did it with Sid Bamberger, who is now dead. Almost everybody assumed that earth-

quake movement was described by applying a lateral force to the side of the structure, $F=MA$, and all that, but in reality it does not work that way at all. The force is applied and the movement starts at the bottom of a structure. We wrote a crude equation to describe acceleration imposed at the bottom that causes certain deflections. Clarence Derrick was one of those who first visualized the importance of that, because it's quite different from applying a lateral force on the superstructure. If the bottom moves over very suddenly, at first the top would not even move. The motion would travel up the structure, and it would take about half a period, if I remember right, for the motion even to be felt at the top.

Of course now that's old hat, with all these finite elements, vibration analyses, and all that now being standard practice. But basically that was the initiation of the concept of the response spectrum. You got a certain motion at the bottom, and tried to figure out what would happen at the top or somewhere else.

Scott: To do that, you wrote an equation that calculates and describes the motion?

Moore: Yes. It was nothing unusual or particularly notable. It was based on the concept of a flexible structure whose bottom is suddenly moved over by small amounts, and seeing what would happen to parts of the structure up above. The calculations had to do with earthquake motion as it starts at the bottom and travels up a structure. The equation was a way of calculating how the portions of a structure moved in sequence, over time, when responding to a lateral force. It dealt with deflection and time. It balanced the force against the mass

6. Freeman, John R., *Earthquake Damage and Earthquake Insurance*. McGraw-Hill, New York, 1932.

and acceleration, and then we integrated that. It's the same thing as what is now going in design, where you have all these "lumped"

masses, and you move the bottom over and then something happens to the structure at certain intervals.

Dames & Moore: The Beginnings

We try to ... help clients make use of the attributes of the earth.

Setting Up an Office

Scott: Discuss the beginnings of the firm Dames & Moore. I believe you started Dames & Moore as a three-person office that included you, Trent Dames, and his wife, who was secretary and general office manager. For safety's sake, I believe you also kept your other job, for a time.

Moore: Yes.

Scott: What motivated you to set the firm up, and how did things go after you opened your doors?

Moore: There were not many jobs then, so there was not a lot of choice. We knew a good many engineers who were designing schools and other buildings, and we worked with them on trying to solve their problems. That is about the size of it.

Scott: I believe you and Trent Dames had worked together before, at the Los Angeles consulting firm of Labarre and Converse.

Moore: Yes. We had been classmates at Caltech, and had both worked for Labarre. Trent Dames had worked for the

Bureau of Reclamation in Denver, and I stayed in Los Angeles and worked for the Corps of Engineers, and for Labarre. At the time we started our partnership, Trent was working for Labarre and I was working for the Corps of Engineers.

Anyway we decided to rent a one-room office, get some desks and stationery, and set up shop. Business was pretty poor in 1938. Even after we started the partnership, I kept my \$200-a-month job at the Corps of Engineers for several months, until we got a few jobs for the new firm. At the beginning our total staff was Trent, his wife, and me. She was the secretary, answered the phone, and typed the reports. I think our first job was for Mark Falk, a structural engineer in Los Angeles.

Moore: Trent and I went into business in August, 1938. We decided to try to practice in the foundation engineering aspects of the business. We had an interest in that when we were in college, because we both specialized in the soil mechanics and foundation aspects of civil engineering.

Scott: So from the outset you had been preparing yourself to go in this direction?

Moore: Yes. We set up a business basically in foundations and soil mechanics consulting work. We had also already developed a fairly close tie with the structural engineers, because both Trent Dames and I had been active in the Los Angeles section of ASCE (the American Society of Civil Engineers), and also with the structural engineers.

Hard to Get Started: Clients Did Not Understand

Scott: Was it hard for your new firm to get started?

Moore: Yes it was. Clients thought they were interested in a certain amount of soil mechanics, but did not really understand what the information was for or how to use it. So one of our principal needs was to be able to talk with clients long enough to figure out what it was they were trying to do, and then figure out how to use soil mechanics information to help them do what they needed to do.

Scott: Were they often in too big a hurry for that?

Moore: No, they just did not understand what soil mechanics was. They simply wanted to know what bearing pressure to use—that was all they were concerned about. Of course, foundation engineering consists of much more than just figuring out what bearing pressure to use. It also includes anticipating what settlements are likely to occur, deciding whether spread footings are a better choice than piles, and if spread footings are used, how deep they should be, as well as what their behavior and cost would be.

Every engineering situation involves compromises between costs and behavior. So it was necessary to develop some understanding of the different choices that were possible, and of the behavior and costs associated with those different choices. That still goes on now—it is still an important element of the engineering business.

Scott: But when you were getting started, it was hard to get clients to understand that?

Moore: Yes, it was, because at that point their primary interests were in getting enough information to satisfy the building department, and in the cheapest, least expensive way. They were not much interested in improving the procedure.

Scott: They did not grasp the significance of some of those choices regarding foundation engineering?

Moore: No, not really. Some of our best successes came when we started working with clients who had to pay for the results and live with them for a while. They became more interested in looking at the choices available and the implications of the choices.

They could pay for piles or not pay for piles, and they had to live with a building for 20 or 30 years. Many engineers tend to take too short-term a view, wanting only to know how big a footing needs to be shown on the plan in order to get the project approved by the building department. That overlooks the implications of settlement of the structure afterwards—recognizing that a structure always does settle to some extent.

Defining Our Work

Scott: I believe you began carving out the firm's role early the development of soil engineering and soil mechanics.

Moore: Yes, that started early—defining our firm's work. We basically do foundations, soil mechanics, and environmental studies—mostly work having to do with the ground. Earthquake studies having to do with the ground. We are

not structural engineers, we do not design buildings, and we do not design bridges. We do design some earth dams and dikes, and that sort of thing, but we work mostly with others on the design of major projects.

Scott: You work closely with structural engineers, but professionally speaking you are not yourself a structural engineer?

Moore: No. I'm a civil engineer with a special interest in structural matters, and the interrelationships of structural engineering and foundation engineering. I think an understanding of structural engineering is essential for somebody to be involved in foundation engineering. But I am critical of some structural engineers who do not seem to care about what happens below the ground.

We try to see how we can help clients make use of the attributes of the earth. In site selection we help them pick out a site that is not, for example, already filled in with garbage, or if it is, advising how they can use the site. From that, we got into studies of groundwater pollution, which is a big deal now—cleaning up polluted sites. We also get into air pollution, meteorology and where pollution goes, and so forth.

Scott: Would you discuss how your firm's role developed along with the field of soil engineering?

A Little Background on Soil Mechanics

Moore: The earliest work in soil mechanics was done by Dr. Karl Terzaghi who might be called the father of the science of soil mechanics. He came to MIT and also worked at Har-

vard. Terzaghi's work⁷ and that of some of his people on the east coast motivated other engineers to do some soil mechanics work—I guess Moran and Procter in New York were among those who did that. Professor Fred Converse of Caltech began to pick up on Terzaghi's work and gave courses that Trent Dames and I both took, probably in 1932.

I should emphasize the considerable difference between the emphasis of the work done on the east coast and the west coast. On the east coast, attention centered on the compression of marine clays, such as Boston blue clay, which got a lot of attention because of the settlements observed, probably at MIT. On the west coast, however, we did not have any of those deep marine clays, but had a lot of alluvial soils, of fine sand or coarser sand. So as a matter of necessity, we needed equipment that would enable us to get samples of those fragile granular materials.

Development of such equipment had actually started with Labarre and Converse—Converse did the theory part, and Labarre did the machinery part. Before the time of Labarre and Converse, the soil test business was done more or less through research by universities, and they never made any particular attempt to help the structural engineers figure out how to use the results and apply them.

The need for *usable* information was driven home to me early on, when I worked with the Corps of Engineers. I mentioned before how their soil lab made sieve tests, particle size tests, grain tests and plasticity tests, but they had no

idea how to get samples that were relatively undisturbed, intact enough to be usable in testing the actual properties of the material on-site. Once in a while they would cut out a foot square of material and try to do a shear test in the lab, but it did not work very well.

Then when Trent Dames and I went back to school, we did our thesis work on the permeability of friable soils of different densities and structures. We also developed the practice of making large-scale tests and correlating the laboratory work with the results of the field tests.

Building on our early experience, from the outset what Dames & Moore tried to offer was an attempt to do soil mechanics work, but put the results in a form that the design engineers could use directly—what behavior and what settlement to expect, whether to use spread-footings or piles, and what loads to put on them, and so on.

Scott: So Dames & Moore was among the first in the field to try to do that? You picked up from Labarre and Converse, and went on from there?

Moore: Yes, I think that is right. They were about the only other ones out here in the west who did that. The testing labs would do tests, but that was all they would provide. We learned from Labarre and Converse, and from our firm's beginnings, we built on what they had begun.

Scott: You apparently took some leadership in doing different kinds of things to get better and more usable results? And you moved into and developed the role of interpreter of soil mechanics findings?

7. Casagrande, Arthur, *Karl Terzaghi, 1883-1963*, Harvard University, Cambridge, MA, 1964.

Moore: Yes, I believe that is right. I think we built ourselves into the position of being interpreter of soil mechanics to the design engineers, so they could use our results directly. I think that is the principal thing that we did contribute.

Developing Soil Sampling Equipment

Scott: Understandably, you need good soil test results in order to make interpretations that will be valuable to your clients. In the initial period of your practice I believe there was a real shortage of soil sampling equipment and methodology. Nowadays, of course, if someone wants a sophisticated piece of soil sampling equipment they can pretty much buy it off the shelf. But such equipment was not available until about the late 1940s. So from the outset I believe Dames & Moore is credited with taking the lead in developing some new and different equipment. Is that right?

Moore: Yes, although I also want to acknowledge that the whole business was an evolutionary process, and other organizations were also engaged in this kind of activity, so we cannot claim all the credit. You might say these developments occurred by necessity—new methods had to be developed in order to get useful soil samples.

Anyway, Trent Dames and I worked on new sampling equipment from the very beginning of our practice. Moreover, fairly early in our history, say 1939 or so, our firm set up an equipment design section with two or three people, which actually Trent pretty much ran back then. As I say, we borrowed ideas from

Labarre and Converse, and at the outset built on them, but equipment development has been a long-term continuing activity in Dames & Moore, which still has an equipment development section.

That section built our own equipment, and also sold quite a bit of equipment, although we have never had the big sales that the soil test group in Chicago did, which became marketers of soil sampling equipment. I think we might have been ahead if we had marketed our equipment more. So you might say we made the equipment for our own use, but we did also make it available, and sold some equipment, including to the Corps of Engineers.

Scott: I take it one of the most important activities in equipment development was devising innovative soil samplers so you could get usable soil samples that would provide data useful to your clients. Would you say a little about those activities?

Moore: Yes. The key to it was developing sampling equipment with which to get samples of the friable, sandy, silty materials.

An Early Leaf Sampler

Moore: One of our first samplers was a "leaf" sampler. It had some fold-in leaves that would open up and catch the sample. One of our early jobs was down in the Los Angeles River, for the City of Los Angeles. We had to make some studies for a bridge foundation but could not get any good samples, so we had to develop a sampler to do the job. We needed a sampler that would retrieve these friable granular, water-soaked materials to get some samples we could then use in making conclusions that

could be translated into a form that the structural engineers could use directly.

The job involved the Aliso Street Bridge, downtown near the railroad station. The river bed is full of sand and gravel, and it is miserable stuff to take samples of. We had a job to try to help the city design a bridge. We went out there with a boring rig, but could not drill a hole more than three or four feet deep until we were in water and sand, and could not get a sample.

So over a weekend we invented a new kind of sampler, and soldered it together on the floor of my kitchen. You see, for years and years core drillers have taken a circular spring and made a core catcher, as they call it. They made springs out of it, and as a core goes up in the barrel there is a "catcher" to hold the core. That works for a solid core, say a rock core, but does not do much good in sand and gravel, because the springs cut the sample material up.

What we did was to make a modified type of sampler. We cut out a bunch of little leaves and recessed those into the walls of the sampler. We soldered on some wires to act as hinges, so the leaves could be withdrawn smooth with the wall, and not stick out like rock core catchers do. They were flat with the wall, recessed in the wall. Then when you started to raise the sampler and the sand started going out, these retractable leaves would fall down and almost close the opening. That way you could take samples of loose sand. You can take samples of hydraulic fills.

Scott: You needed to get samples that were sufficiently intact so that you could learn something about the properties of the material.

Moore: That is right. They were criticized by some of the eastern people, because there was of course a certain amount of disturbance of the core sample, so that it differed some from the natural material. But we found that the disturbance was not all that serious, and that we could correlate the results. That is, the material was not strictly speaking "undisturbed," but was sufficiently undisturbed to make the tests usable. Incidentally, after we developed the leaf-type sampler, the Corps of Engineers bought one of our set-ups for doing that kind of sampling in connection with some of their work in the Pacific islands. It was the only thing that would get usable results.

Ring Samplers

Scott: Talk a little about some of the other samplers and innovative devices that you have developed over the years. What about the ring samplers?

Moore: I believe the first of the ring samplers was built by Labarre in his laboratory for his own shop. Then we developed other ring shear testing equipment, based on the device originally developed by Labarre and Converse, and which we adapted for more routine type work. A lot of the soil sampling had been done with small samples of 1-1/2-inch diameter, but the disturbance was too great, so you needed a larger sample. For that, we used rings about a 2-1/2 inches in diameter.

Scott: Would you describe the ring sampling device?

Moore: The rings were usually brass, and were approximately one-inch-long segments or sleeves cut from standard tubing, 2-1/2 inches

in outside diameter with walls about 1/16 of an inch thick. The rings could be stacked one on the other inside a split-barrel sampler, the number of rings depending on the depth of sample desired. The tubing that had been used before in some samplers was generally 1-1/2 inches in diameter or sometimes even 1 inch. But the sampling process disturbed about the outer 1/8 of an inch or so of a sample, so smaller diameter samplers caused proportionally much more disturbance, whereas the test results of the 2-1/2-inch sampler tests were quite usable, despite the criticism they got from the theoreticians at some eastern universities.

Incidentally, we once actually had one made up with an 8-inch diameter, but it was awkward, cumbersome, and expensive, so we used it only in special circumstances, such as encountering gravel or large rocks. Anyway we settled on the 2-1/2 inch sampler as one that could be made to work and would give usable results. This was quickly copied by many other firms that sprang up out here—Shannon and Wilson was one of the early firms.

Piston Samplers

Moore: We also developed a piston sampler that provided a vacuum to help hold the sample in the sampler.

Scott: This was basically an addition to the ring sampler, so some ring samplers were used without the piston, and some with it?

Moore: Yes. We developed the piston idea because weak soils would fall out of the ring sampler before they could be gotten out of the hole. The vacuum the piston provided helped

hold the sample in the sampler when it was pulled back up.

The piston sampler could be lowered on a string of drilling rods to the bottom of a boring, and a sampling tube forced into the soil below the bottom of the boring to obtain a relatively undisturbed sample. The piston was withdrawn from the sample tube as the sample tube was pushed into the ground, which helped pull the sample up into the tube. That way we could get the sample out of the hole, without actually going down in the hole to get it.

We actually used to go down in the hole ourselves. Back when I started working for Labarre and Converse, we worked a lot with 30-inch diameter borings, and would go down in a boatswain's chair to dig samples out of the side of the hole. That was not only rather difficult, but also there was always the risk of the walls of the hole caving in on you. In contrast, the piston sampler, being lowered down into the hole with the drill stem, enabled you to take samples that could not otherwise have been taken using methods that worked for the heavy clay found back east. Even the piston sampler, however, would not hold the sample if the soils were quite friable and more or less water-saturated, so we used the leaf sampler for those.

Pneumatically-Controlled Consolidation Test

Scott: Neville Donovan also mentioned a consolidation test used to prepare estimates of settlement. At first those involved consolidation test procedures that required doubling the load at each successive increment, and called for the use of large and awkward weights. I believe Dames & Moore developed another

procedure for dealing with the big loads that eliminated the need for the heavier weights.

Moore: Yes, the big loads required too much space and too many weights. So probably in 1939 or 1940 we developed a consolidation test that applied most of the load by pneumatic pressure, eliminating the need for the large weights. There was a pneumatically controlled consolidation apparatus that provided a steady pressure on the sample. Recognizing that pneumatic controls are not very reliable at small pressures, the apparatus was also designed to provide control of small loadings by a lever arm system with modest weights.

Our Interest in Seismic Design

Moore: We were also very much aware of seismic considerations, which almost always figured in our work. Nearly always some attention was paid to the earthquake aspect of projects. We tried to evaluate the probability of different kinds of earthquake shaking and what that motion would do to the foundations—whether it would cause a lot of settlement, or would not make much difference. At least we tried to get people to think about the earthquake possibility.

Scott: You had been interested in seismic matters from the very beginning of your career, hadn't you?

Moore: Yes. Back while we were still working for Labarre and Converse, one afternoon Labarre came to me and said, "Bill, call up your wife and tell her you won't be home for dinner tonight. You're going to be assistant secretary of the Structural Engineers Association of Southern California." I said, "Oh?" He said, "Yep."

So I became assistant secretary to the structural engineers association—in about 1936. I suppose that was my introduction to participation in the structural engineers association.

In 1936 the earthquake aspects of structural engineering were practically the whole of the structural engineering business. At that time we had the Field Act, which was enacted in 1933 after the Long Beach earthquake, and public schools had to be redesigned and rebuilt for some degree of earthquake resistance. The foundation work we did for schools and other buildings always had an element of providing for earthquake resistance. So naturally we worked very closely with the structural engineers to do that. I think that became the basis for the entrance of the Structural Engineers Association into the earthquake business, and its role in the development of seismic code provisions.

I mentioned working for the Coast and Geodetic Survey on their earthquake program. That is where I worked with John Blume, and with Franklin Ulrich, who was the chief of the program. A part of the earthquake research program was to measure earthquake ground motions and vibrations. I worked directly with Ralph McLean, a structural engineer in southern California. This got me going, particularly in connection with the earthquake engineering business.

I wrote a few articles for the Coast and Geodetic Survey's publications. In fact around 1934 to 1936 the Coast and Geodetic Survey published a whole flock of articles by various people on earthquake behavior. I also helped arrange programs for the structural engineers, and did committee work for the structural engineers and ASCE on earthquake-resistant

design procedures. I worked with such people as John Blume, Oliver Bowen, Steve Barnes, and a lot of others. This was probably in about 1935 and 1936. Trent Dames and I kept on with that same interest after we started our business in 1938. We maintained close relationships with structural engineers and their committee work with earthquake-resistant features. In 1941 Trent Dames and I wrote a report for Chevron for several refinery structures over in Richmond, with recommendations noting the proximity and distance of the San Andreas and Hayward faults. We recommended that Chevron consider earthquake effects, gave them pile capacities for tower structures under earthquake conditions, and that sort of thing. Interest in earthquake behavior has always been part of our foundation practice, and we are still doing it. In fact, that was one of the ideas that we got from Labarre and Converse.

Since those early days, our firm has continued its emphasis on seismic considerations. We have some people right now who are at the forefront of the business of trying to evaluate—I won't use the word predict—the kind, the severity, and magnitude of motions that are likely to occur from different earthquakes and on different ground conditions. These factors need to be put into the reports made for the developments of whatever facility it might be. Two of the key people who were doing this were Neville Donovan and C. B. Crouse, although they also worked with several others.

We also had pretty good contact with earthquake design developments in research going on at California universities. We maintained good communications with researchers at Caltech, Berkeley and Stanford.

Scott: Did you personally maintain such communications, or your firm, or both?

Moore: Both. I did that individually, and also the firm did. This gave me contacts with people such as Perry Byerly at Berkeley and Hugo Benioff at Caltech.

Scott: Say a little about those people, and how you cultivated them or maintained the contacts.

Moore: My contacts with Perry Byerly at Berkeley were mainly as an employee of Labarre. I had opportunities to sit in at meetings and listen to Professor Byerly and Labarre talk about earthquake behavior, so I learned a fair bit about that. I also mentioned that I worked in southern California for the Coast and Geodetic Survey on measuring building vibrations. At the time, Benioff was also engaged by the Coast and Geodetic Survey to develop some of the early strong motion instruments. Benioff was at Caltech, and I think was also an independent consultant for a while. At any rate, Benioff developed some instruments to record vibrations in structures—records made at different locations in the structure at the same time. In those days very little was known about what happened when a building shook during an earthquake, and Benioff was involved with that work.

Structure-Foundation Interrelationships

Moore: The foundation engineer needs to understand what is going to happen above the ground. He needs to understand the above-ground structure as it relates to the foundation. In our own practice, doing earthquake engi-

neering required us to evaluate the dynamic and seismic behavior of foundations and soil materials—the relationships of foundation behavior to structural behavior. We took part in many technical sessions for structural engineers and ASCE on the development of earthquake-resistant design concepts and procedures.

That led, of course, to our participation in the Earthquake Engineering Research Institute (EERI). Every annual meeting of EERI included papers on experiences with earthquake-resistant design ideas, and observations of what happened in earthquakes. I think one of the big things EERI did was to develop a program of observing what happens in an earthquake, and trying to learn from that how to avoid some of the troubles. I, individually, and we as a firm participated in some of the EERI activities.

The structural engineers also included seismic design issues in their programs, particularly their annual conventions—yearly meetings of the Structural Engineers Association of California (SEAOC). We also participated with SEAOC, the American Society of Civil Engineers (ASCE), and the Consulting Engineers

Association of California (CEAC) in developing recommendations for improvements in building code procedures and how to develop desired resistance.

Scott: These code recommendations took the form of *Separate 66*⁸ in the early 1950s, and the *Blue Book*,⁹ first issued by SEAOC in 1959?

Moore: Yes, and it really continued constantly over a long period. There were certain accomplishments from time to time, like *Separate 66*, and then the *Blue Book*. These things crystallized some of the work that had been going on, and record the results of the progress, or lack of it, as the case may be.

Scott: *Separate 66* and the *Blue Book* were ways of developing seismic design and code thinking, and disseminating the information.

Moore: That's right. The work of SEAOC was one of the major factors in developing a better understanding of how structures behave in earthquakes. And the EERI work was also important.

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8. Anderson, Arthur W., et al., "Lateral Forces of Earthquake and Wind," *ASCE Proceedings*, Vol. 77, Separate No. 66, April 1951.
 9. *Recommended Lateral Force Requirements and Commentary*, SEAOC Seismology Committee, Sacramento, CA. Editions issued periodically, beginning with the first edition in 1959. Current edition is 1998. For further information on the *Blue Book* effort, see R. W. Binder and W. T. Wheeler, "Building Code Provisions for Aseismic Design," *Proceedings of the Second World Conference on Earthquake Engineering*, 1960, Japan.

Growth of Dames & Moore

What people really want is to talk with somebody who can help them understand their engineering problems and their engineering options, and help them make some selections.

Scott: Would you discuss the growth of Dames & Moore. One presumably important growth move was opening the firm's first branch office in San Francisco in 1941. Maybe you could start there.

Opening the San Francisco Office

Moore: The opening of the San Francisco office, which we did in 1941, was kind of interesting. We became acquainted with a young fellow by the name of George Potts. He'd gone to school up in Berkeley, he knew San Francisco, and was very much interested in and a booster of San Francisco. So he was telling us how much potential business there was for us up in San Francisco. Since he knew everybody, he figured he could come up here and set us up in business.

Like naive folks, we hired him as a business developer, and he came up and ran up a pretty good expense account taking people for lunches and so forth. But the worst of it was his talking

to somebody over in Oakland who wanted to build an addition to a shipyard. Without conferring with us first, Potts told him Dames & Moore would save them about 25 percent of their pile costs if they would retain us to be their consultants on the foundations. The guy says, "O.K., you're on—if you can save 25 percent of our pile costs, that's pretty good." So George Potts called me and said, "Well, we have a nice job up here." So I said, "We have what?" He said, "A nice job—all we have to do is save them 25 percent of their piles." I said, "Twenty-five percent of what?" There were no plans for the project, so nobody knew how many piles they would need to put in. How were we going to save 25 percent of the pile costs?

I had to take the train up to the Bay Area. I met with the fellow at the shipyard, talked to him about what we would do, and helped him figure out how many piles they needed, what load they could put on them, how long the piles would be, and all of that sort of thing. But I said, "I can't guarantee we're going to save you 25 percent of what you think you're going to spend. Maybe when we get done you'll have to spend twice what you think you're going to spend for piles." Nobody knew what was underneath the site. So that was the first job that we did *not* get.

Scott: You did not get it?

Moore: No. But I guess that illustrates the naiveté of some people who think they can sell engineering work.

Scott: His approach to landing jobs was not appropriate for a responsible engineering firm?

Moore: No, and I think this experience made a considerable impression on me. I now

have a fairly strong conviction that it is difficult to impossible for someone to sell, let's say engineering services, unless they are really an engineer, and understand what they can do and what they cannot do. I have had and still have the view that a sales department is not of much use to an engineering firm. What people really want is to talk with somebody who can help them understand their engineering problems and their engineering options, and help them make some selections. I doubt that a potential client can do very much of that with a sales department.

Scott: Not unless the sales department staff also has some engineering expertise.

Moore: And even then the client does not want to talk to the salesman, but to talk to somebody who speaks their language. I am expressing what is probably my own prejudice, but it is a fairly strong sentiment. We keep running into this idea of setting up a business development or sales department for an engineering firm, and I've seen a lot of them do it. I suppose that it works for some firms, but is not usual for engineering consulting firms, in my view. While a few have used non-engineer sales departments, I believe this is quite rare

At any rate, following the first ill-fated effort, I wound up coming here to the Bay Area a lot, and started talking to some of the business people and engineers and so forth up here. I guess for almost a year I came up almost every week and stayed for anywhere from two to four days. That led to our doing a good deal of work up here in the World War II years, mostly military work and harbor work. We did work for the Navy and the Army bases, and Hunter's Point

and Mare Island. At the time there was a lot of harbor work going on, rebuilding harbors in Oakland, in San Diego, in San Francisco, and so forth. There was quite a lot of construction, mostly war-related, but a lot of it was private. For instance, shipyards like the Kaiser shipyards were private, but related to the war effort. We worked on two or three of those.

Scott: So your early-day salesman George Potts had at least been right about the potential for work up here?

Moore: Oh, yes, he was right about that.

World War II Progress in Engineering Practice

Moore: World War II had a big impact on Dames & Moore and on engineering practice generally.

Scott: Nearly everything in the engineering business shifted to war-related work, no doubt.

Moore: Yes. A lot of engineering was done during the war, but much of it was fairly routine engineering—such as airplane factories and munitions factories. A lot of that kind of thing was done in a hurry, and we at Dames & Moore were very much involved in that. But not much research and improvement in engineering was done while the war was actually going on or even in the first part of the postwar period.

Everybody was busy trying to build military facilities and industrial plants for the military. So there was unquestionably a considerable gap in research efforts in earthquake engineering. During the war and in the postwar period we

pretty much continued to build things the way we already knew how to do it.

Immediately after the war, the pressure was to rebuild facilities in a fairly standard fashion, and fast. I think that continued for almost twenty years after the war. We were busy and all the engineers were busy, but they were not doing much that was new. The United States had about the only significant economy that was not seriously damaged in the war. American engineers were working throughout the world building the things that they knew how to build.

Later, after things kind of got built out, we began facing much more competition from engineers in other countries in Europe and Asia. There was also pressure to improve practice and do research on improved engineering methods. The Japanese have done a lot of this—they have done a great deal to improve their engineering processes since World War II. In the U.S., engineering has not done nearly enough since World War II to keep up in that competitive ballgame.

Now in earthquake engineering and electronics, the U.S. is doing a lot. Perhaps we are still leading in the electronics industry. And particularly after recent earthquakes, a great deal of research and study is going on in earthquake engineering. But I think it is a different story in other engineering—civil engineering, mechanical, and electrical engineering. I do not believe that much has been done towards improvement. The engineering in some of those fields seems almost fifty years old. That may be part of the problem we have now with Caltrans, although they and their engineers are now beginning to pay more attention.

Scott: When you refer to Caltrans, do you mean they have not been in the mainstream of engineering, or maybe particularly earthquake engineering?

Moore: That is right—I think they have not kept sufficiently in touch with what has been going on. But I should not just pick on Caltrans. There are not enough engineers in either the private sector or public sector who are really thinking ahead at what needs to be done. They are more occupied with the job they are working on, or how to get the next job and do it as cheaply as possible. I think not nearly enough money and effort are going into engineering research in the U.S., especially considering what the Japanese and the Europeans are doing.

Impact on Dames & Moore

Scott: What about the war's impact on Dames & Moore?

Moore: Despite what I just said, wartime pressures did result in some improvements in professional practice. In our own foundation engineering work there were improvements that increased the capacities of pilings, and improvements in the methods of excavation and shoring.

Scott: You had to learn quickly how to do some new and different things?

Moore: Yes. The need to do things fast was an incentive to use some initiative and do some things a little differently than before. Long duration of service was not a big issue. Higher risks were more acceptable in wartime than in other times.

Scott: What about the impact of the war-time period on you and on your firm?

Moore: During those years most of our work was related to the war effort—a great deal of it was for the military, the Army, Navy and the Marines. I did a great deal of work myself at Hunter's Point, Mare Island, and many of the other Navy and Army facilities. But at least half of our activity then probably involved industrial work related to the war effort, such as building airplane plants, shipyards, etc.

In that period we developed some concepts for the use of piles—for instance, the aircraft plant in San Diego, which is at Lindbergh Field, was built during the war. We proposed and carried through the consultation on the support of the plant by means of steel H-piling because that could be done quickly. Up until then, steel H-piling had always been considered to be useful only when you were driving to bedrock, but there wasn't any bedrock in San Diego at reasonable depths.

