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CONVERSATION WITH A MASTER: LEROY CRANDALL

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1. BIOGRAPHY

L. LeRoy Crandall was born in Portland, Oregon, and was raised in San Diego, California, by his paternal grandparents. After graduating from San Diego High School, he attended San Diego State College majoring in civil engineering and transferred to the University of California, Berkeley, and became interested in the relatively new field of soil mechanics within civil engineering. After graduation from Cal in 1941, LeRoy accepted a position with the California Division of Highways in San Diego. However, LeRoy decided that his career should go in another direction and accepted a position with the firm of Dames & Moore in Los Angeles in December 1941, just a few months after marrying his college sweetheart, Eileen.

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After gaining much experience and advancing in the organization, LeRoy became the Managing Partner of the Los Angeles office of Dames & Moore where he worked with the leading engineers of his generation. In 1954, LeRoy, along with two other former Dames & Moore colleagues, started the firm of LeRoy Crandall and Associates in Los Angeles with the encouragement of many of his engineering compatriots that had enjoyed his service, knowledge and friendship. LeRoy and his associates established a consulting business that grew quickly and shortly became recognized as the premier geotechnical engineering firm in Southern California. LeRoy amassed a portfolio of projects that included Disneyland, major refineries across the country, and almost every high-rise building constructed in downtown Los Angeles.

LeRoy also brought innovation to his craft, having been involved in the pioneering use of tied-back anchors for deep excavations, replacing cross-lot bracing and internal rakers, which impeded construction of deep subterranean structures. LeRoy was also instrumental in the first use of seismic base isolation in a building in the United States. He also contributed to the development of the State of California's Strong Motion Instrumentation Program and was an appointed member of the State of California's Seismic Safety Commission. He has also served on the Board of Directors of the American Society of Civil Engineers and the Earthquake Engineering Research Institute. He was granted the Martin S. Kapp Foundation Engineering Award by ASCE in 1982, and was elected to distinguished membership by ASCE in 1984.

LeRoy was civic minded, serving on the YMCA of Metropolitan Los Angeles Board of Directors and a long-time member of the Rotary International. Even after retiring from the firm that he established, LeRoy is still active in a consulting role sharing and using his knowledge.

2. INTERVIEW

2.1 Question: How and when did you know that you were going to be an engineer?

L. C.—When I finished San Diego High School in 1935, it was during the Depression, people didn't have much money, and my family was among that group. So I aimed towards the Naval Academy because you could get a free education. They gave an exam, and a local congressman nominated two people to go. I passed the exam, but they also had a physical exam, and one of the things that excluded you was having so-called hammertoes. I think the physician was prejudiced, and liked someone else better than me. So they thought I had hammertoes and I was not appointed to the Naval Academy.

The alternative was to earn some money so I could attend college later. So after high school I worked for one and a half years at various jobs, driving a cleaning truck, delivering and picking up clothes (three-piece men's suit, cleaned and pressed, for 49 cents) around San Diego, which is my hometown, and made $20 a week. Then I worked at a neighbourhood movie theatre, the Ramona Theater, which paid $20 per week and I worked 7 days a week, opened in the morning and closed it at night. Unfortunately, my grandmother (my paternal grandparents raised me) got sick and needed surgery, so my money went towards that instead of college. Anyhow, I decided that if I wanted to go to college I had better go.

But how did I pick engineering? I always felt I liked, did better in, and seemed to enjoy math and physics, and that sounded like civil engineering to me. I went to San Diego State College, which was not too far from home. My brother had a hunting accident, so I got the use of his car. I was one of the few students that drove, so I picked up some of the other kids for $1 a month and that helped pay the gasoline bill.

I started at San Diego State mid-year in 1937, which turned out to be a very smart move. I got enough units there that it made the rest of my life a lot easier, taking just general courses. In my freshman year, I took pre-engineering courses at State, and did well. They didn't have engineering

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degrees at State at that time. There were only four schools in California that had engineering degree programs: USC [University of Southern California], Caltech [California Institute of Technology], Stanford and Berkeley [University of California]. Being a fairly poor kid, I went to Berkeley, and it worked out fine.

2.2 Question: How did you get into Soils Engineering? Weren't you part of the 'famous' class of 1941?

L. C.—Yes. The competition was intense, scholastically. So I go to Berkeley, Bill Brewer and I both. I met Bill at San Diego State, which is where I met my wife, incidentally. So Bill and I drove up in his Model A Ford (his father was fairly well off, a naval captain, and gave it to him). We checked in at Berkeley, got an apartment, and got two other guys to move in with us at $25 per month total. Bill and I had to sleep together in the same bed; the other two each had separate beds. We were very close friends for a long time.

Anyway, so I get to Cal, and looked around for work. I washed dishes at a little restaurant for meals. The most expensive meal was 39-cent rib-eye steak; half the time I didn't eat the meal because it wasn't that great. The other assignment was NYA—National Youth Administration—which was prominent at that time to help kids through school. They paid about 35 cents per hour and you could work up to 10 hours per week, no more than that because you were supposed to do your schooling. I applied for NYA and got an assignment that turned out to be in the Soils Mechanics Lab of the Civil Engineering department. Harmer Davis was the professor at that time. He had gone back East and took a course from Arthur Casagrande. Arthur was an Austrian-born American civil engineer who made important contributions to the fields of engineering geology and geotechnical engineering during their infancy. Then Harmer came back and was teaching the Soils Mechanics course which had just started the year before, I believe. They had a laboratory being built with a shear machine and consolidation equipment. My job was to keep the place cleaned up; I painted things and just did odd jobs around the lab.

That's how I got interested in Soils Mechanics. After being exposed like that, I learned it was a new field, and there were lots of openings, so I thought I would give it a shot. It was a graduate course at that time. So I got permission, with having good grades and friendly with Harmer Davis, to take the graduate course of Soil Mechanics in my senior year. It was a hard class because we had 15 or so graduates of the Naval Academy who were coming out to get their engineering training for the Navy Seabees, which was a new organization at that time. Well, these guys had plenty of money, it seemed to me, and some were married, and they had the time to devote to their scholastic activities, so they set the grading curve pretty high for the rest of us. I managed to get an A out of it, but it was a real struggle.

I got my degree in civil engineering from Berkeley in May 1941, and graduated with the likes of Irvan Mendenhall.

2.3 Question: How did you end up in Los Angeles?

L. C.—Good question. While I was in my senior year, Bill Moore of Dames & Moore came to Berkeley. Bill was contemplating opening an office in San Francisco and wanted to meet with some of the soils students to see who were interested in employment. So three or four of us went to lunch at the Faculty Club at Berkeley, my first time there. Bill picked up the tab, and Harmer Davis was there. Bill said if we would like to work for him at Dames & Moore to drop him a letter stating our interest and qualifications. So I did that.

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Towards the end of the senior year, around April 1941, I was looking for a job and I hadn't heard from Dames & Moore. So several of us took a train and went to Sacramento. The California Division of Highways was hiring, and they had just upgraded their entry level for graduate civil engineers from Senior Aide, which paid $140 per month to Junior Highway Engineer, which paid $170 per month, so that sounded reasonably attractive, and they gave me a job in San Diego, close to my home.

Believe it or not, the next day the telephone rang and it was Bill Moore offering me a job. I told him I just accepted a State Highway job, and I couldn't back out on them. Obviously, I was terribly, terribly sorry. I began in May 1941 as a Junior Highway Engineer with the San Diego office of the Division of Highways. While it was a good job and great experience, it wasn't really appealing to me. I was assigned to work on the first cloverleaf interchange at Rosecrans and the Coast Highway, and I did the design calculations for that project.

We had a state holiday in 1941, Admissions Day I think it was. Eileen and I drove up to Los Angeles to visit the Dames & Moore office.

2.4 Question: Were you married at that point?

L. C.—Yes, we got married in September 1941 (see Figure 1). We drove up to see Dames & Moore. I called them first, so we went to their offices in Los Angeles. Bill Moore offered me a job then, and I decided that was where I wanted to be, not at the State Highway Department. On 17 December 1941, we moved to Los Angeles to join Dames & Moore (see Figure 2). Bill said he would pay me $175

Figure 1. LeRoy and Eileen at Cal graduation (1941)

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Figure 2. LeRoy Crandall, managing partner of Los Angeles Office of Dames & Moore

per month (he was only going to pay me $170, but I pleaded my case for being in a new city). Eileen and I lived in an apartment for $25 month that was only about five blocks from the office.

Anyway, soils engineering was where I decided I wanted to be and I joined Dames & Moore. They had some good equipment. Trent (Dames) and Bill had designed a soils sampler, and they designed and built their own shear machine. And their consolidometers were using mercury tubes for measuring the load. It was very interesting stuff that they had developed themselves. Trent was the one that liked to do that kind of thing. In fact, he was working on an automatic shear machine. He spent more time and money on it, and finally got it finished 10 to 12 years later. By that time, the techniques had changed so much it was no longer very useful compared to what was available commercially.

I got along well with Trent who ran the L. A. office; Bill was then in San Francisco. Trent was a good mentor. We didn't always see eye to eye, but he had me write reports very early on. We sat down together at his desk and went over each report word for word. He gave me some really good tips about writing reports, and how they should be organized. I have to give him credit; he really educated his personnel so they improved from when they started. And hopefully I did some improving there too.

In those days, the predicting of settlement and bearing values for foundations, which is the main thrust of most soils mechanics work, was not too reliable in terms of laboratory testing. And often the initial program before any laboratory testing occurred was to go out and run load tests on steel plates (1-, 2-, up to 3-ft square) to see what was happening that way. So we had that as a check on our laboratory tests on driven soil samples.

I remember one job for the Long Beach School District we did in the early days. Based on the laboratory testing, I predicted about 1500 pounds per square foot maximum bearing value and some pretty significant settlements of these fairly light classroom buildings. Well, the head guy of the engineering department of Long Beach didn't believe it. He said, 'The soil is better than that because we've been using 3,000 pounds per square foot here'. And I said, 'But if it gets wet, that's what we're concerned with'.

We had saturated the samples and tested them that way. I said, 'If these soils get wet they are going to collapse and you're going to have big settlements, and you don't want that'. 'I don't believe it', he

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said. Well we took the steel test plates, which he did believe in as he'd been doing that all of his engineering life. So we set up a test program out there, dug some holes around the test plate, ran the test dry and then added water to the holes we dug around it. Sure enough it settled appreciably after. The settlement increased four or five times, from about ½ inch to 2 inches. So he was immediately willing to accept our predicted recommendations. I think they involved extending the footings deeper than normal so that the water problem wouldn't occur. [*Note*: This phenomenon is commonly referred to as 'hydroconsolidation'.]

I still have dreams about a close call we had on an early project. The Broadway/Crenshaw shopping centre was being tested by Dames & Moore in about 1950. There's about 10 to 15 feet at poor bearing quality organic soil overlying good bearing quality sand and gravel. Since we couldn't get good drive samples due to the coarse gravel, we decided to perform a horizontal load test in a boring into the sand and gravel deposit. We had a large diameter hole (about 3 feet). Fred Barnes, our chief field man, and I were going to do the downhole testing. We were preparing to install a lateral load test, squaring up opposite sides of the boring in the sand about 15 ft deep. Fred and I were there with a ladder down in the hole. Fred was already down there, and I started to go down the ladder with some equipment, when Fred yelled, 'Crandall, get out of here real quick, there's gas down here'. We raced up out of the hole as it was filling up with methane gas from the organic material. We both could have been asphyxiated if we hadn't left the boring when we did. We then brought an airblower to the site to let us proceed with the testing.