The innovation was the use of that type of pile as a friction pile. It went through a lot of soft mud and fills, which are going to settle, and went on down into some firm sandy soils that were firm enough to hold it up, but there was no bedrock for a long way. So it was a case of figuring out how to work with the H-piles, estimating how much downward friction would occur from the settlement of fills and the soft soils, and how far the piles needed to go in the firmer, sandy soils to develop the friction needed for support.

The first use of steel H-piling for friction piles that I know of was in the San Diego City Hall, which I worked on for Labarre and Converse,

about 1936. The Bethlehem Steel people were very much interested in proving that the steel H-piles could be used by developing skin friction in stiff sandy clay soils below the soft bay mud, but without going on down to bedrock. That was what we did at Lindbergh Field, but it had not been done very much, and was not yet accepted in most codes. As I noted, Labarre had started that innovation earlier, and I had worked with him on it.

Anyway, that kind of application represented progress in engineering technology. In doing that, we did give thought to the effect of earthquake vibrations on those pile stress conditions, safety factors, stability and so forth, because we didn't want those things to fail in an earthquake. That type of thing went on quite a bit during the war.

There was also quite a bit of development of other types of foundations, like drilled-in piers, because they could sometimes be built without much steel. Drilled-in piers were suitable for building things rapidly under wartime conditions. They drilled holes and filled them up with concrete, reducing the amount of steel that had to be put in underground. Sometimes they were belled-out and made large at the bottom, or sometimes just made straight.

There again you have to figure out how far down to put the pile to develop the support you need. If there is no bedrock, you have to figure out how far the pile has to go into the firm materials, and what will be the skin friction that develops. So we developed quite a few techniques for calculating and estimating this type of thing, and checking it with loading tests.

The 52-story Bank of America Building in San Francisco is on some of those drilled-in piers. They were drilled into Franciscan rock formation that is common here in San Francisco. There are many, many buildings like that in San Francisco and throughout the state.

The Firm's Geographic Expansion

Moore: Another thing that occurred in the war years was the firm's geographical expansion. We started our overseas work during those years. In 1943 I went to Saudi Arabia for Standard of California, which later became or was taken over by ARAMCO, the Arabian-American Oil Company. The purpose was to locate a site for a refinery in Saudi Arabia, because at that time there was need for aviation fuel on the war's eastern front.

When I went to Saudi Arabia, General [German Field Marshal Edwin] Rommel was in North Africa, headed for Cairo. To get to Saudi Arabia I had to fly to South America, then fly across to Africa, up to Cairo and back down to Saudi Arabia. There was no direct communication at all—no mail, and no phone. So it took a little bit of initiative and imagination to figure out how to do some of those things.

We also developed some soil sampling equipment for the Navy that could be used by the Seabees—the Naval Construction Battalion units—for operations in advance areas, before the areas had actually had been occupied. They were needed for rapid determinations as to how quickly—in hours—they could build an airstrip that planes could land on. They were also used for taking measurements to help determine the behavior of landing craft landing on beaches.

The Navy had to be able to test some of the soil conditions in those areas, ahead of occupation forces. First you needed to try to estimate the conditions, and then when their people got on the site, they had to have test results immediately, NOW! There was no time to send the tests out and get the results a week later. The results had to be immediate for decisions made right then. They needed an airstrip, not for huge planes but mostly for fighter craft. We did a lot of that sort of thing.

Scott: How did you deal with the need for great speed in testing and getting the results?

Moore: We developed a little portable and rather crude shear-testing machine. It was like a metal tool kit. The sampler had retainer rings like those in our shear testing apparatus in the lab. You could shove the sampler in the ground, take samples quickly in the field. Then we had a little lab tester with which you could do rather simple ring-type shear tests to get an approximate measure of the strength of the soil. You would put the three rings on and put weights on until it slipped. It was a crude and simplified replica of our shear-test machine.

With most soil sampling, you send in the samples and get the results two weeks later. But since they had to be able to do things right away, there was not time to send the samples back to San Francisco or Hawaii for tests. Instead, they wanted the results immediately. What they really wanted was some way of making tests just by flying over the area!

I was involved in some of the soil stabilization studies and experimentation done by the Seabees for rapid construction of air fields and roadways for vehicles. What preparation was

necessary? What was essential in order to have a road they could get over without getting stuck?

Scott: What kinds of paving or surfaces were used?

Moore: Some were steel mats, although I wasn't involved with that particularly. I was involved in experimentation with various kinds of cementing materials—other than just plain asphalt and cement—plastics and synthetics that might gel quickly and allow vehicles to move over areas of loose sand and mud. There were a lot of ideas, but there wasn't a lot of success with this. Some of the things would work, but none of them really worked like magic. A lot of the information developed then has been used in construction work since, however, to stabilize working surfaces and embankments.

Operated as a Partnership

Scott: The firm's long history of expansion began during and after World War II. I take it that for a long time you continued to operate as a partnership. When did you incorporate Dames & Moore?

Moore: Not until much later, in 1992 I believe.

Scott: So Dames & Moore continued as a partnership up until quite recently? That was a big operation to run as a partnership, was it not?

Moore: Yes, it was. We were running around 3,000 people as a partnership. In 1987 we converted from a general partnership to a limited partnership, and then incorporated in 1992.

Overseas Expansion Started With Saudi Arabia

Moore: Our firm's overseas development actually started before World War II was over, when I went to Saudi Arabia for Standard of California in 1943. After the war was over, that work continued while they built refineries and other things. Our attitude was, if they wanted us to go, we went. The work in Saudi Arabia was what got us started overseas. In fact we are still working for Chevron, and for ARAMCO, the Arabian-American Oil Company in Saudi, and we have offices in Riyadh and Abu Dhabi.

Scott: Say something about what you did when you made the wartime trip all the way to Saudi Arabia.

Moore: The basic reason why Standard of California wanted me to go to Saudi Arabia in 1943 was to assess the bearing capacity of formations near the surface. But near the surface there was only weak, lightly cemented sandstone. They had done some preliminary looking for oil, using geophysical exploration equipment. Regular coring equipment—typical rotary rock-coring equipment—will not take a sample in dense or lightly cemented sand. It will go right through such near-surface formations like going through cheese, and the resulting core is mush. With that equipment, they had to hit something hard in order to core usefully.

Scott: A formation has to be fairly resistant before they can get a decent core?

Moore: That's right. So for the first 200 feet, the results of the geophysical exploration only told them that there was nothing but mush, whereas in fact there was a very firm but weakly

cemented limy sandstone. When they were drilling for oil they were just looking for the hard stuff and went right through the weak sandstone. In short, they had to have a different kind of equipment to take cores of that.

Scott: When they were just looking for oil, they really did not care what was in the first 200 feet, but when it came to locating structures in an area, they needed a pretty accurate estimate of the bearing capacity of what was immediately underground.

Moore: Yes. And the nub of it was that their equipment would not do the job. So I took machine-shop drawings of our sampler to Saudi Arabia, and we built samplers over there. If they had already had good samplers, there would probably have been no reason for me to go over there.

Engineering After World War II: Expansion, Then Competition

Moore: After the war, a great rebuilding was going on in this country and overseas. There were industrial facilities, transportation facilities, highway programs, school buildings. There was a lot of engineering and construction work, and it seemed like the market was unlimited. I think for about 30 years—from 1945 to about 1975 or 1976—not only we ourselves, but also American engineering and construction capabilities generally, had a largely free run of the world market. American engineering and consulting capability was at the forefront of rebuilding Europe and Japan. This postwar overseas work had a great deal to do with the American industries that were going overseas, and to some extent with American

foreign aid. Almost all of this work was done by U.S. engineering and construction people.

This overseas extension of American activities is now causing us a lot of trouble, because the other economies have developed—the Japanese, the Germans, the British, the French—and have good engineers and good construction people. Consequently, there is a great deal more engineering capability in the world than there is market demand for. There is plenty of need for facilities, but the financing cannot keep up with the need. The problem is financing the things that are needed. We see that here with our toxic waste, water supply, and environmental problems—the needs are clear, but the facilities cost money, and lots of it.

Furthermore, the American engineering and construction industry is facing extremely severe competition right here at home, as well as overseas. More and more Japanese and German people are coming into this country, because the U.S. represents about a third of the world market. Those countries have developed the engineering and construction capabilities. That is true even in the earthquake field. The Japanese have always been very much interested in earthquake engineering, and they are now beginning to export their ideas on earthquake engineering into this country.

Scott: Over the years, what have been the major shifts in the kinds of work Dames & Moore does?

Moore: Immediately after the war we got involved with refinery work in Australia, the Philippines, South America, India—everywhere you looked there was energy development, petroleum development, refinery develop-

ment, petrochemical development. That extended on into the 1970s, particularly in the Middle East, even before the oil embargo and price hikes. After the war we were also involved a good deal in the development of other facilities overseas in Australia and Europe.

To sum up, our firm got very heavily into energy—the petroleum power plant business, and then the nuclear power plant business. Then all of a sudden the nuclear work came to a screeching halt. Now we are involved with a lot of the toxic and hazardous waste cleanup work. While that kind of work is necessary, it does not give a construction-oriented engineer a great deal of satisfaction because it doesn't produce anything new. It is more of an "overhead" effort that is required to clean up the mess. There are going to be changes in industrial processes to reduce the amounts of that stuff produced—there will be better processes, reduction in the amounts of toxics and pollutants, and improvements in chemical treatments and incineration.

Scott: Apparently you and Trent Dames made an early decision that you were willing to grow, to go from a single office to a two-office firm or a multi-office firm. Was it in 1941 that you started coming up here to San Francisco?

Moore: Actually, I probably started coming up here to San Francisco about 1940 or thereabouts. Yes, we did make such a decision. I don't know that it was a terribly well-thought-out decision, but we did decide that we would do work for clients, and if we got good clients, we would go where they wanted us. I guess that was the philosophy. I don't know that we particularly said we wanted to expand into a lot of

different locations. I think we said, "If we get a good client and if they want us to go, we go." That has been the policy we have followed for 50 years. We followed the oil companies to different locations. We followed the Navy wherever they wanted us to go, including developing some portable test equipment that they could send out with the Naval Construction Battalion Seabee units to build airfields in the Pacific.

We now say that we try to be a "client-oriented" firm. We had never heard those words, but that's what we were trying to do. We were trying to find clients who would understand what we were trying to do, and whose needs we could understand. We understood what they needed, and just tried to go with them and stay with them.

Providing Careers for Our Employees

Moore: Our fairly strong commitment to trying to provide careers for good people working for us was another part of our motivation to expand. We wanted to give employees growing room. We figured that to provide careers for the good people, it was probably necessary to grow geographically and otherwise. We've seen a number of firms and organizations that did not want to grow, or would not share the benefits of growth outside a closely-held owner group. The result has been that the good people left the firms and set up their own shop, or joined another firm.

As a matter of fact, when both Trent and I worked for Labarre and Converse, I believe that if Labarre had been willing to give us a

small piece of the action, an ownership position, we might very well have stayed with him until he retired, and finally died, or have taken over after he decided to leave. He was smart, and very good, but he ran an autocratic one-man show.

That experience with Labarre made a considerable impression on both Trent and me. So when we got good people that were bright, capable, and able to do good work, we gave them a lot of leeway to develop. We kept in touch with their work and watched them and consulted with them, and so forth, but we did not tie them down. To put it another way, we gave them running room to develop business, and make it part of the Dames & Moore team. I think that was the principle we really did follow for 50 years.

Scott: In dealing with your employees, you have tried to help open up opportunities for career development and advancement?

Moore: Yes, and then also possibly leading to their participation as partners. If they were successful in developing good client relationships and doing good work, we gave them the opportunity to run a show of their own. Maybe we opened an office in Seattle, or we opened one in New York, or we opened one in Chicago, and so on. We took a partner or associate who had been working with us for a while and put him in charge of an office. I think there were two elements in this: One, we tended to follow good clients who appreciated what we did, and we tried to continue to do good work for them. Two, we also wanted to provide the opportunity for good people who could help the firm succeed.

Delegation: A Basic Difference in Philosophy

Moore: By contrast, I know of other engineering firms that are very closely held. They have two, three or only a handful of partners. If they get some other good people, the partners want to keep control of it, so in time the other good people go off and do their own thing. Maybe the firms will even help them set up their own practices, which of course is not bad, either. In fact, there may be a good argument for that as the better way to do it. I don't know.

Scott: Those are two clearly different philosophies.

Moore: Yes, it is a basic difference in philosophy. Would you let new people in the firm take over and run their part of the business and the consulting work—run it engineering-wise, financially, and so forth, with a relatively small amount of supervision? Or did you want to maintain a rather tight control over client relationships and the types of business the employees would do?

Scott: It got to the point where you argued those issues out, either between the two of you as founding partners, or among all the partners?

Moore: By that time I think we had four or five partners. Trent and I had brought in first one partner, and then a second and a third. Then we had the opportunity, let's say, to have some new partners go open up an office in Chicago or New York or some other place—and to provide an opportunity for some of the younger partners to build their practice in conjunction with the firm. Some of the earlier partners did

not like that. In their view, these new people should be controlled and supervised.

We had some good partners—good employees who had become partners—but who were very uncomfortable with the idea of letting some younger people take off and run a piece of the business in their own way, without very close supervision. So some of these people left. They wanted to run a business that they controlled, and knew what was going on all the time at all locations. We came to the point where we had to make that choice. We chose not to try to keep things so that Trent and I could control everything.

That forced us into a rather traumatic decision when we came to the point of losing a few partners. We lost some good partners because they didn't like our decision, preferring instead to maintain a closer kind of control. That seemed to be more important than doing a wide variety of interesting work—wherever it was—and providing substantial growing room for staff and younger partners.

Concerns About Expansion

Scott: What were the central concerns of the partners who did not like the firm's expansion and the opening of many offices? Were they worried about quality control?

Moore: I am sure they were worried about quality control. Also some people, if they are going to be responsible for something, want to check every detail. They find it very difficult to turn responsibility over to somebody else, especially to younger people. I think the root of the disagreement had to do with delegating such responsibilities to others.

Scott: If the firm grew and opened a number of offices, some responsibilities obviously had to be delegated. You would have to depend a good deal on people you could not supervise or even see on a regular basis.

Moore: Yes. Concerns about that relationship of delegation was one of the reasons why some people left. LeRoy Crandall was one of those who left for that reason, and I think there were some others. Although Trent Dames and I disagreed now and then, we always took the view that we would get good people and they could do the work. We might check their work, but would not try to hang onto all the details. I think that was fundamental to our operation. When we found people who were good, we would try to push them and encourage them and let them do the work, and not try to control them in detail. Such delegation does, of course, bring up the question of effective quality control. In Dames & Moore, we have gone through several iterations of trying to develop quality control, and I guess they are still trying.

Scott: You have had to keep an eye on quality control all along?

Moore: Yes, constantly. But as Edwards Deming says, the best quality control is to get good people who have both the capabilities and responsibility to do good quality work. You get capable, reliable people, and then you encourage them to do it *right*. Don't push them to the point where they feel they have to get it done Friday, even if it's wrong.

The conflict between doing things in a hurry and doing them right reminds me of this story Gus Saph told me. Gus Saph was a San Francisco structural engineer who was a great help

to me. I guess you would call him one of my mentors. I've never forgotten this story of his. Saph did a lot of work for contractors, and one Friday afternoon a contractor brought in drawings, saying he had to get some details done. He said, "I need this done by Tuesday." Gus thought about it a minute and said, "Well, that is kind of tight, but probably we can do it, though we will probably have to work over the weekend." Nobody worried much about weekend work back in those years. Anyway the contractor came in on Tuesday—"Have you got those plans for me?" "Yes, there they are, wrapped up and on the desk." The contractor picked them up and started out the door, pausing to say, "They are *right*, aren't they?" Gus said, "Hell, you didn't say you wanted them right, you said you wanted them Tuesday."

I had another experience along that line but with a different slant. A friend I worked with at Chevron also said he needed to have a decision by "next Tuesday." I said, "We don't have our work done yet, and really do not have the data." He said, "Well, my boss and I are going to have to make a decision next Wednesday, and if you can't help me, I'll do it by myself." So there are times when you simply have to meet a tight deadline and cannot wait for all the data you really need.

LeRoy Crandall

Scott: You mentioned LeRoy Crandall's leaving. He talked about the matter in his oral history interviews with me. Would you discuss that a little more?

Moore: Yes. I mentioned how many firms would not share the ownership benefits outside a small closely held group. In contrast, we

decided a long time ago that when we had capable people we would let them go on and do their work, in Chicago or wherever, and we did not try to control it all from the central office. That was a very definite, conscious decision by us. Whether or not it was a good decision is something else again. It has worked.

It is also true, however, that we lost control of things because we got a lot more people in. In contrast, a lot of good firms have been carefully controlled by the people who ran them. LeRoy Crandall's firm is one. Another is the Mueser firm in New York, which has stayed small and under the control of the partners. They are very good—one of the best in the world.¹⁰

Both Crandall and William Brewer left Dames & Moore in 1953. I think Crandall left because he wanted to run his own office and control everything himself. When Brewer left, I think he expected to join Crandall, but didn't. Robert Lawson and Oliver Merwin left in the later 1950s and set up their own firm, but they have since sold, and I think it has gone out of the engineering business and into the environmental business.

LeRoy Crandall and Associates was very active but stayed relatively small, although it has now been sold to Law Engineering, and I think Leroy Crandall himself is pretty much out of it. Anyway I don't know who is to say which is right, staying small or expanding the way we did.¹¹

10. Mueser is the successor firm to the first soil engineering firm in New York. First it was Moran and Proctor, then Moran, Proctor, Mueser, and Rutledge, and then Mueser and Rutledge. The current name is Mueser and Associates—its present head is Jim Gould.

Scott: In his own oral history interviews, LeRoy discussed his decision to pull out of Dames & Moore. He indicated that he decided to leave and set up his own firm because of his fear of losing control if the firm expanded greatly.

Moore: LeRoy wanted to keep it small enough so he would know what was going on, and I think the same was true of the Mueser organization. Who is to say which approach is better? We grew, but they may have made more money than we did.

Scott: So experience has demonstrated that either approach will work.

Moore: Yes...at least so far. I think when Trent Dames opened a general office, that was really preparing for expansion, was necessary for expansion. To allow room for growth and to allow new partners to run parts of their own business, it was necessary to have some central headquarters and control. That required the setting up of a general office—a headquarters office. We had no specific plan about the firm's growth, but we were convinced that if we got good young people we would try to get work for them.

Scott: When you decided you needed a headquarters office, did you more or less definitely designate the Los Angeles office as the headquarters? Or did it just sort of develop that way?

Moore: We decided it should be the headquarters, because that was where Trent Dames was located. I think it was Trent's idea that the

11. The Crandall firm was sold to Law Engineering in 1982, after some thirty years of active practice under the Crandall name.

Los Angeles office was where the management decisions should be made. Trent was there pretty steadily, whereas I was flitting around up here and going other places. But I was also down in Los Angeles frequently, and of course he and I shared the top positions—he being the executive partner and I being chairman of the executive committee. We worked very closely together.

Scott: When would that headquarters setup have been developed, after World War II?

Moore: Yes. I think that was one of the things LeRoy Crandall did not like—I think he felt the general office took some of the profits that maybe we could have had if we had not prepared to grow in that way. You have to be willing to give up some of your profits to allow room for some people to go out and run parts of their own show, and as a result maybe develop a bigger total operation.

Decision on Expansion

Scott: So the issue of expansion and delegation came to a head, forcing you to make a very clear-cut decision on growth, as well as on degree of control or supervision?

Moore: That's right. The matter did come to a head, and that was a definite decision.

Scott: Was that basic decision on expansion and not having tight controls made by you and Trent Dames—the founding partners?

Moore: Yes, I think that is right. I don't know whether Trent and I ever argued about or thought about that decision a great deal—it was just the direction we wanted to go. And some of the other partners who were then junior partners did not like it, so we just separated from the junior partners, or they separated

from Dames & Moore. They went their way and we went ours.

Scott: As you mentioned, this was fairly early in the life of the firm.

Moore: Yes, fairly early, after the war years and in the early or mid-1950s. During the war years nobody had much time to think about it, but then the issue got a good deal of consideration. Anyway when the issue came to a head and was resolved in favor of continued expansion, at that point some of the earlier partners left to run their own store, which they could control, supervise, and run their way.

They did that, and successfully, too. They did not want to expand, and in fact never expanded much. They probably made just as much money doing that as they would have had they expanded. I think there's a very valid question as to whether or not the partners have made more money by expanding into a larger firm. Many firms with only a few partners are very successful financially.

There is probably a lot of reason to believe that adding partners and getting more people and a bigger operation does not necessarily increase the financial rewards to the partners. Expansion does, however, enable you to do some kinds of work that you cannot do as a small firm. Frequently, I think, the work is more interesting—more exciting, if you will, and more technically challenging—but it is not necessarily more profitable.

Scott: You had already started to expand by the early to mid-1950s, when that basic decision was made.

Moore: Yes, we had expanded some. We started with two people, of course, then three, and four, and five, and ten and so forth. I suppose by the mid-50s we might have been up to between 50 and 100 people, but it was not yet a big operation. The decision made then, however, was a definite decision to the effect that the way to go was to follow the interesting clients and the interesting work, wherever it was, and to try to provide for growing careers for people, without telling them that they had to go start from square one by themselves. It was a very basic decision. Up to this day, I do not know whether our approach is the right way or not. Both approaches can work—but they are quite different.

I think the primary advantage of expanding is the interesting work it enables you to do. At the relatively early point in our history when we were first expanding we were probably following the oil companies. We did refinery work, and refineries have very interesting foundation problems because they build heavy and very expensive structures, and sometimes locate them out on soft mud. They frequently pick a bad site because there always has to be ready waterfront access. And the same thing is true for harbor works. Or power plants, which have to be near where there is water for coolant. Such locations provide a whole series of very interesting engineering problems, especially foundation problems. You've got soft ground and water to deal with, along with expensive equipment and expensive operations.

We found this work to be interesting and also fairly profitable. There is quite a bit of engineering work involved—not just the routine business of running sieve tests or compaction

tests or concrete tests. Those tests can be mass-produced, and you can take in a lot of money on routine testing in soils and concrete and so forth. But our kind of operation was quite different from a shop where engineers and technicians are turning out tests or drawings. Where somebody brings in a truckload of tests to do, and they do them. We frankly were not excited about that. So we made what proved to be a fundamental decision—although I do not know whether we realized at the time that we were in fact making such a decision.

Developing Business— Relationships With Clients

Scott: Talk a little about the growth pattern and about how you promoted it. In other words, did more and more business tend to come your direction, or did you have to go out and very actively work for it?

Moore: The way you develop business is by using shoe leather. My policy—and our policy—was never to eat lunch alone, because if you do, pretty soon you don't eat lunch. So we would always eat lunch with a prospective client. One of our mentors was Clarence Derrick—a structural engineer who used to say that a consulting engineer had to learn to spend the day with his clients and do his work at night, because that is the only way he can make a living. Well, it was not quite like that, but there's a lot of truth in it.

In meeting with people you have to be underfoot and to see a lot of people. But you do not just go around looking for a job. You try to bring them something potentially useful. You need to show them something that they like—

something that they can use and that will be good for them. Usually they want either to avoid trouble or to save money.

Scott: You have to be watching for ideas that are relevant to their operation?

Moore: Yes. You have to help them do what they're doing. If they do not understand that you are helping them, then you are wasting your time. You need to come up with something that they will find interesting. Our mode of operation was to find out what their problems were, and try to help get the problems solved. Actually when we got new people I would introduce them on a job and let them carry it on and continue to do it. Pretty soon they were doing the same thing with their people.

You develop a relationship of mutual interest between clients and professional practitioner. I

think that is a very, very key thing. This is the way that we developed people who were able to go out and promote business, to develop, and add to the firm's business.

Scott: They need to be able to deal with clients and other people—with the outside world?

Moore: Yes, and we wanted our people to understand the relationship between what we were doing, and the problems and issues and objectives of the client. The clients are not interested in soil mechanics—really they don't care. But they've got certain problems. The shipyard people want some piers built, and want them built as cheaply as possible, but safe. If we can help them do that job effectively, then they become a friend. But they do not give a darn about what the calculations show for the skin friction and the niceties of soil mechanics.

Managing the Expanding Firm

You don't motivate people by bossing them around or cracking a whip, you do it by getting them interested.

Passing the Culture Along: Staff Rotation and Management Training

Moore: We rotated staff as part of a management training program. Probably in the 1950s, Trent Dames had the idea that, when we had good people who were inclined to go out, say to Atlanta or Chicago, and set up an office for themselves, we would first run them through a year or two of work in the general or central office—the Los Angeles office. They worked there temporarily, in a planned rotation of people to gain experience. I guess Trent knew what he was doing. We were creating a mechanism for transferring and passing on what we can call the culture and value systems of the firm—the things that made the firm work. The values, customs, practices and objectives that made the firm work. That way, when they went out to work in Atlanta, or Madrid, or wherever, we had a good idea what they were going to do, and they knew what to expect. It was a training process. The same way you go about raising kids, probably.

Scott: As I understand it, after new people had worked for a time somewhere in the firm, perhaps three years or more, they would be rotated to work in the Los Angeles office and participate in the training program.

Moore: Yes, it was something like that. After they had been with us three, four or five years.

Scott: When they were sent to the Los Angeles office, how long would they would work there?

Moore: For one or two years. It was not just for a few weeks, but lasted at least a year or two. Let's say it lasted from one to three years. They might of course work in another office, such as the San Francisco office. Anyway, they worked in another office or the firm's main office before they went and opened their own office.

Scott: How did you administer that training program? Did you have some kind of special in-house seminars, or was it kept pretty informal?

Moore: I'd say it was mostly informal. There was some formal training, but mostly it was informal. We encouraged the people to become active in their professional society, the civil engineers or the structural engineers or whatever, so that they were working with their professional peers. When people do that—say they serve on a program committee in the San Jose section, or something like that—they learn to work with another group. Engineers tend to try to do things alone, to work as loners, by themselves. The things that are group activities are not learned in engineering school. Also in most engineering offices they do not learn it after they get out of school. If you work only in a certain section of a large firm, and only do

that, you don't learn the human factors of working with another group of people.

That is what a coach has to learn to do—get a team working together. The interaction of people working together. You don't motivate people by bossing them around or cracking a whip, you do it by getting them interested. I suppose it's a combination of the carrot and the stick, but people have to buy into what you are doing. They have to believe in it. It is a continual process.

Scott: Could you talk a little more about what the people involved in the training program did? A person who had worked in one of the firm's offices for three or four years would get into this program and come to the Los Angeles office—what would you do with him when he got there?

Moore: He might work on personnel records, or might interview prospective new people, or might work on insurance matters. He might be involved in some technical development. We spent a modest amount of money on developing improved equipment and improved methods. We had a quality control or a quality maintenance program that we tried to review—it was worked on by the different offices and they commented on ways of improving it.

Scott: So they would work on some of those kinds of activities, or maybe on several of them?

Moore: Yes. The idea was they should know the business from the bottom up.

Sharing Profits

Moore: We also had another idea that was very fundamental. We had the "one-pot

theory" of distributing profits. We went through this argument with some of our younger partners. They would say, "I'm running the office in Seattle, so I ought to get 50 percent of the profits of this office." Our argument was that we're all one firm, and everybody should get their share out of the total success of the firm, they should get whatever it is, whether 2 percent or 20 percent or whatever. We resisted very, very strongly the idea of having a separate franchise operation, where people got paid the profits of their own office. Our "one-pot plan" worked for some forty years, but since around 1980 we have changed the way we operate.

Scott: For about the first forty years, Dames & Moore operated pretty much on a concept of share-and-share-alike, those in each office sharing proportionately in the profits of the entire firm?

Moore: Yes. We set up different salaries, different levels of compensation, for partners and key employees, which were approved by the executive committee. But beyond that the sharing of profits depended on the success of the firm as a whole. One person didn't profit on what he was doing, while somebody else was starving to death. We did not all have the same levels of compensation, of course, everybody got different compensation. The executive committee decided upon different levels of compensation for different partners, depending on their experience, responsibilities and so on. They all shared proportionately in the profits of the overall firm.

Profit Centers: Some Inherent Problems

Moore: Now we have "profit centers," and frankly I think that plan has inherent problems. I don't know how outfits like Chevron or IBM work—they have divisions, and everybody has to be viable in their own division. I've run into cases with some of our competitors—or people operating with different offices—where when they had a prospective client, or a client relationship, they would not share this with the people in the other office, because they might get some credit, or get some of the business. The profit-center system builds internal conflicts into the firm, and promotes interest differences that I think can be extremely destructive. It's "What's mine is mine and what's yours is mine." While there may be a way to handle this, it is a very, very sticky wicket.

Scott: I guess income distribution is a tough issue that all organizations of any size have to deal with. I suppose it is particularly a problem if they're geographically divided.

Moore: Yes. Or if they get freeloaders, somebody has to deal with that. On the other hand, if people make the effort to go out and develop a new facility or a new business, but do not get paid anything but their share, some people will start working more for themselves than for the firm. They'll do it for themselves. So that is a very sticky wicket for which there's no easy answer. At any rate I think the system we're using now needs improvement.

Scott: How does the profit-center system work—does it maintain closer cost accounting, cost-and-profit records of individual units?

Moore: Yes. We have been making money at it, I think because of the boom. Everybody's

busy now doing toxic waste business. There's so much of that around you couldn't help but make money. But I am concerned about what is going to happen when the toxic waste business goes away—and things have begun to change.

Competition Within the Firm

Scott: Did the shift to profit centers provide a stronger incentive for employees to try to make their own units look good, as compared with other parts of the firm?

Moore: Yes, that's about right. I do not know whether it is going to work or not. Mac-Donald's maintains quality control and customer control by having inspectors go around and watch the different outlets. I'm sure the operator of one franchise may make more money than a guy at another franchise, but you surely have a job of maintaining quality control if you operate that way.

For the last few years, we have been in that in spades. Years ago, Trent Dames and I decided that we did not like the competition that developed when we had competing profit centers. I have talked to many people who have set up branch offices, and they have set up profit centers, usually set up on a geographical basis. Then after a year or two the profit centers end up fighting with each other within the overall firm.

We are now trying to go back in the other direction, getting back to a program for developing firm-wide teamwork. It is funny. Of course, if you have an office in Reno or someplace else that is losing money like crazy, you cannot keep them. But a balance needs to be maintained between focusing on financial things, and looking to technical competence,

the quality of the work and your reputation for what you do. Maintaining that balance is always difficult.

Scott: So the profit center approach has tended to break down the teamwork?

Moore: Oh, undoubtedly—it ruined the teamwork. Without very strict rules regarding teamwork, you will lose it completely. Now I understand our management is considering an arrangement basing a significant part of the compensation on how good an office is, including its teamwork, with the other part based on their local profitability. Something like that may work. But there could be problems deciding who gets the credit for what, and with some people posturing to get credit for what they did not do. That kind of thing is insidious, and is probably universal.

Scott: I can understand how that is very tough to manage.

Moore: Yes. It is a real challenge. That is one of the reasons why many people do not like branch offices. Being a big firm is not necessarily the best answer, although it does enable you to do some things that are not possible in a small, single office. But it does create other problems.

Quality Control and Quality Maintenance

Scott: You mentioned quality control before in connection with the decision to expand, and have already made it clear that quality control is a very important consideration for a firm that expands and has many offices.

Moore: At first we tried to review every report, but found we could not do that after the firm had expanded significantly in size and technical disciplines. We set up a quality control manager, Don Roberts, so in the 1950s Roberts and Dave Liu were two who worked at reviewing. Then in the late 1950s we gave up trying to maintain anything like a central quality control. Then we developed some internal technical bulletins, in which we described things that worked, as well as some things that didn't work and how we had to fix them. We sent those bulletins around to all our people so they could see some of the problems that had been confronted.

Scott: Say more about how you dealt with the issue of reliable quality control, both earlier when you were a smaller firm, and later as a larger organization. You mentioned having one or two quality control reviewers, but giving up on central quality control in the late 1950s.

Moore: Yes, at one point we used to have all of the reports sent for review by one man. Usually this was Don Roberts or Dave Liu. Maybe the one person did not review all of the reports, but he would review one out of every five or ten from each office. If he saw them kind of drifting off in one direction, he then had discussions with them. He tried to correct it more by persuasion than by edict, by discussing what were the pros and cons and the benefits.

Scott: Presumably the reviewer had to be a fairly senior person, because he would be exercising substantial judgment?

Moore: Yes, quite a senior person.

Scott: Draft reports were reviewed mainly to get feedback or information for quality surveillance?

Moore: Yes. In engineering work or in an engineering study, there is usually not one specific answer that is right and all the other answers are wrong. Usually there is a whole range of answers, some of which may be too far out, and even wrong, no matter how you slice it. But most times there is a considerable range for different judgments. The decision may depend on the nature of the project, may depend partly on the particular objectives of the client, and of course also depends on the skill and the savvy of the engineers who are working on it. That is why the quality review function we are talking about requires a pretty high level of judgment.

Ideas of Edwards Deming

Moore: I think we have relied more on developing an attitude among people at Dames & Moore—an understanding that they are responsible for quality, and if they do something that is not right, they have to fear the consequences. You make the people who do the job the first time responsible for the follow-up. If they have to do the work over when something has to be fixed, that motivates them and encourages them learn how to avoid future repetitions of unsatisfactory work.

A lot of this thinking is similar to that of Edwards Deming, whom I have already mentioned. Deming observed that the trouble with industry was being satisfied with 95 percent of "perfection." They don't figure out that it costs five times as much when something has to be done over. That means spending a lot of money

to take care of a relatively small percent of products—say 5 percent—that is not up to top quality. So the goal is to struggle for the 100 percent, although you never quite make it. But you can get closer than 95 percent.

Scott: Say a little more about Deming.

Moore: Deming was a management consultant who went over to Japan for General Douglas MacArthur. He coached the Japanese on how to set up their business. In my interpretation of what he has written, he told the Japanese three or four things.

1. First, stop making junk—make products that stand up. Products that people will be glad they bought, and not get fed up with the products.
2. Second, find out what your customers need and want. Do not just try to sell them what you now make, or what is on the shelf. In other words, know your customers.
3. Third, know your own people—the people who work for you—and encourage them to follow those policies, because that is the only way you will take care of your customers properly.
4. Fourth, keep improving your product every year, because if you don't, somebody else will.

That about sums up the Deming recommendations to the Japanese, as I interpret what he said.

He also said, "Forget all these profit centers, numerical things and all that stuff. No matter how carefully you set them up, people will beat the system. Get your people on target as to what the real object is." Obviously, of course,

you have to make more money than you spend, so it is important to know the numerical things and what your finances are, but if that becomes dominant, it screws you up. He was very strong on that.

He also said that there is no way you can set up numerical guides that people cannot figure their way around. We have people right now in Dames & Moore that think they can manage by numerical guidelines. Also, it seems that throughout industry we have a lot of young people who think they can manage by computer printouts and numbers, without walking around the shop or keeping close contact with clients. While Trent was a little inclined that way, he did still want to maintain contact with the people in Dames & Moore and with clients. He would consult with them and ask them what they thought.

Scott: You believe in more of a hands-on kind of management—maintaining good contacts and communications with personnel and clients?

Moore: Yes.

Scott: I would like to include references to Deming's work.

Moore: He has written a bookcase full. I had some of his books, and gave them to everybody I could think of. The book on his method that I used most was by Mary Walton, *The Deming Management Method*, 1986.

Introducing Improvements

Scott: Would you say more about how Dames & Moore dealt with the need to strengthen and maintain quality?

Moore: One part of it was introducing improvements, and support for research and development (R&D). Things like improved processes and improved equipment and things about quality control—those are things that affect the success of the entire firm. For example, if the office out in Chicago screws up on their quality control and does something wrong, and it backfires with a client in Houston or Los Angeles, the firm is going to suffer for that. The client does not give a damn whether it's a different office of the firm that was responsible. They just say, "Well, Dames & Moore screwed up on that, and we don't want to deal with them." So the dependability of quality control is extremely important to maintaining the reputation of the firm.

If someone develops a new idea, a new way to figure out capacity of piles, or to deal with the toxic wastes of something, if they keep that to themselves instead of using it throughout the firm, it's not good for the firm. If a client finds out that he'd hired a Dames & Moore office somewhere else, and he didn't get that technology, he's going to be sour on Dames & Moore. There is what we call the "one-firm concept." In the unified firm or a coordinated firm common values and a common philosophy are extremely important. If you get crosswise in different locations, then the firm is going to suffer for it.

This is very difficult to deal with under a "unitized" or so-called decentralized organization. IBM has apparently dealt with it. I don't know how they've done it, but I know that making people belong to the IBM team is a very, very important part of their culture. They don't belong to the Los Angeles team or the New

York team—they belong to the IBM team. I know the same thing is true with Xerox. Xerox makes a big advertisement out of it. I suppose those are really inherent conflicts in issues and demands. Dealing with them is very difficult.

I mentioned the internal bulletin. We used to put out what we called an *Engineering Bulletin*, issued five or six times a year, in which different people would describe some particular development, issue or project they'd worked on. The bulletin was circulated around to other people throughout the firm. We also gave it to people outside the firm and to client organizations, as a means of spreading new ideas. We've stopped doing that now, which is kind of too bad.

Quality Maintenance: An Educational Process

Moore: Anyway, I think "maintenance of quality" may be a better phrase. It's more an attitude than regulation. It is not the same as quality control in the manufacture of some products, where if an item does not come up to a standard, it is rejected. It is more of an educational process. To make a comparison, I suppose it's more like what the Japanese are doing locally here in Fremont [California] with the General Motors plant, now that they've taken over. They have put their quality control right on the assembly line. They don't have inspectors running around looking for something that is being done wrong. But if something comes out at the end that isn't good, the whole group suffers for it. How they train them to do that, or how they get that attitude, I don't know. But I think this is something which we were trying to do when we were trying to deal with the so-called quality surveillance, or whatever you want to call it. It's more of a process of

education—more of a process of persuasion—
than it is one of direction and control.

Surmounting Crises and Shifting to Environmental Work

When we got into a period of financial stress ... we certainly increased our emphasis on profitability.

Scott: When reviewing an earlier draft of this, Neville Donovan made an observation about the "fun" having gone out of the work at Dames & Moore.

Moore: Yes, Neville talked to me about the loss of the sense of fun in the Dames & Moore work. In a nutshell, he said that for maybe 45 years or so, working at Dames & Moore had been fun and was exciting. Things were going on, and people were doing things. But then there was a change after about 45 years, at about the time when some major management changes occurred. The fun seemed to go away, and instead work became mostly a matter of struggling to watch the financial details and the computer printouts. I think what Neville says is true. Anyway, when we got into a period of financial stress with the nuclear power business and the Iranian affair, we certainly increased our emphasis on profitability. I would like to talk about those things a bit here.

Nuclear Power Plant Work

Moore: For 45 years we had our ups and downs at Dames & Moore. There were busy times, as well as slack periods and recessions, maybe four or five of those. Then in the early 1960s we got into the nuclear power plant business. It was a big business and provided a lot of work for us, and also for a lot of other people. There was the idea that nationwide in the U.S. they were going to build a nuclear power plant about every six months for the next 20 years. We at Dames & Moore were doing a large part of that work, particularly in the east, south and midwest.

During that period I think we neglected maintaining relationships with some of our clients who had been our bread and butter in past years. We also neglected improvements in the firm's research and development, and that is sort of the life blood of a continuing organization. Next, the catastrophe came about 1977 when the nuclear work came to a stop in this country. I think it was about when Jimmy Carter and others contributed to the cessation of nuclear power plant work.

Scott: Yes. A rather active anti-nuclear movement sprang up, and also there was the highly publicized Three Mile Island nuclear accident, which probably occurred about 1978 or 1979.

Moore: Yes, and that Three Mile Island incident was exaggerated way out of proportion. Around that time, and maybe starting a little before, there was a media blitz against nuclear power, and a growth of anti-nuclear sentiment. And in fact the business dried up—it stopped. When that business stopped, Dames & Moore

was seriously affected because we had not adequately maintained our previous relationships or our emphasis on geotechnical and the other kinds of work we had done. Thus when the nuclear business stopped, much of our income stopped with it.

It had really been a major activity for some five or six years, and did consume a great deal of our energy and time—maybe some 40 percent. We expanded the work force and hired a lot of new people. We also enlarged the range of things we did. That is when we really got involved in the environmental work, because with nuclear power plants you had to think about a lot of those issues. If there were a nuclear spill, would it go into the groundwater? Where would the groundwater go? Would it go into the air, and if so where would that go? Working on nuclear power plants was really what put us into the environmental business.

When the income from nuclear work stopped, it became necessary for us to figure out how to avoid spending more money than we were receiving as income. We could not run a million-dollar deficit. Adding to our problems was the Iranian affair, and the management problem I mentioned. I will say a little about each.

Dealings With Iran

Moore: At about this time we had some very serious financial problems and were not getting paid promptly. We did a substantial amount of work in Iran that had not been paid for. Our financial circumstances required a greater emphasis on profitability. We had somehow to stop the hemorrhaging. This was about the time when George Leal came in as chief execu-

tive officer. So while Neville is right about the big changes, the emphasis on financial details, this was in part forced on us by the firm's economic circumstances. Certainly after the Iranian debacle in 1979, we increased our emphasis on profitability.

We had done some nuclear power plant work in Iran. Then when they threw the Shah out we were left with about \$5 million worth of work that we had not been paid for. We finally wound up suing for that, and after several years, got maybe one-third of it back. Anyway, that was one of the things that forced the changes and the attention to profitability. There was serious question as to whether the firm could survive financially. The Iranian affair was one of the key elements that led to our focus on finances and profitability. There were other factors, but as much as anything else, Iran was what really did it. Of course the collapse of the nuclear power plant business in the United States was also part of it. We had gotten into the nuclear power plant business in the mid-1960s, and the Iranian plant was one of the last ones we worked on. We had five or six years of really booming business in nuclear power in the early 1970s.

The Iranian story is interesting, however, including our appeal to the U.S. Supreme court, which ruled in our favor, after a highly expedited process. But the Supreme Court ruling did not give us any money, so we then had to take the matter to the international tribunal in The Hague, and then back to the U.S. courts. Eventually we got a settlement, but we spent an awful lot of it on lawyers.

Scott: You sued the Iranian company?

Moore: We sued the Iranian Atomic Energy Commission. I think we finally got about \$2 million of the settlement that Iran made with all the American firms that had lost money when they threw the Shah out.

Top-Management Problem

Moore: At about the time of the Iranian affair and the loss of the nuclear business, we also got into a difficult top-management problem. A bit earlier, when it came time for Trent Dames and me to step down, we of course had to make some major changes. That was in 1975. Trent was what we called the executive partner—who served as the chief executive officer (CEO)—and I was chairman of the executive committee.

New CEO and Executive Committee Chairman

Moore: There was competition for the CEO position between two long-time Dames & Moore people, and there was a lengthy committee study as to which one should become the executive partner and CEO. After considering the matter a long time, the executive committee selected the man to take over the position Trent Dames held as executive partner and become chief executive officer.

The person chosen was one of our senior partners who had been involved in the operations of the company for quite some years. He was smart, and a good engineer, although he did not have any special training for fiscal retrenchment. He had run some projects overseas—such as a refinery project in the Philippines, studying geotechnical conditions.

So he had experience in managing projects, but no management training particularly, except what he had learned on the job, or perhaps from Trent. For some time, he had headed our operations division. I should note that we had divided the firm into what we called "operations," and "client development." The man chosen as the new CEO had managed the operations office for the firm as a whole, having charge of all the operations in the different offices, and having local managers who were in charge of local operations.

The other candidate for the CEO position was the manager of the client development division. He was an engineer who joined Dames & Moore after World War II, during which he served in the Air Force and for a time was in a German prisoner-of-war camp. He was with us for maybe about 40 years, starting as a junior engineer and working up until he was in charge of our client development work. He had been in charge of one of our other offices, and then moved to southern California to manage client development for Dames & Moore, a post he held for several years before becoming chairman of the executive committee.

He was very good at working with clients and developing business relations, and I worked with him a great deal. As head of our client development activity, he worked with people located in all of our offices—we had people throughout the firm who worked on business and client development. He also became very well known outside the firm, being very active in engineering society affairs, including being vice-president of ASCE. He would likely have become ASCE president if we had not asked

him to move to California and take on a top-level responsibility for the firm.

While he did not get the CEO position, at about the time the CEO change was made, I also decided it was time for me to stop being chairman of the executive committee, so we moved him from the client development division up to take my place as chairman of the executive committee.

Resolving the Conflict

Moore: Well, quite a conflict developed between the two—the new CEO and the new chairman of the executive committee—who had very different personalities. For a long time, Trent Dames and I had worked together in those two top positions, and while we sometimes had our fights and arguments and got at cross purposes, we had always talked things out. But for reasons which I cannot explain to this day, the new CEO and new executive committee chair could not do that.

Scott: So now they occupied the firm's two key positions, but it turned out they could not work well together?

Moore: That's right, they just did not work together—their communication was zero. We hired management consultants to come and work with them. A management consultant would come in, sit them both down together, and they would agree they should work together. The management consultant would go away, and come back two weeks later to find that they had not talked to each other.

I don't know why it was this way—I suppose we had created a condition of competition between the two. The CEO, who had run the

operations division, had always thought that the client development business was too expensive, a lot of baloney. He saw it as going out to lunch with people and spending a lot of money. He always felt that he did everything that made the business, and I don't think he ever understood the importance of the clients. In sharp contrast, the new executive committee chairman, who had headed client development, thought the clients ran the business.

In any event the relationship between them did not work. The two of them just would not work together, and did not while they occupied those positions for some three or four years. Meanwhile our business was going bad, partly because those two would not or could not work together. Cooperation between operations and client development was bad. Finally in the end, we saw that we had to make some changes, which did not come easy.

You see, the executive committee appointed the CEO/executive partner, so the executive committee was the one to remove him. But the new executive committee chairman would not do it, although I do not know why. One of the saddest things in my whole life was having to replace the executive committee chairman, and coming back in as chairman. Then the executive committee had to remove the CEO and relieve him of his position as executive partner.

The sequence was as follows. I was made chairman of the executive committee, relieving the new man in that post. Next, I worked with the executive committee to remove and replace the CEO, which happened within two or three months of my having become chairman. We felt we had to do something quickly before we went bankrupt. So when I came back in as

chairman of the executive committee, I met with the committee members privately, as well as with other partners. We said, "We have to stop going broke." We were going broke, with this conflict all the time. So I finally got agreement from the executive committee members that we had to remove the CEO. When I told him about our decision, he asked, "Well, do you have the votes?" I said, "Yes." So we removed him.

We then selected George Leal, who moved into the CEO job immediately after the other man left. At about the same time, Leal also became chairman of the executive committee, thus combining the two jobs. I think he did not believe the thing would work with the two positions divided. He had certainly watched during the period when it was not working, and maybe learned from that.

Scott: When that top-level conflict persisted so long, you ended up feeling that both the CEO and the executive committee chairman had to go?

Moore: Yes. Technically the CEO/executive partner could not be removed without the executive committee acting. The executive committee chairman whom I replaced asked afterward, "Why didn't you folks tell me you wanted to remove him [the CEO]?" But for his own part, he had provided no leadership for dealing with their conflict or with the firm's crisis. Also, the CEO had a lot of friends among the partners and so on. Anyway nothing was done. Later the man I replaced seemed to think the executive committee should have told him to remove the CEO, whereupon he would have done it. But like most committees, the

executive committee cannot do much of anything just as a committee.

So when I came back in as chairman I had to discuss the matter with them—we talked it over until we decided what needed to be done. I had to work with the members of the committee, talk with them individually, and discuss our firm's circumstances until we reached a conclusion as to what we had to do. The executive committee of five partners agreed that we had to do something to make things work better. After all, by then we had spent money on consultants for two or three years, and with both parties agreeing to work together—and then not doing it.

Reflections on Why it Happened

Moore: I still cannot explain or understand it. The two of them both possessed the ability to do their jobs. But personality-wise they could not do it. The CEO never respected the other man for what he did inside or outside the firm, and always belittled the importance of relationships with clients. He apparently resented the fact that the other man was popular outside the firm, being elected vice-president of ASCE, and president of this and that, while he—the CEO—was not elected to anything. But the CEO also had his clique inside the firm, among the operating people.

Scott: Were you aware that the CEO had those attitudes? Had they been expressed before he became chief executive officer?

Moore: No. He probably had them, but he never expressed them. And from his side, I think the executive committee chairman had always wanted the CEO's job—but would not

have been good at it. While he was wonderful in business relationships, he was not cut out to be an executive manager.

Scott: Yes, I suppose his failure to act in the crisis was indicative of that. In any event, after those top-management changes had been made, did people at Dames & Moore talk much about their views as to what had gone wrong, or why the two were unable to function together? Their relations must have gotten to the point of near-hostility.

Moore: Yes, it was close to hostility. But there was not a lot of talk about the situation. I decided, and the executive committee decided, that we would try to get them to work together. We brought in the management consultant, who tried for over a year and could not seem to get them to cooperate with each other. They were not able to talk to each other. There was not nearly enough discussion among us of how things were going until it became a crisis, and it became a crisis because our income dropped and client development had deteriorated very seriously. Meanwhile you see, the executive committee chairman would never act as a real chairman and direct the CEO, who in turn would not talk to the chairman about what the problems were.

Scott: Since you and Trent knew both men pretty well, why do you think you did not foresee that the two might behave the way they did? In hindsight, do you think this kind of non-communication and conflict could have been foreseen?

Moore: I don't know. We did know, of course, that the executive committee chairman felt that he should have been made CEO,

instead of the other man. He was not appointed because we realized that he would not have been the guy for that job. But we did not realize that they could not work together. It produced gridlock at a time when we were stuck with the Iranian problem and the loss of the nuclear power business.

Parallels

Moore: There were parallels between Trent and me on one hand, and the two who did not work out. I myself had tended to think somewhat the way the chairman of the executive committee did—that is, emphasizing the importance of clients. I have always been interested in clients, whereas Trent thought more like the CEO did, being more interested in organization and internal operations.

Trent and I were more adaptable to each other, however—we would differ, but would work things out. Also, I understood that somebody had to do what Trent was doing for the firm. Trent was good at that, and it was what he liked. While he had worked with clients some, he did not like doing that.

Scott: So the division of labor between you was a good one, and it worked.

Moore: Yes, it worked. It was not always smooth, of course, but we would talk about things and find out where the problems were. I can remember a few times telling Trent, "I guess I'd better get out, and you do it." But then we would agree, "We don't want to go that far."

Scott: So even when you disagreed, you at least were communicating and resolving things.

Also each of you recognized the importance of what the other one was doing.

Moore: Yes, we did, and that was not true of the new CEO and executive committee chairman. Each did not really seem to grasp the importance of what the other had done in the firm.

Scott: When it comes to top-level policy and management, I guess performance is hard to predict?

Moore: Yes. But let me also mention something else that is interesting and may be relevant. When I selected George Leal and he came in as CEO, he insisted that he also be made chairman of the executive committee. He had seen how it had been operating, and said he feared it would not work, or at least he did not want to take on the CEO job unless he held both jobs—CEO and chairman of the executive committee. Quite a few firms are run that way, too.

Scott: At least it avoids the kind of top-level non-communication that you had experienced.

Moore: It is also interesting, however, that when George Leal stepped down and Art Darrow was appointed CEO, George stayed on as chairman of the executive committee.

I think Leal felt that as chairman of the executive committee he was the ultimate boss. Which means that in the final analysis he has the authority to remove the CEO, with the executive committee's approval. So Leal stepped down from being CEO, but did not step down from a position of major responsibility. I think we always felt that if you had the right people, it was O.K. for the two positions

to be in different hands. But at the point where we were when Leal took over, it had not been working.

I think most companies have maintained the two separate offices, with the idea that the chairman of the executive committee (or chairman of the board of directors) has responsibility for looking to the long-term well-being of the firm. I do not know of any company where the chairman of the executive committee is subordinated to the CEO.

An Important Part of the Story

Scott: The whole thing was a major episode in the history of Dames & Moore.

Moore: That is right. For a time our problems sort of pyramided, the firm was facing a double crisis, and we had to make the changes. For years afterward, neither of the two would speak to me. That is a sad story, and a strange sort of story. For me it is a very, very painful part of this whole history. The executive committee chairman—who is dead now—had been a very close friend of mine, but after his removal always blamed me for ruining his career by pushing him out of chairmanship. Never, to his death, did he ever, ever understand that as chairman of the executive committee he was the boss, and if it was necessary to remove the CEO, he should do it.

The man whom I replaced as chairman resigned from the firm soon after I took over as chairman—he thought we had played a dirty trick on him. And, of course, his old job in charge of business development had been obliterated. The CEO whom we removed left the

firm about the time George Leal came in to become chief executive officer.

Looking back, it all seems kind of incredible. The whole thing was a sad, sad episode. The emotional stress at that time was tremendous. Frankly, I think that is where I lost my hearing. The stress level was enormous. Things kept getting worse for two or three years. And the nuclear power plant business collapsed. Everything seemed to come at us almost all at once. I have been giving you my gut-feeling account but maybe this is one of the most important parts of the story. It is funny—you go along in these oral history interviews, and you finally get to the guts of things.

Scott: Yes, it is an important account. Knowing something about experiences like that is part of understanding engineering practice, especially in large offices.

Retrenchment and Rebuilding

Moore: Anyway, in the late 1970s to about 1980 or so, we were not even making salaries. Some of the things done in response, and to which Neville Donovan referred, tended to focus our attention on the financial printouts. This resulted from measures taken back then, when some pretty drastic action was essential. After the traumatic period with the serious top management problem, George Leal became CEO as part of the effort to deal with the financial crisis brought on by the collapse of the nuclear power plant building program, which happened about 1977.

Leal was a good engineer with an MBA and an interest in business. He had gotten an MS in civil engineering at Caltech in 1958, became

associated with Dames & Moore in 1959, and was placed in charge of the Chicago office in 1960. Through part-time study at the University of Chicago, he obtained an MBA in 1965. Leal had been with Dames & Moore for some 20 years, and also had been in charge of our nuclear business. He had also been assistant to the CEO, the one who was removed, for several years before that man had become CEO. Then after that CEO left, we asked Leal if he could do something to stop the hemorrhaging. He said, "I don't know, but I would like to try." And he did. Leal of course realized that we had to stop spending money at the rate we had been, so he instituted a lot of the financial constraints mentioned before.

Scott: Dames & Moore used its own home-grown, in-house talent to deal with this crisis? You didn't bring in some Harvard or Stanford business school graduate trained in fiscal management and cost-cutting, or call in some special troubleshooter from the outside?

Moore: No. Leal had been around Dames & Moore a long time and knew what was going on. Some of the drastic retrenchment actions taken at that point were necessary, or at least defensible. But they have persisted in the firm since then. Now, in fact, that same attitude pervades our whole country. There is a cost-consciousness and concentration on weekly or monthly profit-and-loss accounting, on the latest "bottom line" figures. This seems to have taken hold of the entire U.S. industry. Anyway it was during the period of belt-tightening and retrenchment that the fun part of our work was lost, and we became focused on profits. That is understandable, of course, given the circumstances.

Scott: With expenses exceeding income, you had to take pretty drastic action of some kind.

Moore: Yes. So we put in the new management group and made a lot of internal changes.

Environmental Work and Client Development

Moore: The next thing that came along was the hazardous waste business, starting say around the mid-1980s. We had already been doing environmental work for nuclear power plants, so we were in really a very fortunate position to take a lead role in the other environmental and hazardous waste work. Unfortunately, however, some of the cost-cutting and belt-tightening attitudes and management techniques have persisted long past the original crisis. We continue pinching pennies and expecting employees to work 100 percent of the time for billable accounts, and provide no money for client and business development, and no money for professional development.

In any event, with the collapse of our nuclear business, it became necessary to rebuild client relations, and that is a slow, long process, which many of the people in charge at that point did not even understand. I think at the management level they had gotten away from doing client relations, and maybe that was true to some extent of the people below the management level. They had never gotten back into it. There was also a curtailment of other things, such as professional development. Looking back now, I conclude that what Dames & Moore did at the end of the nuclear boom was probably the right action at the time, but it should not have persisted.

Cutting Professional Support: A Pervasive Policy

Moore: I now have a hard time differentiating Dames & Moore's experience from developments that affected the whole of the U.S. business and industry. If we had been wise enough, we might have avoided this permanent or long-term over-correction. The upshot has been that all of our U.S. industries, such as autos, other manufacturing, and oil, began curtailment of their expenditures.

I use the analogy of a ship that is running aground. First the mariners saved it from running on the rocks on the right side, but then the retrenchment-type philosophy has the ship in danger of running on the rocks on the other side. The basic point is that when you try to get out of trouble you may overcorrect. Then you may find that the over-correction itself gets you into some other kind of trouble. Financial problems—loss of profits—prompted Dames & Moore to curtail their business development effort. They did this to reduce expenses, but they took out the wrong thing. Others have done the same.

The result nationally has been a drastic reduction—practically a cessation—of support for professional activities. With the engineers nationally, that included ASCE. The Engineering Library in New York went bankrupt, after having been in business for a hundred years. The Engineer's Club in San Francisco has

gone bankrupt, or at any rate has closed. This has been true of other engineers, such as the mechanical engineers, and true of other professional associations. All have been having trouble even collecting the dues needed to keep the organizations going.

I emphasize this because it is easy to say that Dames & Moore made a mistake when the nuclear power boom was over, and should have just gone back to our other business. And we probably should have done that. On the other hand, this same kind of illness has widely affected other parts of U.S. business and industry.

Scott: It is a complicated series of related developments. Maybe with the nuclear power debacle Dames & Moore got a quick and bad case of something that has also been more generally affecting much of the U.S. economy.

Moore: Yes, many other industries and businesses were affected. Hundreds and thousands of other businesses were affected. But with regard to Dames & Moore, Neville Donovan is right when he says that work at the firm had been fun for forty or more years, and then stopped being fun. Or at least the fun was much reduced by the other concerns. This about sums up the story. It is an important story because it is a significant part of the evolution, not only of Dames & Moore, but also of other fields. Anyway, if somebody wants to learn from history, there may be some lessons here.

Quality of Professional Practice

Two key concerns were quality control and relationships with clients.

Scott: Throughout your career you have been concerned with elevating and maintaining the quality of professional practice. You might start with some observations about peer review, which seems like a very important methodology for quality maintenance. You talked earlier about quality maintenance and the ideas of Edwards Deming, but peer review is a rather different angle. It is not really new, but recently seems to be getting a good deal more attention.

Peer Review

Moore: Yes, peer review is important to the profession in general, as well as to individual firms. We have learned that the hard way, with the growth of liability litigation and professional insurance premiums in the last couple of decades. I can talk about that in connection with remarks on the maintenance of quality in professional practice generally. Quality review is really a peer review, or vice versa. We're seeing more of that nowadays, too—there are more and more projects where more than one consultant may be involved. Sometimes consultants for different clients, and sometimes more than one consultant for the same client.

Two Basic Types of Peer Review

Scott: Would you describe how peer reviews work? As I understand it, there are two basic types of peer review: 1.) of projects, and 2.) of offices. In general the concept of peer review refers to deliberately seeking a second opinion from one or more other qualified professionals as a way of checking and verifying the original professional's work, findings, or procedures.

Usually when I have heard it discussed it has been in connection with a review of the seismic design adequacy of a specific engineering project. But I know the term is also often used for reviews of an entire professional office and of the adequacy of its procedures and work documentation. In addition, the peer review process has long been used very widely in several other fields such as health care and accounting.