Another lesser catastrophe involved the Raymond Concrete Pile Company, who was the lesser big pile driving company in those days. I went on one of my first jobs to inspect the pile driving at the San Pedro shipping terminal. I'm out there with my clipboard to take down the pile blow counts, and the pile foreman says, 'Come over here, Crandall, to get a better view'. They started the hammer, which was a steam hammer. As a first timer, I didn't realize that when they make the first stroke all the crud and accumulated water comes out of the exhaust pipe. I was standing close to the pile rig, and got doused with exhaust oil and water. This was a great moment for all the workmen. I never got close to a start up hammer after that.

2.5 Question: What was the first tall building that you worked on?

L. C.—In the early days, the City of Los Angeles had a 13-storey height restriction, which people thought was because of earthquakes, but it really wasn't. The first building that was more than 13 stories that I remember was the Bank of California building; Brandow & Johnston were the structural engineers. It was in downtown Los Angeles right next to the Stock Exchange building, around 6th and Spring streets. The Bank of California job had some interesting ramifications. The subterranean levels went about 40-ft deep, right next to the Stock Exchange building, which was several stories high. A vertical cut next to the existing building required underpinning the adjacent wall of the Stock Exchange building. We came up with the idea of slant drilling piling for the underpinning—I believe it was the first time ever done. The idea was to drill a series of holes at the Bank property adjacent to the Stock Exchange slanting down under the Stock Exchange building. Workmen would then straighten the hole so it was vertical beneath the stock Exchange wall for the top 40 ft, and then at a slight slant from there on down. The piles were poured with a jack pocket at the top of each slant pile to bring the pile into bearing. That worked our very well.

We didn't have tie-backs (tie-back anchors) in those days, back in the 1950s, and the excavations were shored by cross-lot bracing. I went out to the Bank of California site and saw massive timbers that were in and out, up and down and around the subterranean excavation. It was murder for the contractor to do his work, and I thought that there had to be a better way than that. Ultimately, this led to the development of tie-back anchors so that you can develop an open excavation to work in. I

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Figure 3. Century City Theme Towers, West Los Angeles

learned a lesson on that job that the standard technique for bracing a deep excavation was a big handicap to the construction of a major project.

The next project that I think deserves special attention is the construction of the twin Theme Towers in Century City (in West Los Angeles; see Figure 3). The excavation for the Century City Theme Towers was about 700-ft square and from 80 to 100 ft total depth. The walls of the excavation were supported using soldier piles with tie-back anchors as shown in Figure 4. There was not a single interfering item inside the excavation. I think we developed some novel ways of pretesting the installation. The City of Los Angeles was very concerned about the west side of the excavation because of the existing Avenue of the Stars bridge above an underpass. They were worried about that bridge and we very carefully monitored that throughout the construction period of excavation. We actually pushed the bridge back a little with our tie-backs rather than let it come into the hole. There was a paper written about the project, and Perry Maljian and Jim Van Beveren (Associates of LeRoy Crandall and Associates) put together a paper that included information on our work on that project (Maljian and Van Beveren, 1974). We developed some good testing programs with monitoring systems and gages to tell us what was happening in sections of the excavation so we would know if anything was going wrong and be able to correct it. If you take 700 ft by 700 ft by 90 ft and divide it by 27 you would have the yards that were dug out (about 1·63 million cubic yards). It was probably the largest excavation for a single building project.

The shoring was rather unique in a couple of ways. Skilling Helle Christiansen Robertson's office was the structural designer. They built the steel soldier piles into the final design of the basement walls. Most of the time that's separate; you build the basement wall inside the shoring. But they said we have all of this steel here, why waste it? Their design and construction of the exterior basement

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Figure 4. Tie-back Anchor Shoring System for Century City Theme Towers; note that the excavation was still not at full depth (circa 1970)

wall included the steel soldier piles as part of the wall design. That required that we put the tie-backs between the soldier piles instead of adjacent to them. It was a unique design, and it cost extra money as a shoring system but they got the advantage of using the soldier piles as part of the design steel in the wall. So I guess it worked out economically.

2.6 Question: So then the final wall didn't really count on the tie-backs for support?

L. C.—No, it did not, the tie-backs were temporary, and later ignored.

Bringing up Century City reminds me of an unfortunate occurrence out there. One of the first buildings was going to be on Raymond Piles, and they had a big celebration for driving the first pile—I didn't get under the hammer this time. But they had all of the dignitaries out there. They set up the pile driver and started driving. The pile goes about 20 ft with no blows. It keeps going with hardly any blows for 40 ft. What is the matter? Did we hit a fault trace? (We had one of those that went through a Beverly Hills site.) I'm out there and everybody's saying 'Crandall, how much is that pile good for; is that a 40-ton pile?' No, it isn't a 40-ton pile, what is the matter? I get out the soils report and, believe it or not, they had driven the pile exactly at one of our large-diameter borings. They drove another pile at a different location and everything was fine.

2.7 Question: Was it the same diameter?

L. C.—The bore hole was about 18 inches in diameter and the pile started at an 8-inch-diameter. That was not a prize-winning moment. I would have preferred to have been anywhere but there at that moment.

2.8 Question: I guess from then on you decided the location of bore holes should not be under the column?

L. C.—Well, it was a big column. The pad for the foundation was quite a few piles, and I'm not sure that it was at a specific location. The pile foreman must have picked the spot because he saw a little

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surface subsidence. I'm not sure that the hole was under a column, but no, normally you don't want to do that. But that was an embarrassing moment.

2.9 Question: You mentioned that tie-backs were developed in the 1960s. I thought they existed long before. European countries like Austria and Germany were pretty advanced with construction equipment but did not develop this technology?