Moore: Yes. As you say, there are two basic kinds of peer review, review of a project, and review of an office and its procedures. There is a good deal of variety, however, even among the project-type reviews, which have to do with the technical appropriateness or technical adequacy of the work a professional office is doing on a specific project. In this type of review, focusing on technical adequacy of the work done, you might have two or three different reviewers looking at the situation from the points of view of different interests in a major job.

For example, a second opinion may be sought by the owner or by one or more of the other parties to a project. A consultant may be brought in to represent a third party in the project, and to participate from the beginning of the job. Thus one consultant may represent

the viewpoint of the owner, while others may represent the viewpoints of the people who have put up the money. Still another reviewer might represent the regulators—like the city or something like that. There are several varieties of this kind of review.¹²

ASFE's Program: Peer-Reviewing Offices

Moore: The second basic type of peer review relates to the operations of a professional office—procedures, administrative matters, personnel qualifications, documentation of work, and all that sort of thing. The Association of Soil and Foundation Engineers (ASFE) got a program of that kind started in 1977, and ASCE is now working on such a program. Such reviews of the operations of an office are not aimed at technical work issues. They try to determine whether the procedures in the office provide, let's say, for adequate checking. Does the office have good technical resources, and do they have good people and management practices? Do they have good business practices—do they collect the money they should, and not collect what they shouldn't? In general, how do they operate the store?

Scott: You have mentioned ASFE and several other acronyms. Maybe we should pause here to make sure future readers know what the acronyms mean.

Moore: Yes, similar-sounding acronyms include ASFE, ASCE, and ACEC. The Association of Soil and Foundation Engineers

12. See McClure, Frank E., "Project Quality Assurance and Use of Peer Review," *Phenomenal News: Natural Phenomena Hazards Newsletter*. Lawrence Livermore National Laboratory, Livermore, CA, December 1993.

(ASFE), was started probably about twenty years ago, when the soil engineers could not get any insurance.¹³ Originally "ASFE" stood simply for Association of Soil and Foundation Engineers. Now, however, the association calls itself "ASFE: Professional Firms Practicing in the Geosciences." Thus ASFE seems to be trying to get away from "soil and foundation engineers," which I guess is evolution. The two other organizational acronyms are ASCE (American Society of Civil Engineers), and ACEC (American Consulting Engineers Council).

Anyway, after ASFE got their peer review program started in 1977, others have followed suit. In order to cover other kinds of engineering, the Consulting Engineers Council (ACEC) adopted the same principles of the peer review program that ASFE had initiated.¹⁴ The American Society of Civil Engineers (ASCE) has also done that. So those peer review approaches are similar, all being based on the ASFE program. They all focus on the system of supervision used, and not on a checking of the technical work itself. The main difference is that ACEC expanded that principle to apply to other fields than soil mechanics or practicing geotechnical engineering. I don't think very much of that has been done by ASCE, although they have done some. So far, however, I do not think their programs have taken hold the way they did with ASFE and the soil mechanics people. ASFE has recently issued a whole manual on

peer review: ASFE, *A Peer Review Program Manual for Peer Reviewers and Participating Firms and Offices*, 1994.

Higher Standards and Affordable Insurance

Moore: When disaster strikes, people drag their wagons into a circle like the pioneers. That's what happened to the structural engineers. ASFE was formed after the soil engineers had gotten into terrible lawsuits, then could not get insurance, and also had horrendous judgments against them. To deal with the problem and improve their performance, they formed ASFE and started a program of internal education that led to the peer review program. The program was really one of internal education amongst the soil engineers, and it has been tremendously effective. It succeeded in reducing their losses to the point where now they can mostly be insured, at least those who practice some of the things they've learned.

Scott: If it raised practice standards appreciably and reduced losses very markedly, then it must be a very effective kind of peer review.

Moore: Yes, ASFE's peer review effort is very effective, has raised the standards of practice, and has reduced losses to the point where they got a rebate on premiums for liability insurance.

Scott: I understand they set up an organization to provide insurance for the soil engineers.

Moore: Yes, it is called the TERRA Insurance Company, and was set up by ASFE as a separate insurance company. It does not insure all of the members, but only those who are

13. ASFE was founded in 1968. Its initial emphasis was on limitations of professional liability, and later began promoting other concepts such as alternative dispute resolution, loss prevention and peer review.

14. See ACEC, *Project Peer Review: Guidelines*, 1990.

judged to be insurable. It is administered by insurance people, so the fact that you're a member of ASFE does not in itself mean that you'll be able to get insurance.

Scott: To qualify for insurance, a firm has to measure up, it has to meet some quality or performance criteria?

Moore: Yes. A firm must implement a "loss prevention program." They have to have their loss prevention program for staff and for senior people—it is very important that senior people be included. They also must maintain at least certain standards of office practice in checking, handling contracts, and all that.

Scott: That sounds like office peer review.

Moore: Yes, they tie together.

Scott: How did the profession go about moving in that direction? Were you one of the prime movers?

Moore: To a degree, I was. I was one of those who pushed forward. I did not help to form ASFE, although actually a couple of my partners did—Gardner Reynolds and Don Roberts, in particular, who have been presidents of ASFE. I have not been president of ASFE, but I strongly supported this program when it was being developed. It is a good program.¹⁵

DPIC: Insurance for All Engineers

Moore: I also supported a program to develop insurance available not only soil engi-

neers but also to other engineers. This was done by the creation of what was known as the Design Professionals Insurance Company (DPIC).¹⁶ DPIC started with the example of the soil mechanics and foundation people. DPIC, however, was formed for all kinds of engineers, and for many of the same purposes, because engineers just could not get professional liability insurance. I was quite active in forming that through ACEC, the American Consulting Engineers Council. In fact I was on its board for some years.

Two key concerns were quality control and relationships with clients. One of the most common failures of engineers is in allowing their clients to expect too much. They are reluctant to tell clients about the limitations of technical knowledge. Consequently, they create client expectations that they cannot meet. Actually, however, it is now beginning to be more widely realized that you simply cannot have "earthquake-proof" structures. In the real world, 100 percent security against earthquake damage is simply not possible. The best that can be provided is an acceptable degree of earthquake resistance.

Scott: Nevertheless, you think that some professionals still often speak in over-optimistic terms when talking to their clients? They perhaps promise too much, or fail to emphasize

16. DPIC was formed in 1971 by a group of consulting engineers. In 1984, it was acquired by Orion Capital Corporation, and DPIC Companies was formed. DPIC Services assists clients with loss prevention, claims handling, and dispute resolution. Participation in continuing education earns policyholders premium credits, and additional credits are available to encourage standardized procedures and peer review.

15. The Foreword to ASFE's 1994 peer review program manual indicates that the ASFE peer review program as launched in 1977 was modeled after the one developed by the American Institute of Certified Public Accountants.

warnings that under extreme environmental conditions, including a strong earthquake, things may go wrong?

Moore: Yes, that is correct.

Scott: Then later a client who has not been forthrightly warned may sue if something does go wrong—particularly if the client is already a bit distrustful or sour-minded anyway. As everybody seems to lament these days, we live in an increasingly litigious society.

Moore: That is where the lawsuits come from. At any rate, ASFE set up the loss-prevention programs, which were basically education programs to ensure that professionals understood the limits on what they were going to do, and made certain that they explained the limitations to the clients. Then within two or three years, ASFE was handling their insurance at a profit, because the engineers that practiced that way had reduced losses to much smaller amounts.

DPIC is now trying to do that with all kinds of engineers—structural engineers, civil engineers, and so on. I think they are having some success, but it is difficult to penetrate through the engineering profession. Engineers pass their exams and get their registration and go into business, but do not understand these things. That is still a very important and complex issue—not easy to deal with.

Now, however, we've lost DPIC—it has been sold. That happened because it got to the point where insurance was easy to get, whereupon they started writing other kinds of insurance. DPIC was run by engineers for many years, maybe 10 or 15 years—the board of directors ran it. But it has been sold to the insurance industry, and now is run like any other insur-

ance company. What happened is that we tried to expand it too fast, and did not have the capital resources to write enough insurance, so the insurance regulators forced them to do something. And now we've got to start all over again. Now they're starting back in the engineering societies to talk about forming a new insurance company, which is kind of funny.

Scott: So in effect DPIC had to be bailed out? Was selling it the only feasible way out of the bind?

Moore: Yes, it was. The insurance commissioner said, "You've got to plunk in \$5 million bucks and the only way to do this is to sell the company." So now it's going to make money for some insurance company. Getting in that position was dumb, dumb.

Scott: But DPIC is still active, I believe?

Moore: Yes, but under new ownership and management.

Quality Control and Reduced Losses

Scott: DPIC and its quality control program reduced losses and alleviated high-premium problems?

Moore: Yes, it did that primarily the way ASFE did—primarily by internal education amongst the engineers. In order to be considered for insurance, the engineering firm had to participate in a loss prevention program or an internal educational program. They had to practice it, not just go to the seminars. So, yes, I think it improved the liability insurance picture very much. That was done not so much

through the availability of insurance as through the educational program.

I don't know whether loss prevention programs are given in the schools at all. I don't suppose they even have one over at Berkeley, but they should have. There are some books out on loss prevention programs, however, and we run seminars—DPIC still runs them. Dames & Moore buys them sometimes, and they send people around to different offices to run these loss prevention programs, which are good.

Scott: Is the whole thing still effective, now that it's been bought out by the insurance industry?

Moore: They still have a loss prevention program. As a matter of fact, the structural engineers are now in about as bad a fix as the soil people were 25 years ago. They're just beginning to talk about forming an insurance company for structural engineers. But the point won't be forming an insurance company—the main point will be educating the structural engineers—educating them in terms of quality control and good business practices.

Scott: Your emphasis on education is important. The idea of continuing education for architects and structural engineers is particularly important for future seismic safety. Maybe continuing education could be effective across-the-board for all aspects of the design profession's work.

Moore: That's right.

An Experiment in Landslide Insurance

Moore: I have been interested in the Commonwealth Club here in San Francisco for a long time. I have attended meetings, and at one time, probably in the 1960s, I started a Commonwealth Club section on landslides. That was after landslides had occurred in a previous big wet season in northern California. As an outgrowth of that policy discussion activity, we actually started an insurance company for landslides. That came along after the DPIC insurance experience I have just discussed, and the company was set up in collaboration with DPIC, but as a separate company.

It was fairly simple: we would write landslide insurance only where we knew what the site conditions were, and where they had control of the engineering. We wrote policies only on tracts, and where we knew the engineering. We never wrote policies on single houses. That way a very reasonable policy could be written. You might say we were willing to bet, when it was a safe bet.

When the landslide insurance company was set up, the mortgage companies and banks had said they would require it if it were available. But then a little later when competition got a little tough, they stopped requiring it. We probably had some 25,000 policies out. But there were no longer many policy buyers after the mortgage holders stopped requiring it. The company was sold to a workers' compensation company, and went out of the landslide business.

Caltrans and Peer Review

Scott: Recent damaging earthquakes, especially Loma Prieta in 1989 and Northridge in 1994, devastated some key transportation arteries. Caltrans has responded by among other things beginning to emphasize and use peer review methods more than before. Can you comment on this?

Moore: Yes, I think Caltrans is learning. On the other hand, the state employees have used litigation against Caltrans trying to prevent them from subcontracting out for engineering work.¹⁷

Scott: The state employees want everything done in-house by civil service people—that is a long-standing issue with the California State Employees Association (CSEA).

Moore: Yes, those attitudes are endemic in the state service.

Scott: After Loma Prieta, Caltrans set up peer review committees using private-sector engineers with recognized expertise in seismic design, and also did this after the Northridge earthquake.

Moore: Yes, they have used peer review committees, but only to a degree. They have tended to ask the peer review committees to deal with a very narrow set of questions, and do not seem to want the peer reviewers to talk about their total concepts. They have not yet

quite reached the point where they want a true system peer review.

Scott: You think that attitude of reluctance still prevails?

Moore: Yes, I think so. Some private-sector engineers do the same thing with peer reviewers—they will ask another engineer to look over work they have done, asking for example whether certain beams are big enough. But they do not ask them to look over the *whole* design concept.

Scott: Asking only about designated features of a design seems like a severe limitation on a peer review.

Moore: Yes, a peer review consulting group needs a very broad set of instructions. I think Caltrans and probably others do that—designating particular features rather than making the instructions broad. Partly I think this is because it costs less to have work reviewed that way. The Bureau of Reclamation did that with their dam reviews—limited their scope.

Innovations and Contributions: The Profession's Heritage

Scott: In promoting a high quality of professional practice, I know that you believe strongly that the individual members need to contribute such improvements and innovations as they can, for the good of the profession as a whole. Would you say something about that?

Moore: Yes. Although we have taken out patents on some of the things we developed over the years, I view those inventions or innovations less as something we "own" and more as contributions to professional knowledge and

17. Professional Engineers in Government (PGA), a union of engineers that work for various California state agencies, got the Superior Court to issue an injunction to preclude Caltrans from contracting out work that could be performed in-house. This did not affect peer review, which had to be done by outside engineers. Communication from Joseph P. Nicoletti, April 20, 1995.

to the practice of our profession. Some people call it technical transfer, and it may take the form of technical articles written for the practice. In medicine they talk about doctors writing up what they do. In any profession, and certainly in engineering—civil engineering in particular—there has been a long history of recognizing the importance of engineers writing up something about what they are doing, so other people can learn from their experience. That is how the heritage of the civil engineering profession has developed and is passed on.

Our Experience With Patents

Moore: In some cases we've gotten patents mainly to guard against somebody else getting a patent, and keeping us from using the device or process. I don't think we've ever made any money out of a patent, not that I know of. I think we have two specific patents for equipment being sold today. One was taken out on what we call an underwater sampler, a "leaf" sampler, which we patented in 1943, and still use and sell. I described that sampler earlier—it is the one we originally put together on the floor of my kitchen, probably in 1938 or 1939, and made for use on one of our early jobs for the City of Los Angeles down in the Los Angeles River. The first ones were very crude, of course, hand-sawed with hacksaws and soldered together, but now they're getting pretty fancy.

We had that sampler patented because we didn't want somebody else to patent it and keep us from using it. We sell them, and in fact we sell at least a few each year to our competitors. Some people, however, don't like the samplers, saying the thick walls cause too much sample disturbance in some sensitive soils. They do

cause some disturbance, but the samples are pretty doggone good—still better than anybody else can get. We sold some of those to the Army for their tests at Eniwetok for their atomic tests.

We still use them and sell them, although we've never made any money out of them. In the past we did not market them, although we probably should have, and are now marketing them through our instrument division down in Los Angeles. As I've said, quite a few of our competitor firms have bought them. Quite a sizable proportion of people in the soil mechanics business use them, or use a clone of them.

Another patent had to do with calculating the bearing capacity of pilings. This is so simple that it doesn't seem patentable. The idea had been talked about and what we did was to put together a system for calculating the bearing capacity of pilings by calculating the skin friction on the piling for the sides, and the end bearing on the bottom, and relating that to some laboratory testing.

Everybody in the engineering business thought this was a pretty stupid thing to patent, because it seemed like patenting $2+2=4$. But again, the reason for taking out a patent was primarily to avoid having one of our competitors patenting it and trying to keep us from using it. So we do use it still, and I expect most of our competitors use the same idea, although they may have modified a few details of it.¹⁸

In recent years we have made some of our sampling and lab testing equipment available for

18. Moore, William W., "Experiences With Predetermining Pile Lengths," *Transactions*, ASCE, 1947.

purchase, although not a lot of it has been bought. We have, however, sold some of it to our competitors, and have sold sampling equipment to governmental agencies, particularly the Corps of Engineers. We would probably have been way ahead if we had started to sell our equipment many years ago. We thought that by not selling it we would keep control of it, which of course we did not. They copied it anyway. Graduates from our firm who then went out and started their own business have made the same equipment. We probably should have started selling it at the outset, though I doubt that we would have made much money at it.

Scott: Neville Donovan suggested that there is also a down-side to having patented some products and processes. What do you think?

Moore: I think Neville is right. In engineering—as contrasted to electronics—most of the things developed are really not very patentable. We did, however, patent a couple of things, the two that I just mentioned—the underwater sampler, and the calculations of friction pile bearing capacity. As I indicated, that was done back in our early years because we did not want somebody else to patent those and prevent us from using them.

I've always doubted that there was really any patentable point in the pile capacity calculations, but on the other hand if somebody else should patent them, we would have to fight them, and figured we'd rather be there first, so we patented them. Also we published the calculations so they would be available to the profession.

In mentioning a negative side, I think Neville is referring to the fact that some people in the

profession seemed to be offended by our having taken out those two patents. That is my interpretation of what might be considered the negative aspect of the matter.

Scott: They just thought it was inappropriate to have patented the sampling device and the bearing capacity calculations?

Moore: And I suppose if someone else had done it first, we would have thought it inappropriate.

Scott: Did you get much feedback, such as of people complaining about your having taken out those patents?

Moore: No, we didn't. Instead, the response was sort of a deathly silence. Nobody said anything, nor did we.

Scott: Do you think the existence of the patents influenced the use of those two things in any significant way? Did the patents inhibit other people from using the sampler or the calculations?

Moore: I don't think so. They just went ahead and used them, and it had never been our intent to try to prevent that kind of use. The patents may have inhibited some people, but not very many.

Scott: Were those two patents the only ones, or were there others taken out over the years?

Moore: Those were the principal ones, although there might have been a few other minor ones.

Contributions to Knowledge: Research and Development

Scott: Say more about your main idea here—the importance of contributions to knowledge by members of a profession. Even if some might have quarreled with your taking out patents, the underwater sampling device and the bearing capacity calculations were definite contributions.

Moore: My central theme here is that the contributions to engineering and technical knowledge are very important to the profession. Obviously we inherited a lot of this kind of thing, not only in foundations, but in structures and so on from the people that went before us in civil engineering, for some 150 years or more. They did it certainly in waterworks, and so forth. So I suppose when I first saw the topic here I reared back a little bit or reacted negatively about the list of patents. I've seen so many people who have listed seven pages worth of patents. Now in electronics and something like that, the patenting may be very important, but I don't really think it is in the civil engineering business.

Contributions to your profession are very important. Recording and passing along what we all have worked on. Communicating and preserving what people have developed over the years. Some of this is done in textbooks, and some has been handed down from person to person. In my view, in the last 15 or 20 years, engineers should have been spending a lot more time than they have on: 1.) improving their practices, and 2.) writing those improvements up.

Scott: Are you describing a research function, or a mixture of research and development?

Moore: It is R&D, but it is more development than it is basic research.

Scott: It is applied research—the result of investigation and practical experience in dealing with on-the-job problems.

Moore: Yes. The Japanese are doing a lot of this. For example, some 20 or so years ago the Japanese started an R&D organization in Japan, funded partly by the government, and partly by the industries. And a Japanese contractor—Obayashi—did the North Point sewer tunnel in San Francisco. They had developed some tunneling methods, some shielding and so forth.¹⁹ As I understand, the methods they used were actually developed from American inventions. But they spent thousands or maybe millions of dollars in developing the equipment to do it. Then they came over here and underbid the American contractors by about 25 percent.

Since World War II the U.S. engineering/construction industry has done almost zero in terms of research and development. The Japanese have done some things, and the Germans have done some things, but in the U.S., the only thing they've concentrated on is the short-term bottom line. The monthly profits in the stock reports and that sort of stuff. That's

19. Obayashi/Granite (USA) used the earth balance shield method. Despite its previous use with several projects in Japan, San Francisco was apprehensive about allowing the method here, as the North Point tunnel was its first use in the U.S. It worked out very well, however, with minimum surface distress and traffic disruption during the high tourist season. Information courtesy retired Dames & Moore engineer Joseph Jenó.

why U.S. engineering construction and the U.S. economy is hurting. It's the same thing that happened to the auto industry and the steel industry. They kept selling buggy whips after people didn't use them anymore.

U.S. Construction Industry Not Inventive

Scott: Why has U.S. engineering and the construction industry not been very inventive since World War II? Why do you think they have not done much applied research and development?

Moore: There are several reasons. First, after World War II the American engineering/construction industry had the only viable construction and engineering facilities in the world—they had virtually the whole huge market to themselves. They rebuilt Europe, rebuilt Japan, rebuilt the United States, and so forth. I think they were so fat that they got self-satisfied and lazy.

Second, the U.S. engineering and construction industry is highly fragmented. There are structural engineers, soil engineers, mechanical engineers, left-handed contractors and right-handed contractors and all that sort of thing. The construction industry is the biggest industry in the country. It provides about 10 percent of the gross national product, and yet it is absolutely unrepresented in government in any organized way.

In no other country do you find that lack of government representation of the industry, or lack of a corresponding government role. I think, for example, Japan has a ministry of construction. The Swedes have a ministry of construction. The U.S. does not, and I don't know

why. In Japan many of the big trading companies have construction arms, and they are highly integrated.

"Business School" Mentality: Very Little R&D

Moore: Some Japanese firms spend millions annually on internal R&D within their companies. American companies cannot do that. Even Bechtel, which spends more than most, puts only a few million bucks a year, probably not even ten million. Dames & Moore and other engineering firms spend not more than 1 percent on R&D. This comes either from their own funds, or takes the form of doing work at a discount, with low overhead rates.

Scott: When you say "American companies cannot"—do you mean they simply cannot afford to?

Moore: They may *think* they can't afford to spend money on R&D, but actually they probably could afford it. Perhaps they would be better off if they did spend more. Some people call it the "Harvard Business School mentality," which focuses on the quarterly reports of profits per share and so forth, and cuts out anything that would raise costs a cent or so. Actually, R&D does not take much, in proportion to the total gross taken in. In Japan, I think they're trying to spend about 1 percent of their *gross* on R&D. But the U.S. construction industry spent a tenth of a percent, or maybe even less, maybe only half that—i.e., one-twentieth of one percent of gross. It is pathetic. I think it is due to a combination of the fragmentation of the industry and the concentration on maximizing profits. A lot of the firms have come to be run by accountants and so forth. We need to start

earning our money, but for quite a few years we lived on "easy" money, and we will be hurting before it gets better.

Scott: Firms are probably trying to protect themselves by watching only the bottom line, thinking that will provide some security, but it probably won't.

Moore: You can put up trade barriers, but if our people cannot compete, all we'll have is the steel industry all over again. We're in a world market now. General Motors hired the Japanese to show them how to build cars. They did it and now they'll make money at it. But for years, U.S. industries did not spend significant money on real improvements in the quality of their products.

Consulting Engineers: Leadership and Standards

I think formation of the associations was a part of the evolution of engineering.

Scott: Tom Wosser of Degenkolb Associates, who read an earlier draft of your oral history transcript, recommended that you discuss some of your organizational activities, particularly with the consulting engineers' organizations such as Consulting Engineers Association of California (CEAC), and the international organization that goes by the acronym FIDIC.²⁰ Tom feels you have played some very effective leadership roles in those organizations, and that your oral history interviews ought to reflect this. He said you were pretty modest when it came to claiming credit, and that I should ask you to discuss this general topic.

Moore: I was a member of ASCE, of the structural engineers, and of the consulting engineers. I wanted to do what I could to promote the development of better standards of practice, and to work for the success and effective functioning of

20. FIDIC is the acronym of the international engineering organization's name in French: Federation Internationale des Ingenieurs Conseils (International Federation of Consulting Engineers).

the consulting engineering practice. The people who started the Consulting Engineers Association of California were mostly members of both the structural engineers association and ASCE. But there was a feeling that ASCE—which of course included a lot of people working for corporations and government and so on—did not really address the issues of the private practice of consulting engineering. I know I felt that the practice of consulting engineering was of such significant importance that it ought to be recognized separately from the practice of engineering for corporations and for the government. Not that there is anything wrong with such practice, but it is different.

SEAOC was a good organization, but did not serve the purpose I'm talking about. Nor did ASCE nationally. They did not really understand the difference between the practice of consulting engineering and other engineering. With the consulting engineers, it had gotten to the point where a separate association to represent consulting engineers was clearly needed. It needed to be separate from the technical engineers, electrical engineers and so forth, whose primary interest was not in consulting practice. Part of what the consulting engineers had to do was run a business, along with doing the consulting itself. Anyway the consulting field has grown to where there are probably thousands of firms around the world in the consulting business.

Scott: How did the membership of CEAC differ from SEAOC and the other engineering organizations?

Moore: SEAOC had started with structural engineers who were consultants. They were structural engineers who were in private prac-

tice, and they ran their own firms. As time went on, however, there was a need to include their employees and others in SEAOC. Gradually it included structural engineers who worked for the cities and counties or the state, as well as for industries. So in fact it became a *structural* engineers association, not a *consulting* engineers association. I think that is what led in California to formation of CEAC, the state association for consulting engineers. That was also happening in other states. In due course ten or fifteen states had such consulting engineers organizations, and they felt the need to have the consulting engineers represented nationally, and they created a national consulting engineers council. I think similar developments had gone on in other countries, and eventually they also wanted to establish relations among the associations in the various countries.

Scott: Say something about your involvement with the U.S. national organization, the American Consulting Engineers Council (ACEC).

Moore: I was involved at the time of its formation.

I remember being at some of the sessions when they were beginning to talk about forming it. At first I think it was called something like Consulting Engineers Council of the U.S. Later it became ACEC.²¹ It now has members in at least 40 states.

Anyway, the motivation in creating the associations was to help the consulting engineers get

21. The American Consulting Engineers Council (ACEC) was formed in 1973 by the consolidation of the American Institute of Consulting Engineers (AICE), founded in 1910, and the Consulting Engineers Council of the United States (CEC/US), established in 1956.

together and learn better how to run their businesses, that is, as consulting engineers, not as engineers employed by other private companies or by government. The purpose was also to represent their interests before governmental agencies, regulatory groups and the like. That is why ACEC was started.

I think formation of the associations was part of the evolution of engineering. Engineers started out doing things like building bridges for armies in Europe, then the civil engineering profession developed, and electrical engineers, and so forth. The consulting part of it probably did not start until less than a hundred years ago. At first they probably were individual engineers serving as consultants. As things got more complex, consulting engineering was organized in firms, which were members of ASCE. In fact, most of ASCE's leadership came from engineers who were running consulting firms.

Leadership, Competence, Impartiality

Moore: I want to emphasize an important distinction between civil engineering and other engineering. The difference lies mostly in the leadership. In civil engineering the leadership comes mostly from those in private practice. This is not so much true of mechanical, electrical and other engineering, where engineers from large institutions—private and government—comprise much of the leadership. Consequently it is consulting engineers in private practice who tend to be the ones providing the leadership in civil engineering.

The consulting engineer has the job of building a reputation for competence, and also for impartiality—i.e., not being beholden to any industry, such as wood, or concrete, or something else. Also a reputation of not being influenced by political pressures and considerations. That was a very important part of the engineering profession, and I think it still is.

Frankly, however, I think many engineers still do not recognize this as important in their profession. By contrast, it is pretty clear that physicians and medical doctors are supposed to take care of their patients. Generally, it is not considered good practice—many consider it unethical—for doctors to sell medicine. The sale of medicine has pretty well been separated from medical practice. A doctor is considered a professional, and is retained for his professional advice to help his patients choose among the things that may be available to them.

General Engineering vs. Consulting Engineering

Moore: For a long time I have been pushing for the engineering profession to recognize that there is an important difference between the practice of general engineering and the practice of consulting engineering. That seems kind of fuzzy to some people, but the consulting engineer is supposed to be able to use his knowledge in an impartial and unbiased way in helping clients find their way to the best answer that is available for what they want to do. Admittedly, of course, some consulting engineers work mostly for one corporation or one industry—some may work mostly for the wood industry, for example, or others mostly for the

concrete industry. So to a degree there is some influence on their judgment.

A government employee is expected to represent the agency he works for, and an employee cannot be expected to go against what his boss wants. I believe, however, that there is a role in engineering to try to help each client find the way through the maze of technical knowledge to an answer that is technically sound and that suits the client best. The answer must stand up to criticism and be technically right. It should also be free of, or at least not controlled by, other commercial interests. I have had a lot of trouble with the engineers and with the engineering profession to get them to understand that. We try to compare the engineering profession with other professions such as medicine and law, or to some extent even to the clergy.

Scott: The client should be able to rely on the consulting engineer giving his best possible advice, not influenced by such other commercial interests?

Moore: Precisely. But I have never seen that taught in engineering education. I suppose such concerns were what drove me to go more with the consulting engineering organizations than with ASCE and the structural engineers. Those latter organizations are good and valuable, but they are more technically oriented. They do also talk about serving the client, but I think consulting engineering is different, and I think the engineering profession should recognize it as being different.

Consulting Engineers: Independent Expert Advisors

Scott: Would you describe in lay terms what you mean when you say "consulting engineer"? What is typically accepted as the distinction between consulting engineering and other engineering?

Moore: The world is now completely immersed in scientific and technical matters of considerable complexity. I think there is a need for an individual client or a corporate client to choose their way through this maze of information. That is certainly critical now with all the toxic waste business. Also, lots of the people involved have tremendous commercial interests in particular solutions, or programs going in particular directions.

There is a great need for clients to have access to someone they can rely on, who knows the business, who knows what is going on, to help them find their way. Our primary business should be consulting engineering practiced in this manner to help clients. To find the solutions and procedures that are most appropriate to the individual client's needs, and that are also technically sound.

I have trouble with the engineering societies, and even with the National Academy of Engineering, with whom I have argued that there should be separate divisions for consulting engineers, who are different from the engineers for the telephone company or automobile company or power company. I think this is true, but have not been able to get the engineering societies or the National Academy to understand this.

Scott: You are emphasizing the distinction between the consulting engineer with many cli-

ents, and an engineer who makes a long-term career as an employee of a major company?

Moore: Yes. I think it is inevitable that such long-term employment and association with a particular company influences their judgment. It has to slant their judgment toward the interests of their employer. In contrast, the consulting engineer is supposed to be an expert advisor, and to be independent. I do not think that is understood by very many engineers, although I do think it is now understood a good deal throughout the *consulting* engineering profession. This is one of the things on which I have tried to work with the California consulting engineers, as well as the American Consulting Engineers Council, and also internationally with FIDIC. What is needed is to find a place for the consulting engineer—and his employees.

The engineers need to recognize that there is a place for the kind of service I have been talking about. The role and responsibility is quite different from that of an engineer who is working for an industry that has to be making money out of what it is doing. For that reason, the consulting engineers have always taken the view that they should not get paid for the use of any particular construction technique, or material and so on, but should be independent.

Probably most of the effort I have put into ACEC and FIDIC has been to get other people to recognize this and to help develop an understanding of this difference between consulting engineering and other fields of engineering. We have had some awfully good people in consulting engineering who have helped to do that. In some of the other countries there is a well-developed consulting engineering practice. For a long time, Great Britain and British

countries have recognized the difference I have been talking about. There is nothing wrong with engineers working for industry, or for government agencies—I do not wish to be misunderstood on that point. But their motivations are different, and the influences on them are different.

I guess I am still sort of a missionary in that field, along with a lot of others. I also believe that many of the leading consulting engineers would have this same kind of view. Wilson Binger, a consulting engineer with TAMS [Tibbet, Abbot, McCarthy, etc.] for example. James W. Poirot, chairman emeritus, CH₂MHill, is certainly aware of the difference I am talking about. That is also one of the things that I pushed when I got involved with FIDIC—that is, independent expert advice for the World Bank. I will discuss that a bit later.

I think the difference is very basic to the practice of engineering. I wish it was recognized by engineering educators. Hardly any educators understand this at all. Well, some do, but very few, even among the academics who are consultants themselves. They usually consult on particular technical details.

Wallace Chadwick is one person with a good understanding of this. He was a president of ASCE and for years was chief engineer of Southern California Edison. He has chaired a number of investigative commissions, one in particular being the independent panel appointed to look into the big Bureau of Reclamation Teton Dam failure that occurred in Montana some years ago. The dam was located just outside Yellowstone Park. Chadwick thoroughly understood the role of the consulting engineer as someone who could bring to bear

the ethical as well as the technical principles that can help clients make decisions that require choices between technical and engineering matters. He was very effective in making that role work for consulting boards that he served on either as a member or as chair.²²

The Teton Dam disaster was a sad but beautifully illustrative case, where the Bureau of Reclamation had limited the scope of their consultants. The limitations led to some bad decisions that probably would have been caught by a qualified consulting board free to do a thorough reviewing job. The object lesson is the importance of having peer reviewers who are not restricted too much in the subjects they are allowed to examine.

More recently the State of California appointed a consulting board after the Loma Prieta earthquake to look at earthquake problems and issues. George Housner of Caltech chaired that board, which issued a very good report.²³ One of that board's major recommendations was that proposals for major structures involving the interest of the public and a lot of public safety issues, should be subject to review by competent technical and professional people who are also independent of the sponsoring agency. I believe they have implemented that, but only to a limited extent.

I think that is the *key* issue of consulting engineering—the functions need to be independent. To the best of my memory, the first recommendation along that line was back about 1928, after the St. Francis Dam disaster in Los Angeles County. That brand-new major dam washed out, killing a lot of people and doing a great deal of damage. There were investigations, including coroner's jury hearings, and a report by a state commission appointed by the governor. One key recommendation of the state commission was that dams posing significant threats should be subject to detailed review by people thoroughly independent of the sponsoring agency.²⁴ So the need to assure such independence is very important to consulting engineering.

Scott: A review by a peer body that is independent of the dam-building agency—that was the crucial thing, wasn't it?

Moore: Yes. And you can get that by setting up an ad hoc independent review board, or through a permanently constituted state body such as the California Division of Safety of Dams, which was established after the St. Francis Dam disaster, and given the job of reviewing the design and construction of all significant non-federal dams in California. In the case of the Teton Dam, a special ad hoc independent

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22. Chadwick, Wallace L., Chairman, Independent Panel to Review Cause of Teton Dam Failure, *Report to U.S. Department of the Interior and State of Idaho on Failure of Teton Dam*, 1976.
23. Housner, George W., Chairman, *Competing Against Time: Report to Governor George Deukmejian From the Governor's Board of Inquiry on the 1989 Loma Prieta Earthquake*, State of California, 1990.

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24. *California, Report of the Commission to Investigate the Causes Leading to the Failure of the St. Francis Dam Near Saugus*, p. 18, 1928. See also Los Angeles County Coroner, "Transcript of Testimony and Verdict of the Coroner's Jury in the Inquest Over Victims of the St. Francis Dam Disaster," Book 25902, no date. See also Outand, Charles F., *Man-Made Disaster: The Story of St. Francis Dam*, Glendale, Calif., 1963, revised, 1977.

panel was set up after the disaster investigate what happened. All of what I have been saying here emphasizes how essential I consider a substantial degree of *independence* to be for consulting engineering to maintain its integrity and for the consulting engineer to be truly effective as an expert advisor.

Ethics and Standards

Scott: Would you talk a little about what you did in connection with the state and national consulting engineering organizations, and with FIDIC?

Moore: Yes. I first got started with the Consulting Engineers Association of California (CEAC) in the 1940s. They were trying to bring the people in consulting engineering together to work on improving their understanding of this, and also to work on improving the practice of consulting engineering. The text of my "sermon" to CEAC was to develop their practice as independent consulting engineers in providing a service to the public and to their clients. The service should be technically sound, legally defensible, stand up to technical critics, and be independent of commercial influences.

For the same reason, I became interested in the consulting engineers of the U.S. And that is also what I tried to sell to the FIDIC people. FIDIC has grown from an organization of thirteen countries to one of about fifty, involving people throughout the world who are trying to practice consulting engineering. Part of this is developing professional relationships between competing consulting engineers. The idea is for them to serve their clients and practice their profession without letting, let's say, their per-

sonal interests dominate their thinking. Maybe it is too much to expect people to do that.

Scott: But it is certainly important to ask them to try to maintain high standards of practice.

Moore: Yes. I do not think it is really different from what the medical profession tries to do with practicing doctors. Or the legal profession with lawyers.

An Ever-Present Conflict: Financial and Ethical Concerns

Moore: The consulting engineer needs to maintain his independence and integrity, hold to high standards of practice, and run a successful business at the same time.

Scott: Running a successful business and trying to make money can cause conflicts in motivation when you want also to maintain the ethical standards of the consulting profession.

Moore: That's right, you cannot separate the financial concerns from the ethical. You have to take in enough money to pay your expenses and make a living. I recall seeing this reply by an architect who was asked how long he intended to practice. He said, "Until I run out of money!"

Scott: There is pressure to do some things a client wants—or maybe not do some things on a job—that would shave professional standards?

Moore: Yes. They may want you to do some things that you wish they would not ask for, forcing you to some decisions. At what point do you tell a prospective client, "Go get someone else." I have had a few cases—not too many—where they wanted us to do something we did not want to do, and told them to go

elsewhere. You hope you do not have to do that very often.

I'll give an example. A lawyer came into my office, whose client had a little landslide. A retaining wall had slid out and damaged a house. We discussed it a while, and I said, "If they had put some ties in up to the back of the hill, that would have held it." The lawyer said, "So the engineer made a mistake, he should not have done what he did?" I replied, "I did not say that. He built it like a lot of other retaining walls. But a more conservative design with some tie-backs would have helped." "Then can't you say that he did not meet the standards of the practice." I said, "No." So he went to get somebody else. It was a small job. If it had been a \$10 million job, would I have had the courage to tell him to "get lost"?

Scott: It is one thing to say that you yourself would have used a more conservative design, but something different to say that what was done did not meet the standards of the practice. And of course it is still another thing to testify in court on behalf of a lawyer representing a complaining client. Being asked to give that kind of testimony—even when you think it is justified—must put you very much on the spot.

Moore: There are occasions where it does get that bad—I have given such testimony, but not too many times. But more often it is not a clear case—"He could have done it this way or that way, and maybe his choice was reasonable under the circumstances, although maybe I would have done it differently." But that does not satisfy most lawyers. The attorney wants you to say that the other engineer did not com-

ply with the standards of the practice, of which there are none!

Low Bids and Cheap Jobs

Scott: What you say emphasizes another central point—the importance of getting reliable engineering advice at the outset. That lawyer's client got the wrong engineer to do the job in the first place. More care on the part of the client in choosing and negotiating with the engineer could probably have avoided trouble altogether.

Moore: Yes. Instead, he probably got the cheapest engineer available, and as a result he also got a cheap job. That is one of the problems with competitive bidding for engineering work. I'll give you some examples. Let's say you want to do some foundation work, and you get a proposal from somebody who wants to advise you on that. Whatever that proposed bid is, I could do it for less, and the client would probably never know he had gotten taken. He will not know it at first, and he may never know it. What I am taking about is an engineer making recommendations that are so conservative—unnecessarily conservative—that the engineer can do them after only a drive-by to see the site and job.

Scott: So going for the cheaper engineering bid might get you an ultraconservative design. Such conservatism would take care of whatever might be present at the site, but the overall job might be a good deal more costly than a more appropriate design tailor-made for the site. That, however, would require the engineer to investigate the site thoroughly, and that in turn would call for a higher engineering fee? But it

might save money on the whole job? This is it in a nutshell, isn't it?

Moore: Yes. And of course there are gradations in the extent of investigation. How thorough an investigation is called for? This is why comparisons of bid prices make no sense. We have gone crazy on bid price comparisons in this country, and I think we are squandering enormous amounts of money as a result. By accepting low bids, they end up doing things that are unnecessary. The jobs are more expensive because they wanted cheap engineering.

FIDIC: International Association of Consulting Engineers

Scott: When and how did you get involved in FIDIC?

Moore: In the 1950s a group of us consulting engineers from ACEC went on a two-week trip to Europe, and we visited engineers in England, Germany, France and so on. We found that the consulting engineers there were better organized than in this country. Working through ACEC we had opened up lines of communications with U.S. government agencies, met with Congressmen and that sort of thing, to inform the people in government what consulting engineering was. Then we did the same thing in the international field. In the 1950s my firm was doing some international work, and I was interested in that.

A dozen or so of us were part of the group that helped establish links with the Europeans. FIDIC itself had actually been started a long time before, in 1913, but of course was dormant during World War I, and in fact never really got started much until after World War

II.²⁵ Up to that time it was kind of a small club mostly involving England, France and the Scandinavian countries. Following WWII and with the rebuilding that began then, FIDIC became involved in world markets. It was about that time that I got involved. I went to some FIDIC meetings myself, as an individual, but not in any kind of official capacity.

Scott: Meanwhile you and others were pushing to get ACEC to join FIDIC?

Moore: Yes. Finally in 1959 after several years of effort we got ACEC to become a member of FIDIC. Then several years after ACEC joined, in 1970-1972 I was the first president of FIDIC to come from the United States. Wilson Binger, whom I have already mentioned, was the second U.S. president, serving in 1981-1983. At the FIDIC meeting in Australia in September 1994, William D. Lewis, of ASL Consulting Engineers, Pasadena—he has since retired—was chosen FIDIC president-elect, to serve 1995-1997.

Guidelines for Selecting Engineers: The World Bank

Moore: One of the things FIDIC did when I got involved with them was to try to create relationships, particularly with international financial groups, such as the United Nations, the World Bank, and the various development banks. Concern with the implications of cheap engineering is why the World Bank and other financial institutions have adopted a policy of selecting an engineer on the basis of experi-

25. See Widegren, Ragnar, *Consulting Engineers, 1913-1988: FIDIC Over 75 Years*. International Confederation of Consulting Engineers, 1988.

ence, record, and capabilities. They understand that the engineer should not have anything to do with how much it costs to build the project.

They have also now pretty well accepted the idea that they want *independent* consulting engineering firms to be involved in making decisions as to whether projects being considered are the right places for investment. That is very different matter from contracting with an engineering firm for a design to build some particular facility. The key *prior* question is whether the facility is appropriate. What about other things that might be done instead? The World Bank in particular has come out with guidelines for the selection of consulting engineers, and the guidelines are quite clear on that issue.

Scott: So you and others had pushed for FIDIC to establish contact with organizations such as the World Bank in connection with cri-

teria for selecting engineers? Did FIDIC advise them on the matter—suggest to them the importance of such guidelines emphasizing the need for independent engineering judgment?

Moore: Yes, I was involved and several others were as well. For the last ten or fifteen years we have had periodic meetings throughout the year between FIDIC consulting engineers and the Inter-American Development Bank, the World Bank, the Asian Development Bank, the African Development Bank, and so forth. We have discussed how you get decisions made on appropriate technical developments for those countries. I think they agree that the guidelines issued by the World Bank, and followed by many of the others, are pretty clear on having clients select consulting engineering firms that are quite independent from the economic and business side of the construction or the operation of the facilities being considered.

Observations on the History of Structural Engineering in California

... the pro bono theme goes through all of this.

Moore: The Structural Engineers Association of Southern California and the Structural Engineers Association of Northern California were started back in the late '20s or early '30s, at about the same time. They were separate groups, and it wasn't until somewhat later that they joined together in the Structural Engineers Association of California.²⁶

These two groups of structural engineers had a great interest in earthquake-resistant design. That effort began to take form after the Santa Barbara earthquake in 1925, but did not become a really strong effort until after the Long Beach earthquake in 1933. While interested engineers and seismologists had met and argued on behalf of earthquake-resistant codes and earthquake research before the Long Beach earthquake, it was not until after the 1933 earthquake that the state of California took significant action, when it passed the Field Act and

26. The southern California association started in 1929 and the northern association about a year later.

the Riley Act. The structural engineers' associations were strong factors in supporting that legislation.

Incidentally, following the Long Beach earthquake many of the structural engineers did a lot of business in school design. After I left the Coast and Geodetic Survey, I went to work for Robert "Cap" Labarre and Fred Converse, both of whom I have mentioned before.

Labarre was one of the fellows who promoted the strong motion program, and Converse had been my teacher at Caltech. They were in a Los Angeles partnership as consultants in foundation engineering, and were very much interested in the dynamic behavior of the ground and of building foundations, and how that related to building design. Although Labarre was not a structural engineer, he worked very closely with the structural engineer's association.

Greater Independence of Structural Engineers

Moore: In California, and to some extent in Oregon and Washington, structural engineering is regarded as a separate private practice. The structural engineer works in collaboration with the architect, the owner, and the developer in some cases.

Scott: So the typical relationship in California has been different from what is found in most of the country?

Moore: Yes. California was the first state to separate the practice of structural engineering from the civil engineering license. Probably this was partly because the 1933 Field Act required the structural engineer to sign the plans of any

public school he designed, before it could be approved by the state. I think that kind of requirement has been unique in California. Structural engineering as a separate practice, however, has spread to Oregon and Washington, and Colorado recently added a requirement for a special exam and registration for structural engineers.

In most of the United States, structural engineers do not have much independence, and have much more of a subordinate role, more that of a technician-employee. Also they do not provide any supervision of the construction. Things have been changing in structural engineering licensing and practice, however, so you should ask Roland Sharpe about this—he is well aware of how structural engineering is handled in the rest of the country.²⁷

These are generalizations, and of course there are always exceptions. There are a few good structural engineers nationally, and they do work directly with clients, or with some of the leading architects. Also, some of the leading architects

27. *Editor's note:* California was the first state to separate the practice of structural engineering from the civil engineering license, and for many years was unique in this. Now, however, quite a few states have structural engineering exams, although most do not have a separate requirement for practicing structural engineering. California, Oregon and Washington have a separate two-day examination for registration as a structural engineer. Outside California, most structural engineering is done in civil engineering firms or multidisciplinary firms that provide structural design services. Most structural design is done by structural engineers acting as subcontractors to or employees of an architectural firm, the remainder is done by structural engineers contracting directly with owners or clients. (Based on material supplied to the interviewer by Roland Sharpe.)

do have structural engineers working with them. Generally speaking, however, structural engineering in California has been a very different practice from what it is in most of the rest of the country, although this may be changing.

Some Leaders in Engineering and Seismic Design

Scott: Previously you mentioned some of the leaders of the profession who were mentors and helped you, especially in the early days of your practice. At the risk of a little repetition, would you review this overview of the history of SEAOC and indicate the names of some of the key leaders, giving your recollections and observations?²⁸

Moore: A lot of people contributed tremendous amounts of their time, without pay, for the improvement of the profession, and the development of better principles for the design of earthquake-resistant structures. Many of these people also helped us in the early days. In southern California there was Clarence Derrick and Steve Barnes, Mark Falk and Oliver Bowen, and a number of others, such as Paul Jeffers. In northern California there were people like H.J. Brunnier, L.H. Nishkian, Austin Earl, Harold Hammill, Gus Saph, Henry Dewell, and Edward Knapik. A little later, people like John Rinne, John Blume here in northern California, George Housner at Caltech, and Nate Newmark at the University of Illinois also contributed a great deal to seismic design.

I think all these people, both the practicing engineers and the academics, had inherited an attitude of cooperation, mutuality and support of the profession. I think that went along with the practice of civil engineering. While I will not say it was unique to civil engineers, it was not very common among other technical people. The electrical and mechanical engineers mostly worked for industry or for governmental entities, and not many of them were themselves engaged in practice. The practicing civil and structural engineers, however, gave lots of volunteer time to activities in the interest of the profession. While I think there is much less of that now, a good deal of volunteer work is still done on technical committees of SEAOC, ASCE, and EERI.

Scott: In those earlier days the leading engineers were quite active in volunteer work for the benefit of the profession, and also in the interest of improved seismic design.

Moore: Yes, to them time was no object. I can remember sitting over at the Oakland Hotel across the Bay with Labarre and Perry Byerly, who was the head of the seismological lab at U.C. Berkeley, and a couple of others. We finished our dinners, and this discussion went on until midnight. They were talking about what they were working on, about seismic data and seismic developments and seismic resistance of buildings, and that sort of stuff. It was a hell of an education.

Similarly, down in southern California at Caltech, I worked with Hugo Benioff, whom I mentioned earlier. Benioff was at the seismological lab at Caltech. He was an instrument man, and designed some of the first instruments for recording strong motions. In

28. *The Evolution of the Structural Engineers Association of California: Some Historical Notes, 1931-1981*. Structural Engineers Association of California, Sacramento, CA 1981.

fact, he designed one pretty complex thing to measure strong motions and record them remotely, by having them wired together. Benioff developed this instrument under contract with the Coast and Geodetic Survey, I believe. I visited him one time at Fort Bragg after he had retired. He had a seismograph in his basement, and he would go down to look at it every day—this was a sensitive seismograph, not a strong motion instrument.

Scott: Give a little more background on some of the people you have mentioned here. I take it most of them were both mentors and leaders of the profession. Let's go down through the names you just mentioned.

Clarence Derrick

Scott: The first one you mentioned was Clarence Derrick. I have heard a good deal about him from others, especially LeRoy Crandall. I gather that he was a remarkable person. Derrick was something of a personal mentor to LeRoy, as well as probably to quite a few others. Also, his experimentation impressed LeRoy very much.

Moore: Derrick was a mentor for me, also. As to the experimentation, he thought ahead, and did probably some of the best individual experimental work on earthquake effects, using shakable models of buildings. He was doing that before others were thinking about it, whether in the universities or out. For a year or two he coached us—Dames & Moore—on business development and sales.

Scott: He advised you on how to promote business for the firm?

Moore: He said that one of the greatest salesmen of all time was Jesus Christ. "He had a good product, he understood it, and he believed in it." That also applied to Robert Millikan of Caltech, also a great salesman.

Scott: Say something about Derrick's experimentation.

Moore: I'll briefly describe his experimentation. In his garage or basement, he would set up experiments to find out what happens to buildings when shaken by earthquake forces. People had always looked at seismic forces as if the building had been pushed from the side.

Scott: In the old days, people tended to think of the lateral force as if it actually pushed on the side of a building?

Moore: Yes. Derrick, however, started with the idea that a structure was not pushed from the side, but instead the lateral shove came from underneath. He made a model using some corset stays—two springs with boards between them—building that up to ten floors or so. When he shook it, by synchronizing the motion he could get it really whopping.

He set up his model in his garage, banged it with a ball that he dropped, and photographed the result with a camera that could take pictures in a fraction of a second. When the model was struck, you would see that the bottom moved, but at first the model did not move up above. Then the movement worked its way up to the top, taking about half the period for the motion to get to the top. Everybody knows that now from all the finite element studies. That is why very high frequency motion never gets to the top of a tall building, it just shakes the bottom, but the top does not move.

That was a very interesting machine Derrick used to test his ideas about how buildings shook.²⁹ With his thinking, he was one of those who changed the way engineers tended to interpret seismic motion. He was not alone, of course—others at Caltech, Berkeley and so forth were also onto this. But Clarence was one of those practicing engineers who thought ahead of the profession.

Mark Falk

Moore: Mark Falk was a structural engineer in southern California, who did a lot of school work. After the Long Beach earthquake, from 1933 up to about 1940, the school work really kept the engineers alive during those years. Then Mark moved up here to San Francisco and opened an office. In his later years he became a partner with an architect named Corwin Booth, and they became Falk & Booth here in the Bay Area. Booth is the owner of this building we are located in now here on Main Street in San Francisco. So the circle goes around.

Barnes, Bowen, and Jeffers

Moore: Then there is Steve Barnes, who ran one of the major civil engineering offices in the Los Angeles area. I do not remember right now who his partners were back then.³⁰

Scott: You mentioned Oliver Bowen and Paul Jeffers. They were influential early day Los Angeles structural engineers. Say a word or two about them.

Moore: Bowen had a large and effective structural engineering office in southern California. Paul Jeffers did structural engineering work, but also got very much involved in registration.

Scott: Jeffers, as well as Bowen, was part of the "Dirty Dozen" that, among other things, organized the Structural Engineers Association of Southern California in 1929.

Moore: Yes. It should be recognized that people like Jeffers, Bowen, Falk, and others, while they all developed their own particular specialties, they also worked together. They met together and treated each other with a great deal of personal and professional respect. Jeffers worked a lot on engineering registration and on the concept of trying to protect the public. Now it is another story as to whether registration has actually worked out that way. I think they were all concerned with doing their work in a way that was good for their clients and constructive for the public. For one thing, back then they devoted a lot of their own personal time to professional affairs and to code matters. They were not just trying to make a fast buck out of it. I am afraid we now have a lot of people in all branches of the engineering profession that are trying to make a fast buck.

Henry Brunnier

Moore: Henry Brunnier in northern California had a tremendous influence on the engi-

29. For photographic sequences of Derrick's model in action, see Clarence Derrick, "The Damage Potential of Earthshocks," *Proceedings, SEAOC Annual Convention*, 1954. His ideas were also presented in two volumes that he published to supplement classroom discussions at the University of Southern California, Derrick, *Elements of Aseismic Design*, Part I, "Physical and Theoretical Background," 1955, and Part II, "Distortion Analysis," 1959.

30. The firm is still active: S.B. Barnes Associates, Los Angeles, Clarkson W. Pinkham, President.

neering profession in the Bay Area. I believe Brunnier came here soon after the 1906 earthquake and worked for Ford, Bacon and Davis, and then stayed and set up a practice here. He and U.C. Berkeley Dean Charles Derleth served on the prestigious board of consultants for the Bay Bridge, along with Ralph Modjeski, Leon S. Moisseiff, and Moran and Proctor.

Brunnier was a great one for organizations, and really made a career out of the Rotary Club. He was the one who got me involved in the Rotary Club. He thought I should join, and they created a new membership title or category for me, "foundation engineering." The structural engineering profession gained a good deal of prestige by virtue of Brunnier's term as worldwide president of Rotary International, a community service organization of more than a million members from diverse professions.

Scott: So you both enjoyed it and found it helpful in your business and professional work?

Moore: Yes. And I have gotten several other people involved in Rotary, and in fact I got two new ones recently. The others have retired or died off.

Rinne, Blume, Housner, Newmark, and Bolt

Scott: You also mentioned John Rinne, John Blume, George Housner, and Nathan Newmark as being particularly active in improving earthquake engineering.

Moore: John Rinne was structural engineer for the Standard Oil Company, and did a great deal of work with the other structural engineers. They did that more in those days than they do now. Thus he was employed by Standard Oil but was also working with the other

structural engineers in developing guidelines for structural safety.

In the early days, John Blume had been a student of Lydik Jacobsen's at Stanford. John was very effective in EERI, and in earthquake engineering generally. His interest in that, and in Stanford, led in due course to the creation of the Blume Earthquake Engineering Center at Stanford.

George Housner has been a professor at Caltech since about the end of World War II. He was a classmate of mine at Caltech in the early 1930s. I knew him very well, although not intimately. From the early days and throughout his career he has been involved with the structural engineers, and with EERI and that sort of thing. Among his recent activities was chairing the state investigation committee on the Loma Prieta earthquake, especially on the Caltrans bridge and freeway collapses. A number of structural engineers worked with him, and they put out an excellent report, which was mentioned earlier. One important conclusion of that report was that important structures should be subject to independent peer review by people not connected with the sponsoring agency. He also chaired a similar body set up by Caltrans after the Northridge earthquake.³¹

Nathan Newmark was an engineering professor at the University of Illinois, who did some of the best work on developing seismic design and soil mechanics. He was a consultant to the Atomic Energy Commission on most of the nuclear power work.

31. Housner, George W., Chairman, *The Continuing Challenge: Report on the Northridge Earthquake of January 17, 1994*, California. Department of Transportation. Seismic Advisory Board, 1994.

Bruce Bolt is another one who should be on your list, although he is somewhat younger than those mentioned above. He is a seismologist, who many years ago took over the U.C. Berkeley Seismology Laboratory from Perry Byerly.

Scott: Yes, Bruce Bolt took over from Byerly probably in the mid-1960s, and held that post for some 25 years.

Moore: He maintained a good relationship with the engineers, and assisted in many ways to give the engineers the kinds of information they need. He has a very good head, with a lot of knowledge, an excellent balance, and a good sense of where the emphasis needs to be.

In the Interest of the Profession and the Public

Scott: You seem to have been emphasizing that most of these earlier contributors to earthquake engineering did a great deal of what is called pro bono work. This meant a good deal of time and effort contributed for the good of the profession, to improve design and performance, and also in the public's interest.

Moore: Yes. I had not thought about that for a while, until we started talking about it, but the pro bono theme goes through all of this. They were doing things to contribute to the profession. I feel it myself—I probably have more loyalty to my profession than I do to my firm. I don't know how many people feel that way now, but not as many do that kind of thing anymore. Some do, but I do not think pro bono work is as common now as it was then. Some take the attitude, "Those guys are our competitors, we don't care what the hell happens to them." I also think the corporations are dis-

couraging it, whereas they supported it in those days.

Some of the changes I see may characterize our whole society and business world. Companies are cutting each others throats and trying to make a fast buck, and not doing much for their reputation or for our society. Also some are now trying to be good citizens. That brings me to another topic which seems closely related. Recently my daughter-in-law gave me a book entitled *The Spirit of Community*, by an author named Etzioni.³²

I have not read it all, but the essence of the book is that we have spent about twenty years creating rights for people, while we said little or nothing about their responsibilities. It is a very interesting book, which talks about some of the things I have been discussing here—the self-centered emphasis on make-a-buck, no matter what. I believe the author is onto something. I hope that what they call "communitarianism"—emphasizing our responsibilities to each other and to the community—will become the trend of the future.

Scott: In the past we had that community spirit, at least in some ways and in some communities. But more recently it does seem to have been minimized or lost, while we seem to be a more contentious and litigious society.

Moore: Yes, and the community spirit has to come back. With so much contention, the main ones who seem to benefit are the lawyers.

32. Etzioni, Amitai, *The Spirit of Community: Rights, Responsibilities, and the Communitarian Agenda*. Crown Publishers, New York, 1993.

The Importance of Understanding History

Moore: I think the younger people need to understand that they are inheriting the results of a lot of work done by their predecessors, who labored hard to create a profession that is worth something. The new generation of engineers damn well ought to pay attention to not making the profession worse. That is about the guts of what I want to convey. It is also something that I tell the people here at Dames & Moore. In recent years, the profession has suffered from the immediate, short-term focus on the bottom line. Engineers now often tend to think, "Oh, we know it all, and we have our computers...." The attitude of many engineers nowadays is not to give a damn about what went on in the past. They think they created it all.

Scott: Do you think a lot of the younger engineers seem less interested in the history of the profession, or in learning about past accomplishments and how they were achieved?

Moore: I think that is correct.

Scott: You are touching on one of the main reasons I have kept going with these oral history interviews, having started with Henry Degenkolb back in 1984. I do not have a background in engineering, but during many years of working with engineers on policy aspects of seismic safety and earthquake engineering, I came to realize that some very significant and remarkable developments have been going on over the past half-century or so.

Moore: That is an important part of the continuing history of earthquake engineering that needs to be better understood. In EERI's

monograph on Henry Degenkolb's oral history,³³ he referred to the EERI program known as Learning From Earthquakes. It is critically important to pursue that kind of learning in order to find out what earthquake shaking does to structures, including new designs and new materials.

Nowadays we have a bunch of young engineers who have gone to school, and know how to operate a computer and make a computer analysis. They tend to put those results out and say, "That is what happens." But things do not necessarily happen that way. While computer analysis can be very valuable if compared and correlated with actual observations, the results of computer analysis can lead us astray if just taken on face value. I think this is the point of the earthquake visitations—the visits to earthquake sites that Henry Degenkolb promoted. An analysis and prediction of a building's behavior, whether done by computer or otherwise, is no better than the assumptions on which it rests. Unless verified by being checked against what happens in the real world, those assumptions and predictions are questionable or speculative.