L. C.—If they did, I was not aware of it. In our area it was brand new. There was some similar work supposedly going on in Missouri because there was a soils guy there contacted me about it and he said he had tried to do some lateral drilling for tie-backs. But whether they were doing it in Europe I really don't know. I know they were advanced in many ways, like the slurry walls were done there first. Base-isolation projects were done in New Zealand and Australia before it came here. As far as tie-backs go, we were unaware of them. We knew that you could anchor something back with a deadman. That had been done, but you couldn't go very deep with that and if the excavation was more than one storey, a deadman wasn't going to help you very much. So it all depended on the technique of being able install an anchor in a near horizontal direction at depth. And when the equipment for that developed, drill tie-backs became practical. The newest equipment developments now are really grea; tie-back anchors can now be readily installed on a project.

2.10 Question: Do you know what year that was?

L. C.—Probably in the late 1950s.

2.11 Question: So was it used in that first wave of high-rises after the Bank of California Building?

L. C.—By the time the big high-rises had come in, the Webb-Lipow's system had been superseded by better equipment. They used a vacuum to suck out the drilled soil, and you couldn't be really sure if you got the hole cleaned out or not. The drill had a diamond-shaped reamer on the tip end that made a double cone at the end to develop the reaction. It relied on the cone at the tip to develop its resistance, not friction on the shaft because it was very small in diameter. We were a little concerned about the capability of that cone in all cases because if any earth was left in the hole you've got a soil cone instead of a concrete cone.

We were doing a lot of proof testing on the early drilled shafts. Later on, the testing program consisted of putting in the initial anchors, testing them to twice the design load to make sure you had an adequate factor of safety, and then every anchor after that, when you felt your design values were okay, was tested to one and a half times its design capacity and then locked off at 100% of the design load. We insisted on that testing program and the building code, which used our language, later did the same thing. That is, the Building Department adopted our testing requirements in the building code for the tie-back installations.

The Building Department of Los Angeles still doesn't accept most tie-back installations as permanent anchors. That has hurt a few projects. Not so much building projects, but more like something to hold back a hillside. Every other community permits it, but the City of Los Angeles normally doesn't. We have only four projects, including the First Interstate World Center 73-storey tower (now US Bank Tower; see Figures 5 and 6), that have permanent tie-backs. They are still checking the US Bank installation every year. Gerald Lehmer did the tie-back anchor design based on our data and recommendations. Now Burnett & Young are doing the checking of the anchors, since Jerry has pretty much retired. They get anchor data yearly to detect any loss of capacity. So far, everything has been

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Figure 5. Seventry-three-storey US Bank Building (formerly First Interstate World Center)

Figure 6. Downtown Los Angeles Skyline; almost all tall buildings shown had geotechnical investigations by LeRoy Crandall & Associates or successor firms

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fine. On the north wall of the basement you can still see the set-up where a jack can be used to test the tie-back capability.

Comment: They are actually doing a lift off test of an anchor at least once a year. It started off as being more often but now it's only once a year.

L. C.—Well it seemed like a good requirement because if something happens and one of the anchors goes bad, you can come and put a new one in. It's a little tough with the limited head room now, but it can be done. The permanent anchors take all of the lateral thrust of some 80 or more feet of earth on the north side of that building. Tie-backs are retaining the cut embankment, which was roughly 40 ft above the street level on the other (south) side.

Comment: The entire north bulkhead is permanently tied-back. Because of the ramping of the parking levels, the structural engineer didn't want to take the load across into the discontinuous diaphragms.

Comment: You mentioned that there are four buildings that had permanent tie-backs in downtown Los Angeles.

Comment: There are three other Crandall projects with permanent tie-back anchors. One is Hoag Hospital down in Newport Beach, the Hoag Cancer Center. Another one is the shopping center out in Calabasas. The third project is a permanent wall supporting a residential property in the San Fernando Valley.

2.12 Question: Did you do the Bank of America building downtown (ARCO Towers in Los Angeles)?

L. C.—Yes, definitely. We had a fight with Spencer White & Prentice who got the shoring contract for that. They had a superintendent that thought he knew everything so you couldn't tell him anything. The first tie-back he put in which we were testing pulled out 7 ft and then stopped. He insisted that was a good tie-back, and I said 'the hell it was'. His drilled shaft clean out procedure was poor, but it was a difficult situation going under Figueroa Street.

I came back from a noon Rotary Club meeting one Friday at the Statler Hotel to where I'd parked my car at the Jonathan Club. Standing in the rain in front of the Jonathan Club were about 20 people including the Mayor of Los Angeles, the City Engineer, and a number of building department people. Figueroa Street had stretched because of the hole for ARCO Towers across the street. Some of the shoring had yielded and distressed Figueroa Street. An abandoned pipeline leaked into the excavation and increased the load on some of the tie-backs. That had caused the yielding. They had closed down Figueroa Street. Crandall waltzes up and they grab me and said, 'LeRoy, what's going on here, what have you done?' I went over, took a look and said, 'Fellows, it's over, it isn't going to yield any more, open the street'. They did it and everything went fine, but it was a hectic few minutes. That was a deep excavation, and they got down in part of that thing and they ran into a limestone formation. It was right down under the old Richfield building. We didn't have any borings there so it was completely unexpected. Some guy got a contract to dig it out, and made beautiful table tops out of it.

2.13 Question: What do you remember about the Century City area growing up? What kind of experience did you have?

L. C.—I told you about the pile driving at Century City earlier. The first building in Century City was on driven piling, after that we carried the basements deeper and didn't have to use piles. The big ticket

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item was the Twin Towers as we have discussed. The massive excavation for this project was completely supported with tie-backs. We got ALCOA, the owner, to put up some money to run test sections on the anchor installation. We took one of the deepest parts where the excavation was like 100 ft and took three spans of soldier piles, instrumented all of the tie-backs and the soldier piles and took load and deflection measurements from start to finish. Two of our guys, Perry Maljian and Jim Van Beveren, took the time to write up a paper for ASCE that had this information in it (Maljian and Van Beveren, 1974). This gave us valuable data on how to improve our design techniques that we had been using on tie-backs. But it was a beautiful piece of work when you see an aerial photo of the entire hole, nothing in there to obstruct any kind of construction at all.