I referred to that earlier in talking about Cap Labarre, and the training that Trent Dames and I had with him. We would make our calculations, and then Labarre would come in and review them, and might say, "No, that won't work." He would say that on the basis of things he remembered having seen before somewhere. We would have to fight through and compare our calculations with what he remembered

33. Scott, Stanley, Interviewer, *Henry J. Degenkolb, Connection: The EERI Oral History Series*. EERI, 1994.

from jobs he had worked on. Most of the time, there was something lacking in the calculations.

Labarre was using his intuition. He had seen a lot of things happen over the years, and he was drawing on that background of knowledge. That is the kind of thing Henry Degenkolb is talking about—looking at actual earthquake damage you will see things that a theoretical analysis will not tell you.

Scott: Yes, Henry put great emphasis on the importance of knowledgeable engineers making on-site visits to earthquake damage soon after an event. He was convinced that nothing could match that kind of direct observation and thoughtful speculation as to what had actually happened in the earthquake.

Moore: In Dames & Moore's earlier practice, when we were calculating pile capacities, part of the project was to observe what happened. Do field checking, test it under load—observe what settlement occurred. This is what *Learning From Earthquakes* is—field checking.

Scott: Looked at that way, earthquake site visits are a special kind of field checking, of verifying or discrediting current design theories and practices.

Moore: Yes, and we will never produce engineers without field checking. In short, they need experience, and some opportunity to see

what happens in real life, to become full-fledged engineers. I believe that identifies an important connection between what Henry Degenkolb was saying and what I have been saying.

Scott: This theme has come through in talking to most of the older engineers I have been dealing with. There seems to be a real difference in the conception of what good engineering practice entails. It seems to go far beyond the familiar generational divisions between "old fogies" and "young whippersnappers."

Moore: There is a real weakness in modern engineering education. The graduates come out knowing how to use the computer and what numbers to put in, but they may not understand the limitations of those procedures. That knowledge has to be learned in practice, although the best professors teach some of it, too.

Scott: I am beginning to conclude that these oral histories can make a real contribution by recording and disseminating viewpoints such as yours, Henry Degenkolb's and other older engineers.

Moore: The interviews should make a contribution. This also bears on my earlier comments about the younger engineers failing to learn the background of the profession that they have inherited. They really don't understand it. They don't know their history.

The Human Side of Engineering and the Wise Use of Technology

Anybody who knows anything about engineering realizes that it is not a precise science, and there is not a "right" or "wrong" answer to most design problems, but rather a range of possible actions.

Moore: The progress of our society and our standard of living depend on what I like to call, a "wise use of technology." This poses the engineering profession with a tremendous challenge and offers it a tremendous opportunity. What we need to promote is not the bulldozer mentality that thinks the quickest way to build a road from here to there is right through your house. Instead we need a mentality that seeks out the reasonably right answer, a workable answer that will fit the needs of society. If the engineer can't do that, he will be displaced by somebody who will. But there aren't enough engineers coming out of school now who understand that. I'm not even sure that very many who teach are teaching that, because they have become so highly involved in research on the technical side. But not on the social or political side.

Nontechnical Aspects of Professional Practice

Moore: Much of the nontechnical side of engineering you do not learn out of books in engineering schools. I'm not a historian on civil engineering, but it goes back quite a long time. In America, civil engineering is at least a hundred years old, and the British institution of civil engineers is older than that. In both Britain and America, a lot of effort has gone into developing concepts of responsibility and ethical practice. In this country, ASCE has been particularly interested in such matters as how to deal with clients and how to deal with fellow professionals. So the civil engineering profession has developed a culture and a heritage.

But one problem here in the U.S. is that a lot of people who get a technical education—whether in electrical engineering or electronics, or geology, or some other technical field—do not acquire the cultural background that relates to the practice of their profession. How do you deal with a client, and with the public? What are your responsibilities to your profession, and to other professionals?

Scott: What you are talking about goes well beyond the more technical standards of practice? That gets into behavior and ethics, decisions that are not—strictly speaking—technical?

Moore: Yes. Anybody who knows anything about engineering realizes that it is not a precise science, and there is not a "right" or "wrong" answer to most design problems, but rather a range of possible actions. Whatever the problem, there will be a whole range of possible courses of action or solutions. If somebody chooses one that is different from mine,

that does not necessarily mean he is wrong. I have a right to the choice I would make, and he has the right to his. This is where we can, with the coaching of lawyers, get into confrontations and be led to make really derogatory and damaging remarks about some other professional who happens to have a different view.

There really isn't only one single answer to a problem. In all of our practice, we do engineering studies so we try to get an understanding of the problem. Then we can talk with our client and say: "This is the problem, and there are various ways to handle it. This is a cheap way, but it has more risks, and there are other ways that have other advantages, maybe long-term stability or greater safety, that sort of thing."

Many engineers make calculations and consider their results to be the answer. That is just not so because there are usually several different ways to handle a problem, and they involve different uncertainties and risks and different costs. The problem is to make the most appropriate choice, and to make sure the client understands those differences. The engineer needs to watch this, because clients often are looking for something that provides a simple, positive answer.

Scott: So the engineer needs to see that the client fully understands the options and possible consequences? In short, each client needs to be a full participant in the decisionmaking?

Moore: Yes. The clients need to participate in the decisionmaking. After all, they are going to pay for what is done, and they will have to live with the results. Clients are very conscious of the first costs involved, but in their search

for something that costs a little less, often are not as willing to look at the risks.

Illustrations: A Freeway, A Transit Subway, and a Dam

Embarcadero Freeway

Moore: One of my favorite examples is the Embarcadero Freeway. Probably technically it was okay, but it was stopped by the public because they just didn't like the darn thing. I observed and got involved in the Embarcadero Freeway issue, participating in a committee along with several other technical people—architects and engineers. We considered many alternatives, including putting the freeway underground along by the Ferry Building and beyond. Some of us developed the information and the opinion that, while putting the route underground would have entailed appreciable additional costs, the data also indicated that the cost of undergrounding could have been recovered by San Francisco in tax revenues over several years.

Unfortunately, the money was not available to do more than a piece of it. So the State Highway Department made a decision to go ahead and build part of the freeway past the Ferry Building overhead. This resulted in what I called the "Charley Adams Bridge" because it did not go anywhere. I always felt that his was a wrong decision.

Scott: Ironically, the 1989 Loma Prieta earthquake was instrumental in removing the stub-ended overhead structure on the Embarcadero, which was heavily damaged and has now been demolished.

BART-Berkeley Controversy

Moore: A similar situation occurred in Berkeley, where the city wanted the BART rails put in a subway through Berkeley. Instead, BART wanted to proceed through Berkeley with an elevated structure. That was stopped by a lawsuit brought by the city. I think BART could have handled that quite differently starting as soon as it was clear there was resistance from Berkeley.

In the circumstances, it would have been a lot better if the BART engineers and management had discussed the whole thing with Berkeley at the outset and tried to work out a solution. The BART engineers could have made it clear that the district did not have enough money for the undergrounding, but that if the city would put up the money they would work with them. Of course, that would have required a willingness to negotiate, and probably would have caused some delays in the project.

So instead, BART and its engineers dug in their heels and had to be forced to do that [underground the line] by court order. They could have just acknowledged that they did not have enough money to put the tracks underground, and then said, "If the city wants to come up with the money, we'll do it that way." That is what finally happened, but instead of doing it voluntarily, BART had to be forced to do it by court order. It put the engineers in a bad light—the engineers came out looking like the bad guys.

Scott: That was a huge confrontation between BART and the City of Berkeley. Mayor Wallace Johnson led the fight to underground BART, and Berkeley won.

Moore: It was foolish for BART to have the confrontation. As I say, results like that have engineers coming out as the "bad guys." Both the Embarcadero Freeway and the Berkeley undergrounding issue are illustrations of failures in engineering practice. I can't for the life of me understand why an engineer would want to do that kind of thing. The engineer can design a tunnel down underground, or he can design a bridge aboveground. Should it not be the engineer's responsibility to help figure out what society needs and is willing to pay for, and to work with them until they figure out what to do?

Orme Dam in Arizona

Moore: The Orme Dam case in Arizona is still another example. It was a case of the technical people forcing the ones who would have to pay to choose something they did not really want. We got involved in a study for the Corps of Engineers and the Bureau of Reclamation. Both wanted to build dams to provide water supply and control flooding around Phoenix. They had different programs, the Bureau of Reclamation wanted to build a big dam outside Phoenix, known as the Orme Dam, and the Corps of Engineers planned a bunch of flood control channels.

Anyway, nothing happened for probably about 25 years. There were floods every few years, with tremendous damage, and water supply was a continuing problem. Eventually, Dames & Moore was asked to do what they called a public involvement study. We produced no new information, but worked with the Corps of Engineers and the Bureau of Reclamation, and got all the technical data from them. We did carry out some social studies and environmen-

tal studies, and conducted some interviews with residents. I think we worked with something like 40 or 50 groups in the Phoenix area, ranging from farmers to Indians to Boy Scouts, to environmentalists, etc.

To start with, we had some 30 or 40 possible projects that might be embodied in a scheme to handle the water supply and flood problem. We narrowed this down to about ten schemes. In the process we always put the scheme under consideration alongside another scheme, which was to do nothing, and then worked it through with the committee, the public, all the people involved—they were the ones who were going to pay for it, eventually, anyway.

The governor appointed a committee that had, if I remember correctly, 21 people representing all the political interests that he could find around Arizona. Our staff met with them once a month and we explained what was going on. The interesting thing was, after about 18 months of study and meetings, it finally came down to a choice: whether to do nothing or to do something. I think they voted 20-to-1 for a plan to handle the water supply and flood control, but did not include the Orme Dam. When this was announced at the governor's meeting, the Indians came in and danced and cried, because under the Orme Dam plan their reservation would have been moved.

In the course of the study we found out that different people's value systems and motives were very much different from the motives and values of the engineers. The engineers said, "Look, we give them [the Indians] better land and we give them money." But the Indians did not care about that—this was their home. Also the people of Arizona were willing to pay the

difference, and as it turned out there really was not much of a difference in the cost.

As I said, the technical people were forcing the people who would have to pay for it to make a decision for something that they did not really want. One of the Arizona senators said afterwards that if he had realized there was another solution to this flood and water problem besides the Orme Dam, he would never have fought for it.

Scott: You have to work your way through things like that methodically, and I guess that is what you and your people did.

Moore: When we started with these groups, they were 180 degrees apart, but after they studied the alternatives, they came closer together. And finally the vote came down 20-to-1 to do something, against doing nothing, and also against the choice that the engineers wanted. As it turned out, there wasn't that much difference in cost. I think of this as a good example of what I am trying to convey.

Engineering Education and Interdisciplinary Programs

Moore: Engineering education must look to its own role in this. A very large proportion of the issues confronting a modern society have a pretty high technological content. Societies depend on technology. A number of universities have recognized that interdependence by undertaking interdisciplinary programs. Stanford has one now called Science, Technology, and Society. Caltech has one, which I think they call something like Science, Ethics, and Public Policy.³⁴ I believe the one at Stanford is not a separate department, but is a program

that involves crossing over between engineering, maybe the sciences, and the humanities, and a degree would be granted. As I understand it, the graduates of the program would have a substantial background in engineering, with a minor in social science, or possibly have a substantial background in social science, with a minor in engineering or another science.

Scott: The training is intended to prepare students for an interdisciplinary, interpretative role?

Moore: Yes. This is a very interesting development, and I think it will be very important in the future. This concern with the broader picture has been prompted in part by trying to promote or achieve sustainable development and to evaluate environmental impacts. Those concepts entail looking at all aspects of a major development—what it costs to do originally, what it will cost to get rid of such things as the toxic wastes produced, and what the other major impacts will be. It means looking at a "total" project from start to finish, including later demolition. It means considering costs, as well as what a project does. Today you cannot do much engineering without looking at the social and economic effects—the effects on the community and on the environment. This is extremely important.

34. The program at Caltech includes research, general teaching and a public seminar series. It offers an undergraduate major, as well as a graduate minor called Science, Ethics, and Society. Many other schools in the U.S. also have such interdisciplinary programs. Also notable is the major NSF-supported effort by ASCE to improve and broaden engineering education in U.S. universities.

Separation of Education and Practice

Moore: Another thing happened in this country that I think is really terrible—the separation between education and the practice of engineering. After World War II, the university groups became almost completely dependent on government-sponsored research, on NSF (National Science Foundation) and DOD (Department of Defense), etc. That provided research funding, but they usually worked on theoretical research things. While sometimes they had models that they tested and so forth, there was very little relationship with actual practice. The schools became staffed with people who were research-oriented and not practice-oriented.

Nowadays there is a great big crevice between engineering practice and engineering research in the United States, a gap that did not exist 50 years ago. My professors at Caltech were well-known as practitioners. There was R.R Martel at Caltech, and also Franklin Thomas. Over at Berkeley we had Dean Charles Derleth, R.E. Davis and Mike O'Brien, Harmer Davis, Clem Wiskocil and some others, who were either practitioners or quite active outside academic circles. And at Stanford there was Lydik Jacobsen. I can't remember the names of all of them. Nowadays, however, most professors are not practitioners. At any rate, the issue is that such research as has been going on in the United States for the last 20 years has been mostly theoretical and not application oriented. And I think this is a big problem for our country.

Using Technology Appropriately

Moore: Students are given more and more technical detail. But they also need to have some appreciation as to where and how they fit into the picture, and how they must work together with others. I think the medical profession may have done better in that regard than the engineering profession. There are a lot of specialists in medicine, but they do their work with respect for each other and their disciplines. In professions you need both the specialists and the generalists. But the specialists need to get over the idea that they are the "whole show."

Scott: Do you believe that the technical experts thinking they are the "whole show" characterizes some or maybe many in the engineering profession?

Moore: Oh, yes. Some will do all the engineering on a project without any help. Caltrans is an example of that. They have ignored what was available knowledge in the seismic field. They thought they knew better. That also comes back to the principle of peer review, which gives peers a chance to review a project and check on how well the engineer has done what they think ought to be done.

Another example of what I am talking about was the big flap I got into maybe 20 or so years ago with a geologist, who I think became State Geologist. Anyway the geologist was taking what I considered a hard line that geologists should in effect make land-use decisions on where people could live and build buildings, and what areas they should stay away from.

Scott: When I served with Dick Jahns on the Seismic Safety Commission back in the 1970s

and early 1980s, I recall him taking a position very much like yours and making similar observations, not only about some geologists but also about other experts. At the time, Jahns was dean of earth sciences at Stanford University, and a member of the Seismic Safety Commission.

Moore: I knew Dick Jahns well—he was a classmate of mine at Caltech. His position was, "The geologist should tell them what the problem is, and if they want to go ahead, they have to live with the consequences." Jahns believed the expert's role was to be sure they were well informed on the probable consequences. They should provide the best possible assessment of probable consequences, given the current state-of-the-discipline. They should point out the drawbacks of a site, and in some cases they may take a strong position in advising against a site, emphasizing their reasons. What the geologist and engineer can provide also helps clients design what they need in order to build in the location they have chosen. Sometimes these are poor locations, but after understanding the consequences, they may go ahead anyway. I think the geologist or engineer should help his client understand the situation and the consequences of actions, whether the client is a public agency or a private firm or individual. I think he should not tell him, "You can't do this." There are still plenty of geologists out there, however, who tend to want to tell people what to do.

Scott: To sum up, as I understand it you are emphasizing two contrasting models for the role of the technical person. First, you think a geologist or technical person should provide background for the concerned nontechnical people, working closely with them and advising

them. Second is a quite different and rather "hard-line" role that tends to set the technical expert apart from the others in the decision process. It would have the expert essentially *make* some key land-use and related decisions. And you think the second approach should be a thing of the past?

Moore: Yes, its time is really past. Sometimes, of course, you do have to build on very poor ground or on faults and live with the consequences.

Scott: We certainly do build across faults—look at the Alaska pipeline, for example, or closer to home, water and gas supplies to the East Bay and San Francisco. In a seismic area like this, such facilities have to cross earthquake faults.

Moore: Yes, and we tried to help the builders to design them to permit fault movement without service disruption, or with a minimum of disruption. And sometimes you really have to build buildings across faults. We have an example at the University of California in Berkeley, up in Strawberry Canyon. We designed it as two buildings, with a three-story corridor between them and coinciding with the fault. We figure the corridor is expendable, and if the fault moves, the buildings themselves will not be demolished. Anyway there are some very defensible approaches to the problem of building across faults, when you have to, complying with requirements for special studies and special measures as appropriate.

Scott: If the fault moves at that point, all they lose will be the corridor, which can easily be replaced?

Moore: That is the idea. The problem becomes more difficult, of course, in the case of

a large fault because there may be a fault zone of hundreds or maybe even thousands of feet wide, and you may not know where the next breakage could occur. Even there, it still may be possible to build structures in small units, maybe on a mat or something like that, so that the structures can function and resist being broken in two by fault movement.

Scott: I think that is pretty much the approach taken by the Alquist-Priolo Act, passed after the 1971 San Fernando earthquake. In designated active fault zones, trenching and other special studies are required to determine the geologic situation. Then whatever building is done is supposed to take account of the situation. That may mean not building at all, or proceeding only under special designs to minimize or mitigate identified hazards. Alquist-Priolo does, of course, make it more difficult and more expensive to build developments in fault zones, and some think they can overdo it on the studies required.³⁵

A Responsible Balance in Environmental Protection

Scott: You mentioned that Dames & Moore does a lot of environmental work. Environmental issues have recently come very much to the fore—water and air pollution, toxic wastes, and environmental protection generally.

35. Under the Alquist-Priolo Earthquake Fault Zoning Act, the borders of the zones are set about 660 feet (200 meters) away from major active faults and about 200 to 300 feet away from well-defined minor faults. Local governments must require developers to have specific sites within the zones evaluated to determine if a potential hazard from any fault exists with regard to proposed structures and their occupants.

Moore: Yes, those matters are very important. We need to be acutely aware of environmental pollution and the drastic impacts it can have. On the other hand, we also see environmental over-reaction. Sometimes this is now being terribly exaggerated and polarized. We end up attempting to go farther in environmental cleanup than is necessary or than can be supported by technology, pushing environmental concerns to the point of trying to eliminate all "contamination" in ways that are unrealistic. Dixy Lee Ray recently wrote an excellent book on the subject, entitled *Environmental Overkill*.³⁶

Scott: You would agree with her that our common sense has sometimes been left behind by cleanup laws and regulations?

Moore: Yes. Congress passes these stupid laws almost completely without regard to cost consequences. It is insane and won't work. I think President Clinton is getting wise to this. We have gone into some absurdities in cleaning up, say, oil-soaked dirt or ground that got some petroleum spilled on it. The idea of shipping the oil-contaminated soil away and disposing of it in some remote place—maybe a dump in Utah—is a pretty poor option. Petroleum leaks are found all over the world. They are found in the Los Angeles area in the tar pits, and they come out in the Santa Barbara channel. Those are natural seeps. I don't think our society can afford to pay for excessive cleanup.

We are in much the same fix with asbestos. Asbestos is a natural material. It exists in the

36. Ray, Dixy Lee with Lou Guzzo, *Environmental Overkill: Whatever Happened to Common Sense?* Washington, D.C. Regnery Gateway, Lanham, MD, 1993.

serpentine rock that comes from the hills around here. If you make a road cut, you get a certain amount of asbestos with it. Certainly asbestos is bad for people who breathe it, and sand it, and saw it, and work with it. Those people need to be protected. But I don't think there is any evidence at all that the use of asbestos in wallboard, paint, and such stuff will hurt anybody if it doesn't float around in the rooms involved. In fact, asbestos is fireproof, and there are probably a lot of reasons for using it. There are actually five or six different types of asbestos and many of them are not toxic. But two or three forms are toxic, and exposure to those should be avoided.

Scott: So we should be more selective and more knowledgeable in dealing with asbestos, instead of just considering it dangerous in all its forms?

Moore: Yes, I think the evidence is that the use of most types of asbestos in wall paint and so on will not hurt anybody, if it does not get loose and float around in the room, or get into the air conditioning system. But we have spent enormous amounts of money removing asbestos from buildings when it would have been better to leave it in place.

Scott: We evidently have spent a lot more on removal than common sense or scientific evidence would suggest as reasonable.

Moore: Yes, I think so. I do not believe the rest of the world is going to do what we're doing. There is not enough money to rebuild all of the buildings that have fireproof asbestos in them. Maybe they should be painted so as to contain the asbestos fibers. I don't know what should be done, but I think our reaction has

been excessive. The word for it is hysterical—it is wrong.

In fact, maybe most of the asbestos really does not need to be cleaned up, but right now nobody seems to dare mention that possibility. The school boards are in a terrible fix over asbestos. The school board members can't do anything about it but follow the regulations, otherwise they take on a personal liability, and they cannot afford to do that. Somehow, as a society we have to realize that we do not and cannot live in a risk-free world.

On the other hand, it is true that a lot of other toxic substances are produced that do have to be handled very carefully. Many pollutants can cause quite serious problems. Some of the pollutants, such as some hydrocarbons, do not go away. Some of the PCB [polychlorinated biphenyl] stuff is pretty long-lasting and doesn't go away. Some of that has to be taken care of, depending on where the pollution is. Things like some chemicals and heavy metals are clearly damaging. For example, certain kinds of pollution of drinking water and groundwater—it depends on what it is, where it is, and whether it is going anywhere. If it is in tight clay or an extensive salt deposit, which is impervious, it probably will never do any harm.

We were one of those who proposed a study near the Ohio River above Cincinnati, involving a major facility that did work on uranium for the military. It is a Department of Energy project, which is being cleaned up. There was a lot of uranium dust around. When it rained, it would carry the uranium dust down into the groundwater. It would go down to where the farms are, and there it would be pumped out

and used by people and livestock. That is not good. Somebody has to catch the uranium dust and they will have to wash down some of that. They needed to pump the contaminated water back up, treat it, clean it up, and then put it back into the ground. I do not know the precise process, but they pump the water out and run it through a treatment facility that reduces the radioactivity to nominal levels.

Scott: Dames & Moore proposed a study of the plant on the Ohio River—was the study actually done?

Moore: We did not get the job, and for a long time, they did not work on it at all. I think someone else is now doing some work on that problem, but I am not sure. It was a plant where they had in the past done a lot of work on raw uranium, which as you know, is a metal. They melted it and cut it and so forth. I think it was used primarily for atomic weapons. The plant has now been closed for years, but when I went through it you could see the dust all over the floor.

Engineering and Society

Moore: This discussion again brings up the whole relationship between engineering and the rest of society, and resolution of the conflicts between environmental desires and economic feasibility. In the last few years, an organization has been formed called the World Partnership of Engineers for Sustainable Development. Its underlying concept is that the engineers ought to be part of the solution. They can help figure out how to modify industrial processes and reduce pollutants, as well as

use some of the by-products of such processes as resources for other useful development.

I think this has to happen, because we cannot get things done any other way. We are not solving things through arbitrary regulations and rigid requirements whose enforcement has unduly adverse impacts on economic viability. The extent of governmental regulation is a real problem.

Scott: Yes, in some respects we have overshoot the mark, regulating some things in ways that aren't defensible, such forms of asbestos that are not really hazardous. But in other respects we seem to be sweeping away regulations that are necessary and beneficial. The good is being thrown out right along with the bad. There needs to be some kind of more sensible balance.

Moore: Yes. We now live in a technical world, and most things that touch our lives have an engineering component. Unfortunately, many, and perhaps most, engineers are not prepared psychologically or by training to participate in the development of public policy decisions. The process is time-consuming and frustrating. They have their views, but often are not good at discussing them with non-engineers.

We must develop the inclination and motivation among engineers and engineering groups to spend the necessary time discussing matters with non-engineers and helping find ways of achieving needed environmental development within economic feasibility. So far, this has been done in relatively few cases, but formation of the World Partnership for Sustainable Development shows a recognition of the need and the possibilities.

I guess the real problem is to find engineers and other technical people who are able and willing to spend the time and contend with the frustrations that go along with negotiations to help find solutions. Also other people, including environmental proponents, must be willing to consider alternatives that permit environmental objectives to be achieved without destroying the economic base. This is a great opportunity, and I believe that it will be realized.

Bud Carroll, who used to be a senior partner of J.M. Montgomery in Los Angeles, and Don Roberts, now with CH₂MHill, have been very active in creating the base for the World Partnership. While the organization has no money and exists only on paper, it has been endorsed by a number of national and international technical groups, including the British and American civil engineering societies, and quite a number of others. Negotiations are in process to have the organization's headquarters funded by the UN or the World Bank, and probably located in the Presidio of San Francisco.

Scott: You mentioned arbitrary and rigid regulations. But some regulation is essential for environmental protection, as well as for many other purposes. Regulations need to be realistic, however, in terms of what they are trying to accomplish.

Moore: Regulations need a sound technical basis, and have to be designed to take the economic impact into account. That means having discussions and negotiations, and arriving at acceptable solutions that are economically doable and environmentally adequate. That can only be accomplished slowly over a period of time.

Frank Rhodes, president of Cornell University, gave a paper on this after the world environmental conference in Rio de Janeiro, Brazil.³⁷ Rhodes was arguing that the consequences of environmental regulations must be reconciled with economic reality. Otherwise people will simply not do what will destroy their jobs. This is already being done to some degree, but not nearly enough, and we need more technical community participation in helping work up solutions. These undoubtedly will involve compromises in which the environmental people give some, and those concerned with economic development give some.

Scott: If you have primarily single-minded enthusiasts and advocates on both sides, and maybe free-market folk who want no regulation, it is hard to find a compromise. And an engineer who comes in with his own technical solution that he sees as the only way or the one best way, is really part of the problem, as you point out.

Moore: The engineer has to listen to the other people and help bring things together toward a workable consensus. The process requires some compromises, while keeping in mind the ultimate objective—a sustainable world.

Scott: So you need engineers who have the motivation and flexibility to engage in that kind of negotiation, plus the technical know-how to work up alternate solutions. How do we get more engineers like that?

37. Rhodes, Frank H.T., *Reflections After Rio*. Address, Technology Exchange Symposium, June 18-20, 1992, Scottsdale, Arizona, International Technology Corporation.

Moore: There are presently not enough engineers who think that way. As I noted earlier, however, some university courses do help prepare engineers for this, such as those I mentioned at Caltech and Stanford. Current ASCE efforts to broaden and strengthen engineering education should move us further along in the right direction.

Need for Tolerance and Negotiation

Moore: Often the people involved in controversial issues do not listen very well, and do not listen with tolerance for the others' views. The intolerant attitude is more common. They need to realize that they will have to work things out to find economically feasible and environmentally viable solutions.

There is now a big fuss about global warming. Right now nobody knows whether it is happening or not. But people are demanding that we shut down industries, which will put people out of work and be economically unfeasible. Some steps may be necessary over a period of years if global warming proves to be a real problem. Even then, significant warming will only happen over a period of decades and not in a year or two. We should not destroy the economy in attempting to accomplish things right away.

We ought to attempt something that is actually do-able. They say it is no use talking to a hungry man about the environment—he wants to eat. We cannot help people in the tropics and other places to reduce burning of forests and the like unless we also help them obtain other opportunities for making a living. These things can be done—they are physically do-able—but they require negotiation and compromise in developing programs that work.

That offers a great opportunity for technical people—engineers and others—to participate open-mindedly in the discussions that lead to those kinds of solutions. They need to look at the priorities of the problems. For those that are longer-term, we may have to use some of that time to develop and implement remedial programs that don't damage the economy. To do this, you need technical people who are willing and able to listen to others. Working your way through to technical and policy solutions can be a frustrating and time-consuming process.

Scott: You also need nontechnical people—the policy people and the advocates—who are willing to listen and negotiate.

Moore: Yes. We face the problem in Congress—there are people who want to repeal a lot of environmental regulations, some of which should be changed, but some of which are going to be necessary in some degree. They need to discuss and negotiate and reach solutions that are realistic in their consequences.

We need a greater willingness for the parties to discuss with open minds what can be done, what the priorities should be, what can work economically, and what the time scale ought to be. But we do not have enough good listeners who will really hear and think about what the other parties are saying. The engineers are probably as much at fault as the environmentalists in being rigid about their views.

Scott: If you listen to the other party carefully you may spot the seeds of something you both can agree on.

Moore: Too often that is missing on both sides—there is too much talking and not

enough listening. Also there is too much reliance on bad information—bad science.

Scott: And a confrontational stance, like the attorney who basically says, "Nail them."

Moore: You could argue that a lot of this confrontation comes from the attitude of the legal profession. They tend to believe in confrontation.

Scott: Adversary proceedings.

Moore: Yes, but now many attorneys are going into what is called alternate dispute resolution. That needs to happen in the development of public policies so that issues can be resolved before they get into disputes that have to be resolved in court.

On the optimistic side, I can say that I think we are better off in the U.S. than in many other countries because we have the technical abilities and knowledge to work these things out. And so far, at least, we have the potential economic resources to make them happen.

Scott: Yes, if we don't let the one-track-minded true believers on various sides swamp us.

Moore: If we do that, we will wind up as a Third World Country. I hope and do not think that will happen, but it could.

Scott: Yes it could, if we let things slide. But we do have the intelligence and resources if we can apply them.

Moore: I recall the book by Jonas Salk, *Survival of the Wisest*, published in the early 1970s [1973]. It is out of print, but I have made a few photocopies to give to people. Essentially Salk says the human race presumably has more intelligence than the other species, and it seems pos-

sible, although not certain, that the wisest people may develop to do things that promote our own survival, and not try only to be the strongest or richest or the quickest. It seems like a reasonable argument. Evolution does not go in smooth curves, it goes in jumps and spurts. There is always the struggle between the yin and the yang, the good and the bad sides.

Salk developed this along with population curves for different species. Most species start, then for a time grow fast, and then usually level off. We are still in the growth part of the curve. We have not gotten to the point where wisdom guides people not to raise kids they cannot afford, or cannot train or take care of. Or not to do things that destroy their own life base.

Environmental Impacts in Russia and Eastern Europe

Scott: Would you talk a little about your observations with respect to environmental impacts in Russia and Eastern Europe? They had authoritarian governments, but seemed to have little if any regulation.

Moore: Yes, in East Germany there are towns where zero pollution controls resulted in creating problems that have shortened life spans by years. That was the consequence of an arbitrary government that paid no attention at all to environmental problems.

Scott: Apparently, they wanted to focus on industrial production above all else.

Moore: Funds are becoming available to clean up some of those conditions in Eastern Germany, mostly because of the economic viability of Western Germany. But in countries like Russia and others in Eastern Europe, there

is no money to do it. Private money could be available if the governments were stable enough to allow private groups to make investments and get their money back over a period of years. But current political instabilities work against that. Some of those things are going to take time to work out, and patience, and skills.

The Role of Engineers' Spouses

Scott: The administrators of the oral history program at the University of California, Berkeley, have recently been recommending that all interviewees be asked to comment on the role and contributions of their spouses.

Dames & Moore: Wives Were Partners

Moore: I am very much aware of the importance and value of my wife's presence, support, and participation in all the professional activities—ASCE, the consulting engineers, EERI, FIDIC, and all the others. The key people were present with their spouses or partners at most of those activities. My wife has gone along with me to all of those, and assisted in the development of our friendships and relationships with the others. I would not have done it alone, and think it would be very difficult for a man, or for the individual professional, to accomplish some of those things by themselves. While my wife was not involved in the technical aspects of our activities, what I am talking about is somewhat different. It is the development of relationships of working with people, mutual friendships, and a sense of trust.

Scott: Relationships that go beyond the professionals dealing with each other on technical matters?

Moore: Yes. This started in Dames & Moore very early. When we were getting the partners together to discuss business, we made an explicit decision that the wives were partners in the business. They are partners both legally and in fact. They were part owners.

Scott: You and your partners at Dames & Moore made an early conscious decision that you wanted the wives to be active participants in partnership meetings and related activities?

Moore: Yes, and to participate in the development of relationships among the partners and of mutual confidence and respect.

Deductibility of Wives' Expenses

Moore: We got into an argument with the Internal Revenue Service, probably in the 1950s or maybe the 1960s, when IRS said that the wives' expenses attending partnership meetings were not deductible. We took them to court on that question, and they backed down. Up to that time, we had not kept a specific record of wives' activities at partnership business meetings. Our attorneys advised us to start keeping such records, to pay something, and to sue for recovery. IRS made a reasonable settlement, and never raised the question again.

Most companies, however, do not do it our way. They either do not invite wives at all, or if they come, require that the wives' expenses be paid from personal funds, not company funds.

Scott: That case and the settlement are very interesting—would you say a little more about the matter?

Moore: Our attorneys advised us to go ahead and pay the full amount of the tax IRS

was insisting we pay, and then to sue IRS for recovery, suing in the U.S. District Court—not in the Tax Court. So we did that, arguing that the participation of our wives was important to our consulting business and its success.

Part of the IRS argument was that when wives' attended the place where our business meetings were held, the wives would actually be engaged in other things, such as shopping and that kind of thing. Of course, if the wives just go shopping in Scottsdale, that is not a deductible expense. But they participated in some of the technical sessions and business sessions. Our attorneys advised us to keep a record showing what the wives' participation consisted of, and we kept such a record. We had programs in which the wives were brought together to discuss all the aspects of what it means to run an engineering business.

We argued before the court that this was an important part of our business. We always documented those activities, viewing them as constructive participation in the business operations of our firm. We maintained and still maintain that the wives participate in the communication that takes place, they participate in the business planning and business discussion, are involved in relationships within the firm, and are active and interested in the business operation. My wife, for example, has participated in things involving clients, and ASCE and FIDIC. So we maintained that as actual participants, their expenses were legitimate business expenses.

Before the court rendered a decision, IRS made a settlement with us. I think they did this because they did not want the record to show an adverse decision. So they in effect settled on the

courthouse steps. Thereafter IRS did not contest it when we turned in the wives' expenses. Up until we incorporated, we continued the practice of wives' attending business meetings, we had the wives keep track of their time, etc., and we turned in their expenses. IRS never challenged us again—since the settlement, they have not again raised the issue with us.

Scott: So Dames & Moore's documentation and civil suit got this arrangement accepted by IRS a long time ago—maybe 30 years ago—and you have been doing it that way ever since?

Moore: Yes. In my opinion, IRS settled with us because they did not want a decision against them on the record. That way the settlement applied only to us. But if that was the right answer for us, it seems to me it would have been for others as well.

The "Femineers"

Moore: Anyway, for many years we kept a record of what the wives did, not only at Dames & Moore partnership meetings, but also at ASCE, FIDIC, and other such meetings. If they went on shopping expeditions, that did not count. But if they were associating with the other people who were involved in that enterprise—that did not necessarily have to take place at the technical sessions. At those professional gatherings, meetings were set up especially for the wives to help them understand what was going on.

Scott: While these meetings may not have been on technical subjects, they were related to the profession in some way?

Moore: Yes, and those activities are very important. There is an organization called the

"Femineers," which is still functioning. My wife has been active in that for many years, and in fact we went to one of their annual parties this year. I think in the case of most people recognized as leaders in their profession, you will find that their wives have played a similar role.

The following anecdote is not directly on this point, but is relevant. I was president of ACEC, and the new president coming in was Stan Fosholt. We were seated at the head table, and he was next to my wife. When he was introduced he seemed a little flustered. My wife looked down and saw that his cummerbund was on the floor. He wasn't quite sure what had come off. We still laugh about that incident when we get together. The point of this is that you develop relationships that involve both business and personal things.

It was just a small incident, but illustrates how we develop those friendships that involve both our business and the more personal side of things. If you and your wife get personally acquainted with other professionals and their wives, you develop an intimacy of relationships that can go a long way toward ironing out the problems that inevitably occur among professionals. All kinds of problems, such as recognition of people, budgets, expenses, etc. Those can be settled if you come in with the intention of working something out, and not by bulling your way through.

Scott: Having developed those relationships, you are able to deal with the other professionals as friends—people with whom you share some in-depth understanding and camaraderie—is that what you mean? And the associa-

tion of both professionals and their wives or spouses plays an important role in that?

Moore: Yes. It is more difficult to do that by yourself.

Wives' Participation in Other Countries

Moore: In other countries—in FIDIC's operation—you find that almost all of them are there with their wives. We still have dozens of friends throughout the world—England, Australia, South Africa, Japan, Sweden, Norway, etc. Having those relationships with people, if a problem comes up, you can call them on the phone and get a square answer.

Scott: You are saying that the spouses' active participation in this way is almost universal, pretty much worldwide, at least among those you associated with?

Moore: Yes, I think this country is about the only one where it is not universal, and mostly because of the restrictive attitude of our tax people.

Conflict Resolution: Other Sides to An Issue

Moore: I think what former U.S. President Jimmy Carter seems to have brought to several international confrontations helps me sum it up. He recognized that people on the other side also had a point, and thereby helped change things from a confrontation to an effort to figure out what to do. I think the confrontational attitude has been developed to a high degree in the United States—mostly by lawyers. In other countries they do not want to go to court and fight. Instead they tend to want to figure out how to resolve the issues and solve the problem otherwise.

I think that philosophy is beginning to be accepted in this country, with the development of programs such as those called "alternate dispute resolution." They have found that going to court is expensive, time-consuming, unproductive, and does not work very well. The conflict-resolution approach also relates to developing relationships of mutual trust and respect. Given such relationships, when a problem occurs, the parties can work it out among themselves.

Scott: Those relationships facilitate the resolution of conflicts, without confrontation, antagonism, and litigation?

Moore: Yes. That way they can work things out amicably. You might think that most lawyers won't understand this, but actually there are some law firms that are putting a major part of their emphasis on the resolution of lawsuits without going to court. They are realizing that the system of litigation and going to court to resolve problems is not very productive.

Scott: Of course, the trial lawyers may be the last ones to recognize this, since their bread and butter is in going to court.

Moore: Yes, the trial lawyers will be the last ones to find out. But I do not have much sympathy for them.

A Special Sensitivity: Picking Up the Clues

Moore: While my discussion of the past few minutes may sound like I am wandering, it all kind of ties together. It emphasizes why the issue of the spouses' contribution, the women's contribution, is quite important and appropriate for inclusion here.

Scott: Would you describe your own wife's role in a little more detail?

Moore: She has a sensibility about the reactions of other people that I do not have. I find that nine times out of ten, she is right in these evaluations.

Scott: You mean she senses how they are reacting to the discussion or to what is going on?

Moore: Yes. It is not so much in what they say, but a sensitivity to their attitudes. I don't think she understands how it works, but it works. I call it "woman's ignition." I suppose it is a combination of observing facial expressions, body language, tone of voice, and all kinds of clues that she seems to pick up. These are the kinds of signals that most engineers do not pick up, because they are trying to think about all the so-called facts. Yet business and professional relationships boil down to personal relations. This business of having everything organized and structured, so somebody in this position talks to somebody in that position, really doesn't work well. That is where the Japanese have been way ahead of us. They place personal relationships at a very high level of priority. They do not try to play those down in favor of the "objective," "technical" side of things.

Scott: You mean the Japanese seem to want to develop personal relationships before getting down to business, or as an initial part of doing business?

Moore: Yes, that is why it takes so long to do business there. And then we come in with all that stuff about wanting them to open up their markets. Things just don't work that way. The competitive bid idea is just bad business, any-

way. It produces more lawsuits than anything else. Going for the competitive bid and the low price just manufactures lawsuits.

It All Ties Together: Communication and Sensitivity

Moore: This all ties together. Most engineers, and men in particular, can be pretty insensitive to that kind of communication. They have had it beat out of them in school. The women, however, have their feelings. Women tend to be sensitive to impressions, feelings and non-verbal communication. I have found that I had better pay attention to those. They can be highly relevant to the success of what you are trying to do. You need the facts and the technical engineering, but you also need the sensitivity to the human side of it.

An Illustrative Example

Moore: Dames & Moore once had a sales consultant named Harry Swift. I got acquainted with him through the San Francisco Sales Executive Club. At one of our group meetings of Dames & Moore people, he had this to say:

Look, you will go down and meet this fellow with such-and-such a company, and have an appointment with him Friday morning. You figure on going to his office and selling this job. It is a big job and there is a lot of money in it, and you really want to make the sale. So you are driving over to meet him, thinking about how much money you will make out of the job. If that is

the case, you should stop at a service station, call the guy up and say you have a sick headache and just can't make it today. Then when you get yourself into a frame of mind where you are thinking about how much he gets out of the job, not how much you will make, go talk to him. Otherwise as you go through your spiel and show him the exhibits, he won't hear what you are saying, he'll hear what you are thinking.

I have found what Harry Swift said to be true. If you give your prospective client a standard pitch, he won't hear it. For some reason he will understand what you are thinking in the back of your mind—how much money you will make from the job. Swift had other things to say, such as not to sell somebody something they are going to be unhappy about. If they are unhappy with what you have sold them and dissatisfied with the results, you have made a mistake. What you sell to a person should fit their needs. If you do not understand what the client needs, you'd better not sell something to him. In developing business relationships, one of the most difficult things to do is really to understand what the client needs. Salesmen who don't really understand their clients' needs are not likely to last. But the best sales people do understand.

Scott: How do you achieve that kind of awareness?

Moore: You have to develop a mutual confidence with the client's representatives so they will loosen up and tell you what is on their minds. Find out what is really bothering

them—is it getting the project done so it will work, or so it will last, or is it saving money? Find out what is high in their values for that particular project.

Understanding Clients' Real Needs

Scott: You need to establish the kind of relationship with them where you can "sit down and talk turkey"?

Moore: Yes. You cannot do that with a brochure. You have to sit down with them and find out what is on their minds. Get them to open up, and then listen to what they say. Instead of listening, most people are thinking about what they themselves are going to say next.

Scott: You can get so busy thinking about what to say next that you can miss key things the guy is trying to tell you, or overlook revealing nonverbal clues.

Moore: Yes, thinking, "How am I going to counter what he is saying?" If you take that approach, you are going to get beat. You may make that particular sale, but not listening well may cost you ten other prospective sales later on. The only customer worth having is one who is satisfied enough with the job you did that he will be a good salesman for your services when he talks to his colleagues. If he is happy with your work, he will recommend you to his friends. If he is unhappy, he is going to kill you in the future.

Scott: Word-of-mouth recommendations from friends and colleagues are the best and most trusted kind of advertising.

Moore: Yes. We have our priorities somewhat screwed up in this country when we focus

on all the computer printouts on profit margins and numbers like that, but leave out the human relations part of it. When you do that, you may make it temporarily, but not very long. I really feel very strongly on these issues.

Scott: Some of the non-memo kind of communication can also help illuminate things the technical people need to think about when they plan their work, and may help decide which processes are most likely to be successful and to leave the client happy with the results.

Moore: Probably one essential vehicle is the technical people getting their minds opened up, so they clearly understand what their clients' *real* problems are. In explaining a proposal, the engineer often concentrates so much on what he is going to do technically that he does not really figure out what the client's worries are. Probably the most common failure is starting to design the project before really understanding the client's problem.

Scott: So an engineer who is a good person and means well, and is also technically very proficient, can nevertheless get into trouble by misunderstanding or ignoring significant aspects of the situation?

Moore: Yes, and people can get confused on this. I have heard engineers—including Dames & Moore people—say, "Oh well, we can't just give the clients whatever they want to hear."

Scott: A remark like that almost dismisses some of the client's concerns. It seems much too simplistic an approach to what may be a rather complicated situation.

Moore: Of course it is too simplistic. If you want to understand what the client's *real* prob-

lems are, you had better listen carefully and have them explain their problems as they see them. Also, many times clients may not fully grasp what their real problems are, or do not know how to tell you about them.

You have to work closely with the client and draw them out. You need to ask good questions as you go along, which means that in the process you need to be sensitive and to do some critical thinking. You also must have an attitude of being willing to learn something. You are not there just to tell them what you are going to do. That is probably the most damaging attitude of all—thinking that your role is just to tell them what you are going to do.

Finding Good Answers

Scott: Actually, much of what you have been saying really applies generally, to most any kind of professional who deals with clients and clients' problems.

Moore: Yes. Real communication with the client is what is needed. One big problem with engineers is terminology and jargon—use of language the client does not understand. Engineers need to discuss things in ways the clients can understand, and use the information to find good answers and defensible answers to the problems their clients have.

I will repeat briefly an example from my own learning experience. We were doing work for oil companies, figuring out how to build storage tanks in swampy areas without using piles. The oil companies loved this, as it saved them a lot of money, maybe \$100,000 per tank, because they did not have to put in pilings.

I was talking to PG&E on the basis of our experience with the oil companies. I explained that we could save them quite a bit of money on some tank foundations to be built up near Antioch, here in the Bay Area. We would put in compacted fills and float the tanks on them. I explained how it had worked, was not dangerous, and would save all this money on the piles. I was getting nowhere with this, however, and finally just got a blank stare from the PG&E man.

I said, "You don't seem to understand what I have been saying." He said, "If we put the tanks on the fills, and they settle a foot or so and have to be jacked up, who pays for that? Do you pay?" I said, "Of course not, you saved the money by doing it that way without the piles." He said, "I don't think I like that." I asked, "Why not?" This is what he told me. "If we put piles in, that expense goes into our cost basis and we are allowed to earn 8 percent on it."

Scott: Oh, and then the light went on for you. You saw why their thinking was so different from that of the oil companies?

Moore: Yes. So I said, "OK, we will put in piles, you will spend more money, and it will go into your cost basis." They were operating under accounting and pricing rules set by the utility commission. My lack of understanding of the costing system had led me to recommend something the utility company found unacceptable. But the oil companies were operating under entirely different cost and tax rules, so money they saved on piles was a direct gain for them. That is an example of how tax and rating policies can influence engineering decisions.

Scott: That's a good illustration of the importance of nontechnical considerations to the realities of engineering practice.

Moore: It is a simple and clear-cut example of what I am talking about—some others are not that clear. Clients' problems have all kinds of gradations and shades of variation. That is what the practicing engineer must understand.

One of my projects for 1995 was more work on recognizing the importance of sensitivity to and awareness of the clients' needs, as well as sensitivity to people in general. The idea was to have meetings with some Dames & Moore local managers, and with some select members of the staff, the practicing engineers, geologists, etc., the idea being to explain and emphasize the importance of communicating with their clients, using all the resources available, including what their wives are able to contribute.

While a health setback meant that I pretty well had to put this effort on the shelf, Henry Klehn of the Los Angeles office has been working on a firm-wide approach to improving relations with special "good" clients. You have to be selective about the clients, as there is not enough time to consider all of them.³⁸

Scott: Have you found managers and staff members receptive to this idea?

Moore: Some are interested, but some others do not see it, finding it foreign to what they

are used to. More and more people, however, are beginning to recognize that communication means a good deal more than what is written in a memo. They see that you really need personal communication—what I call "eyeball" communication—but a lot of people still do not realize how much time, effort and attention it takes to understand a client's concerns really well.

Reading for Public Policy

Scott: I would like to ask you about the considerable reading you seem to do. Many of your observations, as well as the variety of publications I see on your desk, suggest that you read a lot of different kinds of things, and not only things related to engineering practice as such. For example I have particularly noticed current issues of *Science*, the journal of the American Association for the Advancement of Science. I'm intrigued, because you do not see it on everybody's desk.

Moore: I look at the table of contents of *Science* for articles that seem to have a public policy angle.

Scott: You also seem to have quite a few other such publications coming across your desk regularly. And in our interviews you have mentioned books by such authors as Edwards Deming, Amatai Etzioni and Dixy Lee Ray.

Moore: Yes, I have publications coming in regularly. It bothers my wife and she wants me to throw them away, but I put them in the pile and won't throw them out until I have looked at them. I look for things that are in technical fields primarily, and that I think should have an impact on public policy.

38. Dames & Moore has a Major Client Program, which involves developing closer contacts with the firm's top 20 clients—mostly U.S. and European multinational corporations. Account managers are encouraged to cultivate client relationships, promote communication between Dames & Moore staff and clients' personnel, and anticipate clients' long-term needs.

Scott: When did you start doing this kind of reading? Have you done it during most of your career, or only more recently?

Moore: I don't think I started this very seriously until I had finished with the FIDIC operation. My interest got piqued when I began to encounter things like Dixy Lee Ray's books and the Frank Rhodes speech that I mentioned. I realized that there was such a conflict between public policy on one hand, and what is actually known technically on the other. It has become almost an obsession with me. I see so much that I know is questionable, or that we do not know much about. Things like global warming and ozone holes, or asbestos. My interest probably picked up around 1990 or 1991, when I started getting things like Dixie Lee Ray's books.

Scott: Were you already a fairly wide reader of things back before that?

Moore: Probably not. I was more interested in the engineering profession and the consulting profession as such. In things related to the profession and the practice.

Scott: So the broader reading interest is fairly recent?

Moore: I'd say pretty much within the last ten years, although I have probably subscribed to *Science* for more than ten years. I may have had this kind of interest earlier, but did not have the time to do the reading.

Scott: You also appear to send copies of things that interest you to quite a few friends and colleagues.

Moore: You are right, I do mark things up and send them along to colleagues in the office and to some other people.

Scott: What kind of response do you get?

Moore: The response varies—some are interested and some are not.

Summary and Conclusion—The Policy Side of Engineering

Scott: This all seems to fit in with your highlighting the nontechnical side of engineering, and the need for sensitivity, communication, and conflict resolution.

Moore: Yes. I think there is a major theme running through this whole subject. In engineering, to accomplish the results you want, things have to be done in a way that takes account of human relationships, of economic and political relationships, and of policy issues. Those have to be considered along with the technical side of things.

It is very important to recognize the significance of the nontechnical aspects of a problem. That is essential, if you are going to achieve the kinds of things I have tried to do, and that other engineers—civil, structural and what have you—have tried to do. In doing that effectively, you have to take advantage of many sources of information, including the kinds of nonverbal communication that I mentioned earlier. That kind of thing is important to the results of any kind of technical endeavor. And you have to recognize that different people have different priorities. I mentioned that in discussing client development and the need to understand their interests and purposes. In dealing with regulations, you need to understand what the effects on people will be. You have to be aware of the human reactions—I do

not know how to say it better. You will not be successful if you do not deal with those things.

Scott: You also seem to be saying that the professional practicing engineer must himself be directly involved in these processes. The engineer should not just sit on the sidelines and let others work through the political, economic, social and human issues. Engineers need the direct involvement in order to develop some sensitivity to people's concerns—is that what you think?

Moore: Yes, that is correct. I have always thought the engineer should be involved with the larger society. To be useful and recognized, and to use the knowledge he has, the engineer must learn how to participate in a constructive way. He must have clearly in mind the effects of what he is recommending on other people, and that is possible only if the engineer is directly involved with some of the other people in some of the organizations and the mechanisms they use to try to come to grips with the issues. This is of course true in regulations for seismic safety, but it is also true of many other kinds of regulations and other decisions. Factors other than the technical ones will tend to govern—the feelings of people and their reactions to proposals. It is very necessary to be tuned-in to understanding the needs of the people involved, however they are expressed. Sticking to a single "engineering" point of view is not the way to do it.

Scott: To be really effective, the engineer must bring a little of this broader mentality and understanding to his technical work back in the office?

Moore: Yes, if he wants to be effective, and also to be appreciated. Engineers are often crying because they think they are not appreciated. When that is true, maybe it is because they don't appreciate other people.

Scott: We all have to work together to get something done. And basically the engineer's objective is to get something done.

Moore: The objective should be to help people improve their lives. The engineer must be realistic in thinking, and appreciative of the fact that other people may have different views that ought to be considered when things are done.

Scott: That gets back to the matter of conflict-resolution that you mentioned earlier. The engineer needs to play a role, and not just as a hard-nosed technical adviser mostly on the sidelines.

Moore: The engineer who decides to stay out of those discussions will be reduced to a non-participant in the key decisions. And that is not good for anybody—either the engineers, or the society.

Scott: That's very true, especially because the engineer has certain kinds of insights that can be invaluable to such discussions. Those insights need to be expressed as part of the policy discussions and dialogue.

Moore: That's right. The engineer should be part of the discussion and part of the solution. If the engineering profession wants to be effective in what is supposed to be the profession's purpose, they have to be aware of and participate in other things besides their technical work. It all sort of makes a circle.

Scott: Yes, and it is important to the profession that the circle be completed, but engineering schools seem to find it hard to allocate much time or attention to that kind of thing.

Moore: They have mostly avoided it, principally because they are not staffed with people who are sensitive to those matters. Some engineers are, but there have not been very many of them in a teaching role in recent years. Not like some of my professors at Caltech in the 1930s, and some of the ones at Berkeley back then, who were aware of this. But the recent very heavy emphasis on research in the engineering schools has tended to work against the development of that kind of appreciation on the part of the students. In any event, in engineering education, you could say that engineers are almost trained to ignore their feelings. They feel they have to be "factual."

We have more information than we know what to do with, but have not looked at the priorities and the values we ought to promote. Fortunately, some of the schools are coming back to look at that. Earlier, I mentioned the interdisciplinary programs under generic titles like Science, Technology and Society. If you look at that, you have to look at the relationships with

people—with different individuals and different groups of people.

Obviously, you need the good technical training, but you also need to produce people who can look beyond the technical side of things. The people who are in the technical specialties must also be taught an appreciation for something else besides that. I think this offers a great opportunity for the engineers to participate in society more actively. They, of course, do participate right now. We live in a highly technical world, yet people many times do not realize how much they depend on technology.

In order to be effective, the technical people and the engineers must be a part of the rest of the world. I think it will happen, and it should be a really exciting happening. The engineer wants to contribute, but must do it as a participant and not as somebody standing aside, saying, "Oh, I do not have time for political things." Those who stand aside from the policy discussions will be relegated to the role of technical assistant.

Earthquake-Related Activities

Just having engineers decide what other people should do does not work very well.

Scott: As you know, earthquake engineering is a major focus of these oral history interviews. In talking about the early days, you have already made it clear that from the outset, seismic concerns figured prominently in your thinking and your practice. Would you now discuss your earthquake-related work in more detail?

Seismic Concerns in Our Practice

Moore: Yes, I noted earlier the importance of the 1933 Field Act, and the fact that earthquake concerns were central in designing or strengthening public schools. That, of course, also applied to our foundation work. I also mentioned working on the Coast and Geodetic Survey earthquake program in one of my very first jobs, predating Dames & Moore. Furthermore, I indicated previously that seismic considerations almost always figured in our own practice, right from the firm's beginning. Our work involved the dynamic behavior of foundations and soils, including behavior under seismic forces. So we got into earthquake engineering early on. ASCE had many sessions on earthquake-resistant design, and of course our

interest in seismic matters led to our participation in EERI.

We had early contacts with some key academic leaders in earthquake and seismic studies, and had good communications with researchers at Caltech, Berkeley, and Stanford. I mentioned earlier the work done on *Separate 66*, and a little later on the *Blue Book*. The successive issues of the *Blue Book* by the Structural Engineers Association of California have been a major influence on seismic design in this country and elsewhere.

Earthquake Engineering Research Institute (EERI)

Moore: Even before EERI, Professor R.R. Martel at Caltech, Lydik Jacobsen at Stanford, and others, such as Perry Byerly, a seismologist at Berkeley, were leaders in trying to promote earthquake engineering.³⁹ So Caltech, Stanford, and Berkeley were all involved in the development of approaches to seismically resistant design.

EERI itself was started around 1949, with perhaps ten and certainly not more than twenty people involved. They were people who were

interested in promoting earthquake-resistant design, and who donated their own time. EERI was formed to encourage and support research relating specifically to the engineering aspects of seismic safety and seismically resistant design. Engineers needed to know more about what was really happening to foundations and structures in earthquakes. They were not concerned with seismological problems as such, but specifically with engineering problems caused by strong earthquake motion.

The seismologists had long had very sensitive instruments to record motion from distant earthquakes around the world, but those instruments could not record anything if the earthquake hit locally. Those instruments could not record the kind of strong motions that affect buildings, and about which the engineers needed to know a great deal more. Entirely different instruments had to be designed and put out in places where earthquakes were likely to occur in order to capture such strong motion records. The Coast and Geodetic Survey's program to develop and install such instruments and begin keeping records had been started in the early 1930s, but was always in need of more instruments to capture earthquake records.

Scott: Yes. I believe EERI's formation was in fact something of an outgrowth of a committee that the Survey had created two or three years previously to advise on the strong motion program, and to serve as a sounding board and support group. The Survey wanted to involve some key knowledgeable people from the western seismic area who were sensitive to the needs for more information.

39. Perry Byerly, a seismologist, was a leader in helping advance earthquake awareness and the need for effective earthquake knowledge for building design. At the time EERI was formed, however, there apparently was no Berkeley earthquake engineering "star" of equivalent rank to Martel or Jacobsen. For a time at the beginning of EERI, U.C. Berkeley was represented by Harmer Davis, who promptly brought in the newly arrived Ray Clough to represent engineering at Berkeley. Davis, a civil engineer, went on to become first and long-term director of the U.C. Berkeley Institute of Transportation and Traffic Engineering, now called Institute of Transportation Studies.

Moore: I think that is right, and the advisory committee evolved into EERI. Anyway, at the time EERI was formed there were a few strong motion records of earthquakes, but not many. So one of EERI's main functions at first was their collaboration with the Survey in promoting its program to put out more strong motion instruments, distributed more widely, to record the strong motions of future earthquakes. EERI offered verbal and moral support to research and development for the strong motion program at the U.S. Coast and Geodetic Survey. EERI also supported work at Caltech and Stanford and so forth.

My Activities

Moore: Anyway, back in 1947 I had become president of the Structural Engineers Association of California (SEAOC). So for some time I had been dealing with the structural engineers quite a bit, and in due course was invited to become a member of EERI. That was a period when EERI membership was by invitation, and I became a member of EERI about ten years after it was formed.

Scott: According to the *EERI Membership Roster*, you became a member in 1960.

Moore: I participated in the First World Conference on Earthquake Engineering, held in Berkeley in 1956. I had a paper that was given in that 1956 program and appeared in the proceedings.⁴⁰

EERI grew very slowly for quite a while, and as I said, for many years membership was by invitation. They did not want to bring in a lot of people who might be trying to promote their own interests, say trying to sell steel, or

cement, or whatever. They wanted people who were interested in the gathering of knowledge that would help with earthquake engineering.

In EERI annual meetings and in board meetings I remember long discussions about membership policy and possibly opening it up to anybody who wanted to join, participate and pay their dues. Opening up the membership was really a drastic change for EERI, and no doubt a good one, because it was when EERI really began to grow. The change began to bring in a lot of new people who were interested in seismically resistant engineering, but who were not necessarily engineers themselves. This included the strength-of-materials people, and other kinds of engineers, including those in public service and so forth.

The Learning From Earthquakes Program

Moore: Earlier I mentioned Henry Degenkolb's oral history interviews, which referred to an EERI program called Learning From Earthquakes. This kind of learning is extremely important. Back before the Coast and Geodetic Survey began getting some instrumental recordings of earthquake motion, all that could be done was to look at buildings that had suffered earthquake damage, and those that did not, and try to deduce what happened from the observed building behavior.

40. Moore, William W. and Robert D. Darragh, "Some Considerations in the Design of Foundations for Earthquakes," *Proceedings of World Conference on Earthquake Engineering*, EERI, 1956. (When the 1956 conference was held it was not yet known that it was the "first world conference," although in retrospect it clearly was, and has been called that since.)

Young engineers who know how to operate a computer and how to make a computer analysis may tend too often to believe their answers and take them at face value. But all computer analysis is based on many assumptions and many simplifications. To make sure that the results of computer analyses are really applicable, they need to be verified by comparing with real-life situations. That kind of world-wide activity and actual observation of earthquake effects is extremely important.