2.14 Question: On a project that big, if you didn't have tie-backs, how could you do the installation?

L. C.—I don't think they could have done it, frankly. Most of the soil was alluvial sandy soil. It wouldn't stand steeper than one to one, and that would be stretching it. So you never would have been able to do the project, unless you drilled continuous soldier piles. We could have used a new technique that was later used at Wilshire Boulevard and Veteran Avenue (in the Westwood district of Los Angeles). I think Robert Englekirk was the structural engineer on that. This thing went down 90 ft into the ground in a very small plan area and we used slurry walls and built the subterranean structure from the top down. In other words, we first excavated at the column locations with a drill rig, put drilled piles down at that point that would support the steel columns all the way down, and then put in the basement walls as slurry walls. This was a new thing in the City of Los Angeles and everyone was watching that thing like crazy. The slurry walls went in and then they excavated for the basement. As they got down each level, they built the floor so that would take the lateral load of the basement walls. Putting in the foundations in advance permitted them to go ahead and construct the superstructure at the same time.

Comment: They were also constructing the superstructure at the same time, from the top down and the bottom up; this is sometimes referred to as 'up and down construction' (see Lew and Maljian, 1991).

2.15 Question: So the slurry wall was not used as the basement wall?

L. C.—It was the basement wall. That was the final wall, and they did a good job on it. There is a lot of uncertainty in that kind of stuff. They had Japanese equipment. The Japanese had developed the process.

2.16 Question: What about any other buildings along Wilshire Boulevard that you remember fondly?

L. C.—We did a building across from the La Brea Tar Pits, The Museum Square, which extended down into the asphalt sand and required special concerns about controlling the gas and getting rid of the asphalt, which is going to keep percolating up. It's a messy operation to build in that stuff. Especially when the sun was out around noon time, it would soften and you could sink into the stuff. But if you worked on it at night or in the early morning hours when it was cool, it was firm enough to do some things. The basement of that structure has a drainage system of coarse material to permit the asphalt to travel laterally under the floor. The floor was built with a very strong resistance to uplift and had a membrane put in place so that the gas and asphalt wouldn't cause problems in the basement. As I recall, the owner of the building hires somebody to come in and collect the asphalt in the sump

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every few months or so. It cost a lot to resist the problems that it could create. We didn't find any elephants or other stuff there, though.

2.17 Question: What kinds of challenges did you have with soil conditions like that to either test or make recommendations? It's so unusual—is there any data available?

L. C.—A lot of people said you can't build there. The same thing was said about a subway out Wilshire Boulevard. Originally, Congressman Henry Waxman (D-CA) opposed a subway on the basis that you couldn't put a tunnel through this area because of methane gas, which is completely wrong. I wrote a letter to that effect. That didn't win any prizes anyway because he wanted it to go down by Olympic Boulevard, more in his territory, or whatever his reasons were. But now they're back talking about Wilshire Boulevard again.

2.18 Question: From Dames & Moore, you started your own office, and I was wondering what philosophy you instilled in the office, how it all worked, as well as projects maybe, but mainly the office environment, how did you train people, what were your goals and philosophies?

L. C.—Before I left Dames & Moore, Vernon Smoots came out from New York to head the office in Los Angeles. I spent my last 2 months trying to help him meet and get to know everybody that we did business with. Then we opened LeRoy Crandall & Associates in June 1954 (see Figure 7). By that time we had our own sampler designed which we made a little larger in diameter because I felt that the one at Dames & Moore was smaller than I liked. Then we had laboratory test equipment on order. We opened the door at 1614 Beverly Boulevard on 1 June 1954, but we weren't yet fully equipped. Some of the work we had before we had our sampler had to be postponed. We were also limited on funding, with a $20,000 initial investment.

Figure 7. LeRoy Crandall, president, LeRoy Crandall & Associates (1979)

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I remember one early project with Jim Montgomery of James M. Montgomery & Company. He was an excellent man and a great engineer. They did water supply, and very fine people came out of his organization. Jim Montgomery called in about a job for the Las Vegas Water District. He was designing a plant up there for them and he wanted us to do the work. It was going to be about a $14,000 job and we were concerned how we could finance the work. We only had $20,000 to run on and we had said it should last us 6 months. If we hadn't done anything by then, we would just call it quits. Jim Montgomery says, 'LeRoy, I want you to do this work. We'll just pay you in advance if you need it'. We didn't need it, we got by all right, but he made our start much easier.

Then Disneyland came along. Wheeler & Gray, who were very strong supporters of ours, were working on Disneyland. Disneyland, of course, was a very prime piece of work, not just from the money, but also from the status. I did get to meet Walt Disney. While we were meeting with the design boys, Walt Disney came in and they introduced me. All he cared about was the railroad. He was into model railroads, so he didn't really care about river or the buildings or the rides, but his main interest was in the railroad going around the park.

By that time, we brought in the first employee. Initially, Eileen did our secretarial work for no salary. We were lucky and a lady came to the door for a job, and her name was Peggy Castleman. Peggy was good in secretarial and accounting skills. She kind of ran the office administration. I think our first hired engineer was Seymour Chiu, a graduate from UCLA, originally from Hong Kong. He was very well qualified, and had great math skills. At the beginning, there were three of us: Crandall, Barnes, and Hirschfeldt. Russell Weber came from Washington to work for Dames & Moore shortly before I left. He came to us and said he wasn't happy at Dames & Moore and that he'd like to join us. So we brought him aboard. We now had three junior partners. They each had 20% and I had 40% of the company. After Weber came in, Jimmy Kirkgard and some field personnel were hired. About 1956, we left the 1614 Beverly Boulevard office because it was getting too small, and we moved across the street to a larger office. By that time, we probably had 15 to 16 people—roughly equivalent to what we had a Dames & Moore when I left the Los Angeles office, which was around 17 to 18 persons.