Theoretical and computer analysis needs to be compared with observations of the performance of real structures to determine whether the assumptions and simplifications are applicable. Such verification is essential through comparison with observations. I think this is really the basis of the earthquake site visits that Henry Degenkolb practiced, and of EERI's Learning From Earthquakes program that he promoted so vigorously. The goal of "earthquake chasing" and Learning From Earthquakes was to find out what happened to structures in an actual earthquake. EERI's Learning From Earthquakes is part of a world-wide effort to do such verification by looking at the structural behavior observed in actual earthquakes.

A Sketch of Some Major Developments

Moore: Many of us have observed and commented on how action on earthquake concerns and earthquake-related activities tend to follow the occurrence of major earthquakes. For instance, after the World War II and in the 1950s there wasn't a lot of earthquake activity. There was the Daly City earthquake in 1957, a relatively small earthquake (5.3 magnitude).

The first big postwar earthquake in this country was the Alaska earthquake in 1964 (8-plus magnitude). That earthquake really triggered a lot of activity.

Alquist Committee: A Real Landmark

Moore: In 1969 the state legislature appointed a committee, Senator Alfred Alquist's legislative committee.⁴¹ The Alquist Committee was a legislative response to earthquakes. It set up subcommittees, one of which had a bunch of engineers and others. I was on that subcommittee or advisory group.

That committee triggered a good deal of thinking about how to handle the earthquake safety problem. At first they just wanted to make things *safe*—just use bigger lateral force requirements, and everything would be "safe." But that gets you into economic problems, and just won't work. You would have to build houses designed like solid blocks of concrete with only a few holes through them.

I think it took about two years of work between the engineers and legislators to reach an understanding that you couldn't have perfect safety. Finally, this effort created a real landmark, in that it was finally agreed to in public policy—agreed to by the Alquist committee at least—that there needed to be different standards of safety. You needed higher standards of safety for so-called essential facilities like hospitals, fire protection facilities, police and so on.

41. The Advisory Group on Engineering Considerations and Earthquake Sciences was one of five advisory groups serving the Joint Committee on Seismic Safety. The Joint Committee, with State Senator Alfred E. Alquist as chairman, was formed in 1969 and was active until 1975.

A "normal" standard of safety is appropriate for buildings, stores, apartments, and other dwellings. Possibly still lower standards of safety are acceptable for some industrial facilities such as waterfront and harbor facilities, where the exposure of people is less, and where the costs of a high margin of safety would be prohibitive or not even feasible. By necessity you take great risks with harbors or port facilities, which have to be built near the water, where soil conditions are usually poor. You accept and work with the high risk that goes with such a location.

Legislation can, of course, attempt to prohibit or regulate building. An example is building on or near faults designated as active. As I mentioned earlier, that comes under the Alquist-Priolo legislation regulating building in zones surrounding designated active faults. But I think it is not realistic to impose arbitrary legislation or regulations to prohibit *all* building across faults.

Scott: California does require geologic studies to precede any significant building in designated fault zones.

Moore: Geologic studies certainly should be done before any building in active fault zones to consider and evaluate the potential dangers. My point is that in some circumstances it may be necessary to build buildings over active faults—and if adequate attention is given to the fault problem and the structure, that can be done without hazard to the occupants. I have already mentioned the structure at U.C. Berkeley that Dames & Moore designed so it could be built in two parts with an expendable corridor connecting the parts across the fault's location.

Scott: With utility and transportation arteries sometimes there is no choice but building directly across faults.

Moore: Yes, they should design the facilities as best they can to accept deformation across the fault, or to minimize the consequences of breakage should it occur.

Other Follow-Through: Federal Legislation and FEMA

Moore: There has been other follow-through on this subject. The national Earthquake Hazards Reduction Act was passed in 1977, and under that program a lot of work has been done by teams of the Federal Emergency Management Agency (FEMA) in developing and promoting criteria for improved seismic safety, not only here, but elsewhere around the country. I have been up to my ears in that. For fifteen or so years I have been involved in the growing interest in seismic safety. This growing interest helped stimulate the structural engineers to create the Applied Technology Council (ATC), which was set up by the Structural Engineers Association of California (SEAOC).

Under NEHRP, the National Earthquake Hazards Reduction Program, and working with the Applied Technology Council and the Building Seismic Safety Council (BSSC), FEMA has proposed different levels of safety for different types of facilities and criteria that can be used by anybody in the United States. It is not a recommended code, but a set of criteria on how to deal with earthquake risk. People using the criteria can decide on how much risk they want to take, and decide accordingly. Some of the NEHRP seismic procedures have been modified slightly into language that can be used in

codes, and by the early 1990s, some of those provisions were being adopted in some locations in the midwest and east.

Applied Technology Council (ATC): Keeping up With Research

Scott: You mentioned ATC, an important topic in its own right.

Moore: The idea was to bring people from places other than California and the western United States into the drafting process for code-related seismic design recommendations. Previously, this had been handled primarily through the *Blue Book*, which was prepared and published by SEAOC, which represents California engineers. Anyway, ATC has since been doing a whole series of earthquake studies. They're mostly funded by FEMA and the National Science Foundation (NSF). They're now making studies of earthquake safety for lifelines—transportation, water, sewers, etc.

Scott: Would you give a little background on how ATC was established and why, as well as something about its experience?

Moore: Yes. There was a high level of public interest in making buildings safe, so there was interest in writing new codes that would—with luck—make them safe. Improved seismic design interested lots of people, from university researchers to state agencies and federal government bureaus. The people involved in the building business were concerned—not only the engineers, but also the contractors, investors, finance people, and so on. One primary purpose of ATC was to speed up and facilitate the process of translating research results into actual structural engineering practice.⁴²

ATC was intended to provide participation, and was set up to help provide a reliable technical basis for writing codes. But ATC was not intended to write an actual code itself. It was to provide up-to-date information and commentary that could then be used by engineers and by code-writing authorities. It was intended to provide credible, responsible reference data and other information that could be used in preparing codes. But actual code preparation was to be left to code-writing authorities, such as the International Conference of Building Officials (ICBO) and the others like it, as well as the local code-adopting authorities.

Some argued that we should have a national code, but the idea was never accepted by groups like ATC, SEAOC, and BSSC. It is

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42. The Applied Technology Council (ATC) is a nonprofit, tax-exempt corporation established in 1971 through the efforts of the Structural Engineers Association of California. ATC was set up to facilitate SEAOC's efforts in code development and technology transfer beyond that possible with volunteer efforts. ATC assists design practitioners and others in keeping up with technological developments in structural engineering and related fields. ATC is guided by a board of twelve directors, consisting of representatives appointed by SEAOC, the Western States Council of Structural Engineers Associations, and ASCE, plus two at-large representatives (from outside California) concerned with the practice of structural engineering. ATC's first major project was ATC 3-06, *Tentative Provisions for the Development of Seismic Regulations of Buildings* (1978), which provided sound technical guidance for developing seismic safety regulations appropriate for state, regional, and local conditions. The document advanced the state of the art considerably and developed a new format for seismic provisions. ATC organizes and implements research, code development, and technology transfer projects with funding from NSF, FEMA, USGS, the State of California and others.

important to recognize that writing a code is a more specific kind of activity, which produces a legal document enforced by law. That was not the purpose of FEMA, ATC, or BSSC. I think they felt it would not be practical, feasible or maybe even acceptable to try to develop a national code. But the question of a national code got quite a lot of discussion in connection with the work of FEMA, ATC, and BSSC. They always wanted to avoid having their efforts interpreted as trying to produce a national code.

Scott: At the same time, I believe they have produced language that can be lifted and inserted into a code almost verbatim. Nevertheless there is a real difference between providing such language, and adopting it in a building regulation or ordinance.

Moore: Yes. Roland Sharpe is very much aware of that intended difference, and might have some suggestions.⁴³

Prime Movers in ATC

Scott: Who started ATC?

Moore: The Structural Engineers Association of California (SEAOC) was the prime mover and official sponsor of ATC's formation. Roland Sharpe, who used to be John Blume's partner, was one of the prime movers of ATC. In the early days he was executive director of ATC. There was also Steve Johnston, a struc-

tural engineer who was with Skidmore, Owings and Merrill at one time, and a SEAOC president, and who along with several others sponsored this development. I think SEAOC actually paid for setting up the corporate form of ATC.⁴⁴ I actually became the first president of ATC, which was an all-engineering organization—largely made up of structural and other earthquake engineers, and maybe had a few seismologists.

Trying For a Technical Balance

Moore: An ATC publication that is famous—or notorious, as you will—is called ATC 3-06. ATC 3-06 is one of the best references I know of on the rationale and thinking on earthquake-resistant design. It includes all of the viewpoints, and is kind of cumbersome, but also covers the concept of different levels of safety. I participated in working on some of the early drafts of it.

Scott: Describe the ATC drafting process.

Moore: We had a board of directors that comprised representatives of the structural engineers associations—not only from California, but also Oregon, Washington and Arizona, I think it was. Then a special effort was made in the committee studies of the projects and so forth to involve all the people who knew anything about the issue. It definitely wasn't going to be dominated by Berkeley or Caltech, or by California. The others were there to get a balance of people involved.

Scott: When they set up ATC, they were in part trying for a balance?

43. ATC-3-06, and later NEHRP provisions, were resource documents written in code-type language to make adoption easier for code-promulgating groups. By the early 1990s, the Building Officials Congress of America, and the Southern Building Code Congress had both adopted NEHRP provisions as seismic design appendices.

44. ATC later repaid the funds advanced by SEAOC.

Moore: Yes, a balance, but that was basically a *technical* balance. To go beyond a technical balance, the next step was to provide a balance that also brought in the various interested parties who would be affected by code-related decisions.

Scott: ATC's focus was mostly on research related to earthquake codes and seismic design wasn't it?

Moore: Yes. A primary purpose was to provide at least the *basis* for codes—although not necessarily the drafting of the details—to be done under the engineers. ATC went on for a spell working on that main objective. Next, a wider interest began to develop in what the new codes would do to various interested parties. A lot of engineers were, of course, concerned as to what might show up in codes, but so were the building industries, steel, cement, the wood people, the labor unions, the insurance people, and so forth.

Building Seismic Safety Council (BSSC)

Moore: When the results of ATC's work were publicized, there was a great fear that the engineers from California were taking over regulating the rest of the country. This concern prompted formation of the Building Seismic Safety Council (BSSC), another very interesting development. The goal was to organize for other forms of balance and representation in addition to the technical.

Scott: I take it BSSC was set up partly in response to concern that ATC was dominated by engineers, particularly California engineers?

Moore: What really caused BSSC to be created was the fear that some government agency that did not have to pay for or live with the results would set design criteria for buildings. BSSC was an attempt to fill a vacuum, to provide a means of creating some guidelines for earthquake safety, before someone else did it. BSSC included private and government participation—it did not exclude government, but it also didn't depend on government. It was a separate corporation, and the work was carried out by committees that comprised both governmental and private sector people.

The main differentiation between ATC and BSSC was the breadth of the membership. All of the people who participated in ATC were from engineering, as it only represented engineers. So a key part of the idea behind BSSC was to get away from having the design regulations proposed only by California and western structural engineers. While California engineers continued to be involved, this was an effort to dilute their influence by providing a balance.

BSSC was conceived as a means of exposing the proposed earthquake criteria to the scrutiny of all the people who would be affected by them—that is, not only the engineers and construction people, but also the building industry, the building owners and managers, the mortgage holders, the insurance people, the public officials, the consumer advocates, and so forth. So for BSSC we made some effort to get any group to participate that was willing to join and spend the time in discussing the issues. We tried to make sure that nobody was left out, unless they just wanted to be non-participants, or only wanted to be in opposition, and we did not need or want any of those.

Also, BSSC was set up by the private sector at least partly for self-defense,⁴⁵ to keep some government agency from writing rules, the way they have done for toxic waste. The threat of that lay behind the establishment of BSSC. BSSC was started by a combination of the Structural Engineers Association of California, with representatives of governmental agencies, and some other engineers as well. Governmental agencies were involved, such as the National Bureau of Standards—now the National Institute of Standards and Technology (NIST)—and maybe the National Science Foundation. Incidentally, I was actually the first chairman of BSSC. I think most of the financial support came from FEMA.

Broad Coverage in the Review Process

Moore: BSSC became and is still today about the only organization that is devoted to

45. *Editor's note:* BSSC was established as an independent voluntary body under the auspices of the National Institute of Building Sciences (NIBS) in 1979 as a direct result of nationwide interest in the seismic safety of buildings. To ensure balance, each of the four major materials groups—concrete, steel, masonry and wood—were given a seat on the Board of Direction, along with one seat each for the AFL-CIO Building Trades Department, SEAOC, EERI, and ASCE. BSSC's primary role with respect to codes has been publishing revisions to ATC 3-06. Almost all BSSC work has been done under contract with FEMA. Thus in 1985 FEMA issued ATC-3-06 with revisions, as *NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings* (1985). BSSC has been updating the NEHRP provisions approximately every three years, after review by twelve technical committees. The revision process resembles that for SEAOC's *Blue Book*, but is done on a national level, with travel and administrative costs funded by NIBS.

giving broad-interest coverage on public policy. This relates to the seismic safety issue. It has taken some of the criteria that ATC developed, with the assistance of FEMA (for financial support). So far, all BSSC's publications relate to the earthquake-safety problem. They relate to criteria for new buildings, education of the public as to what they should be aware of and think about and consider, what risks they want to take, what to do with old buildings—that's a big problem—and what to do about lifelines and service-type things. BSSC has developed the recommendations for NEHRP (the National Earthquake Hazards Reduction Program).

In the BSSC review process, literally hundreds of people throughout the country have been reviewing what the proposed criteria mean in terms of seismic safety, and in terms of economics, as well as what they would do to the cost of facilities, public policy and safety. Providing a balance meant that it had to include a lot of non-engineers in order to represent a larger public. Codes developed by engineers alone were not going to be supported by the remainder of the political spectrum. This was BSSC's significance—it provided for all the people who were going to be either helped or hurt by code changes, so they would have a part in developing the guidelines for the codes. There again, I fell into being the first chairman of BSSC.

What BSSC Did

Scott: To sum up what BSSC did—it would take the research-based material supplied by ATC, as well as material from other sources, review it, and come up with some kind of code-related recommendations. I guess they were

fairly cautious about not using the word "code" to refer to the material they prepared. They actually prepared the procedures and commentary on which codes could be based.

Moore: Yes. They did not want to call it code writing—they said they were preparing procedures and commentary. Their intent was not to develop a national code as such. Instead they wanted to provide material that people could use to develop codes appropriate to their own individual local, state or regional conditions and circumstances. It was intended more as a national source book, providing material that could then be incorporated into a code.

It was not considered feasible to develop a code that would be applicable in detail to all situations throughout the country. I think the object is rather to develop new seismic safety codes, plural. I doubt that we will ever have a national seismic code. Anyway, the main point of BSSC was to expose those criteria, while in draft form, to the scrutiny and comment of all the people who would be affected—who would be helped or hurt by what was proposed. That is a very difficult public policy situation, and BSSC was a tremendously complex arrangement.

So a key feature of BSSC was getting everybody involved. Previously, the engineers had thought they could write the seismic codes without considering the economic effects—e.g., SEAOC, and ATC. They would write a code that considered only or principally the engineering aspects. BSSC's concept was to get the main interests represented and to develop design guidelines that would provide the safety desired and that were "do-able," not only economically and physically, but also politically.

It is a complicated issue. If you do not get the people concerned directly involved, you end up with a conflict—somebody puts out rules and somebody else doesn't like them. I think BSSC's procedures and commentary have been pretty good. They have not been enacted into law, but that was not the intent. It was hoped that people could be gotten to comply because it was good for them to do so.

I have not heard much in the way of criticism that the guidelines were wrong or out of line. The guidelines have generally been pretty well accepted, partly because they were not mandatory, and partly because most of the significant parties have been involved in developing them. Even the labor unions.

Incidentally, as chairman I worked with a guy from AFL-CIO—Jim Lapping. I developed quite a respect for him and learned a lot from him. Previously, I had not been very sympathetic to the AFL-CIO, but this was a sharp guy, an engineering graduate from Oregon. He was reasonable, and asked—"What will this do to my people?"—a valid question. He was interested in the effect the proposed criteria would have on his people and their jobs. Anyway, I began to see from this experience of working with and through BSSC—although terribly frustrating and slow—that it might be one of the very few effective ways to develop public policy.

Participation and Communication: A Model

Moore: I think BSSC is functioning quite well. I also think the BSSC model has some other applications besides earthquake safety. Thus I think the concept of involvement and representation also probably has a place in the

toxic waste business, which I discussed earlier. It probably has some application to the development of criteria and weighing considerations for toxic waste control. We need that, instead of having the one-sided view we have now, with the environmentalists coming down with mandates, mandates. Somebody with a purely technical concern doesn't worry about what it costs, how it is done, or how it is paid for. Limiting yourself to technical considerations will probably result in a different answer that does not weigh these other factors.

How people organize to think about problems can influence the decisions they make. It is time-consuming to bring the interested parties together around the table and hammer it out, but I don't think that is any less efficient than our present approach to environmental cleanup. We are the only country that does it that way, and with very little results, and leaving neither side happy with what has been happening.

ATC and BSSC are very interesting developments as one of the first times that engineers have really participated with other elements of society in developing the basis for public policies that involve technical matters. This is particularly the case with BSSC—even more so than with ATC. That is very important, because engineers tend to decide on these matters of public policy in their own minds, without ever explaining it to the other people who are going to pay for it. It is important to explain clearly to people—and even the general public—what they get for it. Just having engineers decide what other people should do does not work very well. Personally, I think that era of engineering is past. In my view there's a tremendous need for engineers to participate in

the development of public policies on matters that involve engineering—technical issues.

Scott: Yes, a code provision has its technical side that rests on an engineering rationale. If it is adopted and enforced, however, it may have major public policy implications. So a code change can have all kinds of repercussions in the "outside" world.

Moore: That's right, it will draw political support and opposition, and have economic effects, and so forth.

Engineers Should Be Participating

Scott: You clearly think the engineers should be participating, along with the representatives of other groups. What do other engineers think? Have many of them begun to see the need?

Moore: Some have. There's a whole spectrum of opinion—some see it, some don't see it so well.

Scott: Do you see that kind of participation as a central aspect of the BSSC development?

Moore: Yes. I think that kind of participation represents a major development in engineering practice—an evolution if you will. The engineers *must* learn to do a *much* better job of communicating the consequences of alternative choices, instead of just saying "I told you so." Engineers have not been very good at that.

Scott: That development, as reflected in the BSSC experience, has worked out pretty well?

Moore: Yes, and it's still working. There was a lot of contention, but it's working. I think it's a very valuable thing, but also very frustrating to many engineers. Admittedly, the process that BSSC represents is slow, time-consuming

and costly. But in my own view, BSSC has actually worked.

Scott: When I was interviewing Henry Degenkolb in the mid-1980s, I heard him complain quite a bit about some of the frustrations of working with BSSC.

Moore: Yes, Henry complained, but he also participated constructively. Some other engineers did not participate, but instead just backed away from it, saying, "I'm not going to put up with that nonsense." But they're left out, and decisions made that they're not going to like. Those who don't want to participate have simply opted out. I think this kind of participation is an important aspect of the future of engineering.

Wider Use of The Process: Environmental Regulation

Moore: I think this kind of formula ought to be included in the development of environmental requirements. Right now they are written by Congress or lawyers or other people who do not fully understand what they are doing. But it could be applied to what we are now going through in developing environmental standards. We are not doing a very good job of that.

Scott: A process like BSSC's certainly could have helped on some other things, such as the environmental laws and regulations where it now seems clear to almost everybody that we went overboard—asbestos is probably one good example.

Moore: Yes, we have gone way overboard on some environmental things.

Scott: Of course, there is also the other side of the coin. Our environmental programs have achieved some very good things.

Moore: That is also true. But when you come down to the "guts" of it, I am reminded again of the Frank Rhodes speech mentioned earlier. He was arguing that there will not be environmental protection unless there is also economic viability. He is absolutely right. If people are out of jobs, you just aren't going to get the protection—it isn't going to happen. But on the other side of the coin: he emphasized that there will not be good jobs without reasonable environmental protection. His point was that those things *have* to come together. Right now, however, they are not coming together very fast.

Scott: And the deadlock is causing a lot of problems.

Moore: Yes, causing a tremendous lot of problems, and gridlock in our decisionmaking. Partly this is because nobody knows all the right answers.

Scott: You are suggesting that a formula something like BSSC's might work?

Moore: Yes, it might work, and it certainly would be more constructive than going to court like we are doing now. That produces nothing but lawsuits and lawyer's fees.

Scott: In typical litigation, it seems that usually one side or the other wins, and there is little or no compromise.

Moore: Yes, this is where I think the ideas in Frank Rhodes' speech are so important. Unless both sides of the issue are taken care of in some way, it just won't happen. Many of the environ-

mentalists do not seem to believe it is important to take care of industrial concerns, and a lot of industry people do not believe it is important to take care of the environmentalists' concerns. But I believe that both are critical. They need to stop that fighting and get down to some joint answers.

The National Academy of Engineering is working in that direction right now. I went to a meeting the NAE had in at Irvine in May, 1994, on the subject of industrial ecology. They had a lot of people from both the environmental and industry sides talking about what had to be done to resolve the conflicts.

Achieving Acceptance

Scott: In summing up this discussion of ATC and BSSC, do you want to say anything more?

Moore: Neither ATC nor BSSC were interested in confronting each other, but rather in trying to pursue a path that would arrive at workable decisions to do something. As to timing, ATC came first. BSSC came along a few years afterward, when it became evident that what the engineers were doing on their own just was not going to be accepted. It would be accepted by the engineers, but when it got to the legislative bodies, it would be killed.

Scott: What does it take to achieve acceptance?

Moore: Acceptance means working through the building trades, and other interested groups. It was also essential to have support from the building community and from the financial community that would pay for it.

Closing Comments on Earthquake Concerns

Damage is Controllable at Nominal Expense

Moore: There is another important earthquake-related consideration. The crucial point is that most kinds of earthquake damage are controllable at a very, very nominal expense if appropriate measures are taken when they should be. While earthquake damage is bad, everything is not knocked flat, and adequate precautions taken in time can greatly reduce earthquake impacts.

Scott: "Controllable" means taking measures that either avoid or greatly reduce earthquake damage?

Moore: Yes. One of the simplest precautions is to tie your water heater down at home. Another is to have some bracing in the structure of your building. Of course everyone knows that the biggest offenders of all are unreinforced masonry buildings. When a building is constructed it does not cost much to put a little reinforcing in the right place in a brick or concrete block structure. California outlawed unreinforced masonry construction a long time ago, and now they have been trying to get the old existing ones strengthened and retrofitted. Unreinforced masonry is still commonplace in the midwest and southeast, however, although BSSC and FEMA have been working on design guidelines and retrofit methods for use in those regions.

A Change in Thinking is Crucial

Moore: The main thing required is a change in thinking. And that may occur. With the peo-

ple say in Missouri, South Carolina and Massachusetts—areas of historic earthquake damage—a change is probably more likely from the influence of an earthquake center located in New York, than of a center in California. Whether earthquakes are more frequent or less so, almost any area in our nation would benefit from good earthquake engineering and taking other precautions. When you're talking about producing a structure to last for maybe 100 years, a small percentage, or even only a fraction of a percent of additional money is no astronomical number. Yet such expenditures can accomplish a great deal if the work is done properly.

A lot of measures short of building retrofit can help. In a place like Los Angeles that has earthquakes more often, the extra cost of tying down water pipes, and securing light fixtures, glass windows and cladding against shaking would not be more than 1 percent or something like that. It would not be expensive to secure those things so fixtures and glass won't be falling when the earthquake hits—which it will.

Old Buildings: Retrofit or Phase Out

Moore: Existing old hazardous buildings are, however, a critical issue that has not been settled. There are two ways to address the problem of old hazardous buildings: 1.) to retrofit them, and 2.) to phase them out. Such hazardous buildings are widespread throughout the nation. We still have a lot of them in California, although we have made some encouraging progress. Long Beach and then Los Angeles enacted ordinances years ago, and the state is pushing hazard awareness and retrofit programs.

Even in California you obviously can't tear down 80 percent of your buildings, but probably 70 to 80 percent of the old buildings are subject to severe damage in a big California earthquake. Spending a small percentage to strengthen such buildings to improve safety and reduce the loss of life may be acceptable in an area where earthquakes are relatively frequent.

Promoting Earthquake Awareness Elsewhere

Moore: Under the NEHRP program, FEMA and others have been working to increase public earthquake awareness in the midwest and eastern United States, to encourage adoption of stronger seismic codes applying to new buildings, and to lay the groundwork for rehabilitation of existing unsafe buildings.⁴⁶

I also believe it was an attempt to influence thinking and promote awareness that led to locating the National Center for Earthquake Engineering Research (NCEER) in Buffalo, New York. NSF's decision to locate NCEER in New York was made in the mid-1980s. The National Science Foundation primarily funded the University of New York's Earthquake Center in Buffalo, and also of course it got New York state support. While a lot of people, including me, think it actually should have been put in California, I do have to admit that putting it in New York has some rationale.

46. In addition to NEHRP/FEMA's work to promote adoption of seismic codes for new buildings, a major NEHRP effort has focused on developing guidelines for seismic rehabilitation of existing buildings that are appropriate for application nationwide. Both ATC and BSSC have played crucial roles in the preparation of retrofit guidelines.

Scott: Did you observe much of the politics involved in the decision on NCEER's location?

Moore: No, I did not observe much of the politics. The biggest pressure probably came from the people at the State University of New York. I think New York state's proposed funding of the center was probably more generous than California's. And I believe there was probably some New York insurance company support, but I do not know the details of any of that. The financial and insurance people in New York City would be the ones holding the short end of the stick when and if a major earthquake happens in the east or midwest.

In short, maybe that location was a bad decision, or maybe it was not a bad decision. It will raise the awareness of earthquake risks in the east and midwest. There certainly are earthquake risks in other parts of the country, not just in California and the west. There are risks in the Mississippi Valley, which has experienced major earthquakes. In fact, the biggest earth-

quake on record in the United States was centered in Missouri.⁴⁷ There is geologic evidence that something like that has occurred at least two or three times in the last 2,000-3,000 years. That's not as often as earthquakes occur in California, but it makes you wonder—what if such a big earthquake happened again? In addition to the midwest, there have also been damaging earthquakes in other parts of the eastern U.S., such as the St. Lawrence Valley, the Boston area, and in the region of Charleston, South Carolina. In any event, there is a lot of merit in trying to get people to take the earthquake hazard in such areas more seriously.

The mortgage people and life insurance companies with mortgages on buildings all over the midwest and elsewhere are realizing that if a major earthquake happened again, *they* would own the structures, rather than someone who had only made a 10 percent down payment. So they're beginning to look at what would be prudent in consideration of this kind of a hazard. And there's no easy answer.

47. The New Madrid earthquake sequence of 1811-1812.

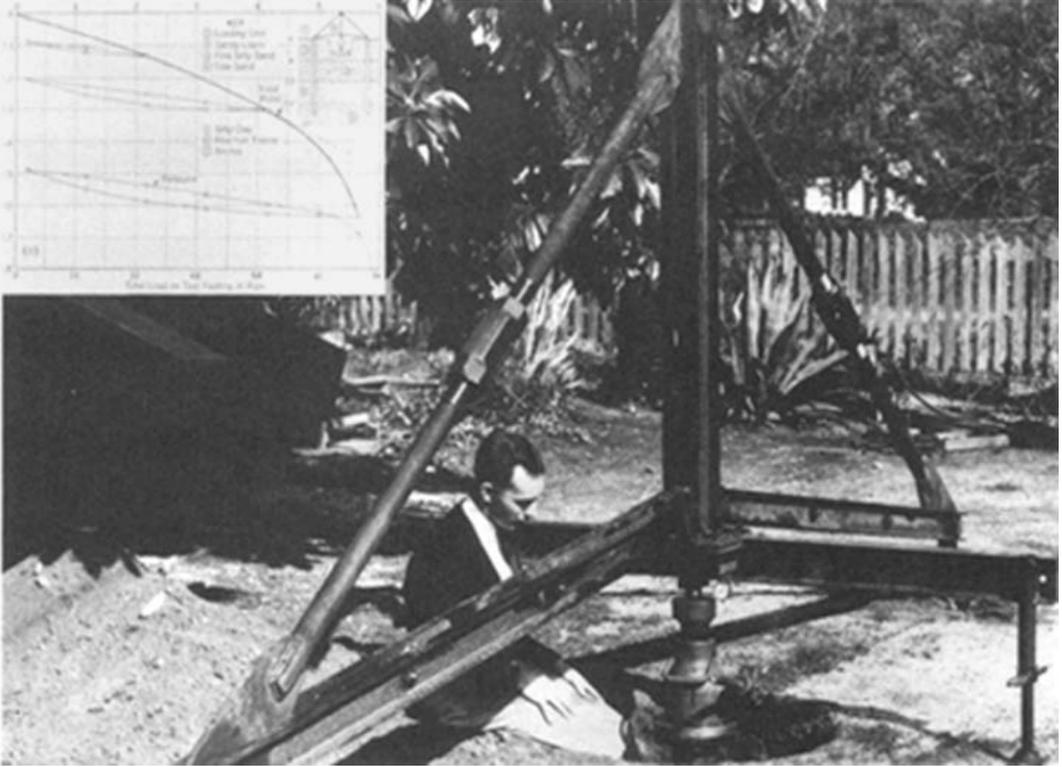
Photographs



William W. Moore, 1978.



Measuring vibrations of an elevated water tank in El Centro, California during work for the U.S. Coast and Geodetic Survey, 1935.



Moore works on Dames & Moore's first load-bearing test frame in Trent Dames's backyard, 1939.



Moore presents a speech at a meeting of the American Consulting Engineers Council, 1970s.

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