Next, we built our own building in 1965 or so. This was Leo Hirschfeldt's idea. He was more of a businessman than an engineer. He was from Sweden, and helped start TERRA, the insurance company for soils engineers. Leo thought we should build our own building, but I wanted to keep the money in the business, why would we want to invest it in a building? Shows how little I knew about financing. But we went ahead and built our own building on Alvarado Street (west of downtown Los Angeles), and stayed there until 1985.

2.19 Question: You obviously attracted good employees. But then what was your philosophy in the office, how did you get things done, and how did you mentor everybody to get out a good product all the time?

L. C.—It may have been mostly luck, but we did have good people, and they were very conscientious. Our first concern was the public, obviously. That's a basic requirement of any engineering service. You don't do something that's going to harm the public. The other concern is the client, the next level of responsibility. Then after that was us. My theory was that we wanted to make money on a job, but we're going to do it right whether we made money or not. I think we tried to follow that procedure. Our concern was to do the job in a manner that we would be proud of whether we profited or not. In most cases we managed to make a little money. We were never out to get wealthy, just to make a comfortable living for us and our people. We went through the recession of the 1980s, and we did have to cut back on our personnel. Everybody took a cut, including the partners. We said, 'We're in trouble here and we don't want to lay anybody off, but if we trim expenses we think we can keep the boat going', and we did. We cut the partners the hardest.

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What did we do that was so special? I don't know of anything, really. We worked closely with the people that were designing these jobs. We were always available for people to call and question us. When I was signing all of the reports, I read every one and went over all of the data. If there were questions, I expected the engineer in charge to be able to clarify them. From that standpoint we had close supervision.

I would like to expand a point about LeRoy Crandall & Associates—what did we do to maintain the staff and keep people in the organization. We were very concerned about that subject, and took the opportunity to add deserving associates to the firm as our engineers became registered and indoctrinated into our theories and procedures. They were offered membership in the firm which in almost every case was accepted. Our idea was to retain our top personnel by bringing them in as a part owner. Those of us with a larger share of the ownership gave up some so that the new person could become a partner and be on the board of directors of the company. I think this way of keeping the top people was the smart thing to do.

2.20 Question: What was your experience on either age or how many years before you had to make a decision to promote a person to Associate? Did you have any guidelines?

L. C.—It depended on the individual. Some matured and were able to direct others, and handle a project on their own, with only minor help and supervision. Age didn't have much to do with it that I remember. I would say that 5 years was probably the minimum that we had an employee before he became an associate, I believe.

Most of our people had bachelor's or master's degrees. When I graduated, Harmer Davis was the soils engineering professor at the time with whom I was quite friendly and familiar because I worked in his laboratory. Just before graduation, Harmer Davis talked to me about staying in school or going out to work. He said if you're going to teach, stay and get your master's. If you're going to work, you're going to learn a lot more outside in the field than you'll learn in school. I thought that was pretty good advice. Those of you who are doctors are probably cringing at what I just said.

Comment: Everybody told me that if I wanted to stay in school, I should keep going because once I left I would probably never return. I only found one person that was able to leave and then went back.

L. C.—At that time you had to have a master's degree to be on the faculty of any of the engineering schools. Later that dropped, and it wasn't enough. Bob Chieruzzi, for example, was teaching at USC with a master's degree, and then they decided they wanted doctor degrees on their faculty. We inherited Bob Chieruzzi on that basis, and he was a very strong addition to our company especially in the seismic area. Bob specialized in the seismic area, and then Marshall Lew took that position over later. But Bob didn't have a PhD, and USC let him go, so we were very fortunate. I don't know how long it was before Bob became an associate, but it was probably a very short time.

2.21 Question: I have the impression that marketing and client developmen in your company was somewhat different from other companies. For example, Dames & Moore tended to go directly to the client, whereas you marketed through the structural engineers. Is that true?

L. C.—I think the bulk of our services were generated by structural engineers and architects who have recommended our firm to their client. That's why we were essentially doing local work rather than international work. Although if the firm with whom we were familiar, like CF Braun & Company who

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designed and built refineries all over the world, if they wanted us then we went to where the job was. As a result, mostly because of Braun's activity, I was registered as a professional engineer with 17 states at one time.

Our source of projects was basically from the engineering and architectural profession in this area, people with whom we'd worked before, who felt we knew what we were doing and we gave them reports that they could understand. That was the important thing—our reports were simple, direct and right to the point for the structural engineering people to utilize in their design. We also provided top quality inspection services for the projects that we did wherever located. For example, we were involved in the atomic bomb testing sites in the Marshall Islands. We sent a man out there during construction. Inspection service was a very important part of our work and we insisted that we do the inspection when we did the investigation to see that the project was built in accordance with the recommendations and to find out if there were any changed conditions. When you do a soils engineering project, you're always uncertain as to what is there. I remember Bill Moore saying one time: 'If you drill one hole at a site, you know everything about it. If you drill more than one, you get confused'. That's pretty much true. Things can happen out there in the subsurface conditions that you don't expect from the few borings you have made. Somebody out there watching what's going on can detect those things in time to make changes if required.

2.22 Question: When you mentioned about promoting your senior staff to partner, you did not mention how much they were involved in marketing. It looks like marketing capability was far down on the list. Is that true?

L. C.—None of us went out soliciting. We never went to the government or the Navy, for example, to solicit their work. Work came to us, and we had enough that was sufficient for the company. I didn't have the desire to have multiple offices or an international organization. I felt we wanted to have a good solid organization within itself and not spread out all over the country or other areas. Now, the situation has changed and MACTEC has several offices. LeRoy Crandall and Associates did expand into San Diego when Bob Chieruzzi decided he wanted to move there. So we agreed to have him open an office in San Diego, but most of the effort was done out of the Los Angeles office.

[*Note:* LeRoy Crandall and Associates merged with Law Engineering Testing Company in 1982 and operated as a subsidiary until 1991. In 2002, MACTEC acquired Law Engineering.]

2.23 Question: You were also involved with the Foothill Communities Law and Justice Center?

L. C.—That was a really interesting structure (see Figure 8). Bob Rigney, County Administrator of Riverside County at the time, was on the Seismic Safety Commission with me (in the early 1980s). He and I were talking one day and he said they were planning this new building in Rancho Cucamonga close to the San Andreas Fault. He knew about the perils of building close to that fault. We talked about what you could do with a building like that. I mentioned this new procedure called Base Isolation that I'd heard about being used in New Zealand on bridges, and I thought something like that could work there to minimize the displacement of the building. If you get the Big One on the San Andreas, the ground is going to move back and forth in a quake which is pretty hard on a building. He wasn't sure how high the building was going to be at that time. So we talked about it a little bit and that this might make some sense.

The County hired us to do the soil investigation, and selected Taylor & Gaines to do the structural engineering. We talked with Buzz Gaines and Bill Taylor about the base isolation system and Prof. James Kelly at UC Berkeley was doing some work on base isolation, along with Alex Tarics and

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Figure 8. Foothill Communities Law and Justice Center, Rancho Cucamonga, California—First Base-Isolated Building in the United States

Douglas Way of Reid & Tarics in the Bay Area. So they decided to give it a shot, and the tests on the isolators were made at Cal and the system was developed and Taylor & Gaines put it all together in the design. We came up with the anticipated seismic motion for the area. I think we suggested that they extend the basement wall 17 inches on each side beyond the building exterior so that the ground and building could move differentially and it wouldn't transmit that much motion to the building. The building was supported on these base isolators (made of natural rubber). Bob Rigney bought that and it was designed that way.

We did get a reading of the seismic instruments that were installed at the building when a moderate earthquake occurred in the area. The building shaking was only about 40% of the ground movement. So the base isolators were absorbing about 60% of the ground motion.

Comment: The Applied Technology Council and the Engineering News Record selected the Foothill Communities Law and Justice Center as one of the top 10 seismic projects in the 20th century. The ceremony was held during the 100th Anniversary Conference of the 1906 earthquake in San Francisco in 2006.

Comment by Gary Hart: We were hired by the county of San Bernardino to do the peer review. Dr. Sampson Huang also worked on the peer review.

2.24 Question: Were you involved with The Forum in Inglewood?

L. C.—Yes. We had to take hockey seats. The owner, Jack Kent Cook, insisted whoever worked on it got season tickets. We had a hard time getting people to go.

We did the Forum, most of the City Halls around here, most of the buildings in the Los Angeles Civic Center, including the Hall of Administration and the County Courts.

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We did the reconstruction of the Los Angeles Memorial Coliseum after the 1994 Northridge earthquake and many other sports facilities including Petco Park in San Diego, Staples Center, Honda Center, Home Depot Center and the remodel of Anaheim Stadium.

I went to my first hockey game in Detroit. We also did the Schlitz Brewery here. Several breweries were being planned here at that time—Anheuser Busch and Schlitz. The design for Schlitz was being done back in Detroit. George Brandow and I went to Detroit to go over the design concepts with the structural engineers in the area. That night they took us to a hockey game. That was one of the most nervous nights I've ever spent. We had really good seats right down in front, but they didn't have plexi-glass, and they're hitting that puck around furiously. They carried three people out that night from the stands that had been hit with a puck. I believe Gordy Howe was playing for the Detroit Red Wings at that time.

2.25 Question: What can you tell us about C. Martin Duke?

L. C.—I knew Marty at Cal; he was a year ahead of me. He was doing his master's degree and working as an assistant in the surveying department. He worked the summer camps. You used to have to go to surveying summer camp at the end of your sophomore and junior years. I went to Fresno State for my sophomore year because San Diego State got out too late to go to Cal. My junior year I went to the Cal summer camp and Marty Duke was one of the workers there. I got to know him very well.

Marty joined the faculty at UCLA and did a really great job. He was an excellent professor and everyone liked him. I only had one graduate class with him.

Marty got into the use of seismic refraction surveying to characterize site conditions. He was pounding on the ground and measuring the results of the impact at various locations and types of soils. He never had an opportunity to do anything going down vertically which we thought was important. I told him we had a job coming up at the Civic Center in Los Angeles on Bunker Hill that had pretty uniform shale material that would be worthwhile testing. So we drilled a hole and put the instrument at successive depths, while Marty hit the ground with his sledgehammer. That started the thing recording, so he got some records on instruments spread out horizontally and vertically as well. We did a lot of work on the transmittal of refractive velocities on that project. Then we did a couple of others that were not quite as thorough. But at least he used those results as a basis for predicting the ground motion from the focus of an earthquake to the point of concern based on the geologic conditions of the subsurface.

He did have some contact with Japanese researchers on that. He got some useful information out of that. It was premature in those days as we were not knowledgeable about these things, but they were good sites for that testing because of the uniformity of the soil that he was dealing with.

2.26 Question: What's the first big earthquake you remember?

L. C.—As a kid, I was in San Diego when the Long Beach quake happened in 1933 and we felt it in San Diego. That started all sorts of stuff when the school collapsed at Long Beach Polytechnical High School. That's the first one I recall.

In the 1950s, there was one in Kern County. I remember going up there and looking at buildings—I was with Dames & Moore at the time. I figured out that we weren't sure which direction the quake was coming from. Then I noticed all of the telephone poles had transformers and they all fell off in one direction. I thought well there's a tool to use in determining what happens in an earthquake. There was quite a bit of damage in Bakersfield and Kern County. We just took our store-house of knowledge and tried to adapt it.

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I was coming back from a meeting in San Francisco on 17 October 1989. I was on the plane waiting to pull back from the gate, and the plane started shaking. I looked out the window and I could see other parked planes shaking. The pilot said well we can't go yet because there's been an earthquake. They sent a guy out in a truck to check the runway to see if there were any cracks, and there weren't. So the pilot got us out of there as fast as possible. We were the last plane out of San Francisco for a day or two. It was the Loma Prieta earthquake in 1989.

2.27 Question: Where were you when the 1994 Northridge earthquake happened?

L. C.—I was in bed in Marina del Rey in a three-storey wood frame condominium that did a lot of shaking but nothing serious. Although our condominium association people tried to collect from the insurance company for cracks in the garage floor which had been there for years before, and had been patched.

I remember going out after the San Fernando quake (9 February 1971) when the Olive View Hospital was being built and it had fallen apart. Jim Slosson and I and some fellows from USC went out and looked around at it. That was a disaster that shouldn't have happened.

2.28 Question: A lot of the geotechnical companies in the 1980s got into the environmental side of things. It's my impression that your company did not. Is that true?

L. C.—That's not quite correct. In 1982, we merged with Law Engineering out of Atlanta and LeRoy Crandall and Associates was only doing soils work, not environmental. Law Engineering provided environmental services. In 1991, we became Law/Crandall and we did the name change so that they could promote environmental work and their environmental branch in the company. LC&A became Law/Crandall so there would be a chance to say we're not just soils stiffs, but we do other things too.

Glenn Brown's group, the engineering geology group, got into wastewater treatment, landfills, and water resources, but that was in the engineering geology phase. Environmental was something we initially stayed away from.

2.29 Question: Any good reasons why you stayed away?

L. C.—I don't know. At first, I didn't believe in a lot of it, I guess. There was a gas station on every corner and they all leaked a little bit. All this to do about we have to clean up everything. That didn't thrill me.

2.30 Question: You didn't do any of the hillside sites, right?

L. C.—No, well that was mostly in the tracts. I did get involved in the development of the grading ordinance. I was on a committee that the City of Los Angeles organized in the 1950s. We had a really bad rain in 1953, and some of the original hillside developments were really in trouble—homes were lost, streets were blocked. So the City decided they needed a grading ordinance, and I sat on that committee with Fred Converse and a few others. We worked with Bill Milburn of the City of Los Angeles and wrote the grading ordinance. The one thing that I insisted on is that they permit variations from the code values if you had an acceptable soils engineering report. That made soils engineering blossom here in southern California. Almost every time you could come up with a better soils value than the code would give you. Prior to that you used the code value, i.e., silty sand—1000 pounds per

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square foot, but silty sand could be sandstone or beach sand. So that insertion is still there in the code.

Somebody said to me once, why don't you go to New Orleans where they have worse soil conditions than anywhere else in the world. But it's all the same in New Orleans. They drive these 200 foot long piles—why would they need a soils engineer? It's lousy soil, but it's uniform.

At least in Los Angeles, we have the advantage of things being quite variable, from granite in the Hollywood Hills to lagoons and asphalt sands. And you never know exactly what you have, thank goodness, unless you've done a lot of work in the area. For that reason, the variability in the subsurface conditions and the willingness of the building department to accept findings based on actually studies and recommendations from a qualified firm caused this southern California area to be the most intensive soil engineering investigation area in the country.

2.31 Question: Did they put a limit on how far above the code values you could go? Was there anything in the code that said you couldn't go above X? So they trusted you as a professional?

L. C.—Well I think they have their own ideas. There was nothing in the code that I know of. You had to sometimes go down and meet with them and maybe make an adjustment. Mostly though, the City of Los Angeles is reasonable. One thing about our city is they never try to con you into slipping them a little money under the table or anything.

We did a refinery job back in the eastern United States, with one of our design engineer clients many years ago. I'm back there looking at the site with their people and they had the structural drawings all prepared. One of the guys said come with me to the building department in case they ask any questions about the soils, and we had just finished our report. So I went with him, and he had a big roll of drawings so he put them on the counter. There were several people there to wait on us. So the guy asked, 'How long before you'll be able to review this?' They are always in a hurry. The guy behind the counter said, 'See that stack over there, I'll add them to it, so it should be 2 to 3 weeks or so'. So my guy says 'Can you speed that up a little bit?' He reached in his pocket and pulled out two $100 bills and he slipped them in the roll of drawings. The counter guy says 'Well let's see what we can do'. The guy took the drawings and stamped them right there, never even looked at them!

2.32 Question: Was that in the 40s, 50s or 60s?

L. C.—In the 1950s, I guess. It was a big refinery. I didn't say anything then as I didn't want to stir up trouble for them, but it was quite common in order to get something done. The other thing in that town is I stayed at their hotel while I was there. I had the worst night of my life. There was a sign on the corner that said, 'Benjamin Franklin slept here', and I felt I had the bed he slept in, it was atrocious.

2.33 Question: Who were some of the men you worked with?

L. C.—Harry Seed (H. Bolton Seed)—I didn't have any projects with Harry and we didn't use him as a consultant. He was in the forefront of the experimental and analytical soil mechanics. He was active on the Seismic Safety Commission as the soil representative when it started originally, and he helped to form the Strong Motion Instrumentation Program (SMIP) in California. A committee was appointed to advise the state geologist where the instruments should be put. I was fortunate enough to be on that original committee and stayed on it until not too long ago.

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At that time everyone was oriented to putting the instruments in buildings. The Los Angeles Building Code had three instruments per building. [*Note*: At base level, mid-height, and at the top of the building.] We felt we needed to know what the (free-field) ground is doing to relate it to the building behaviour. We insisted then that they have free field instruments—put an instrument out in the open somewhere where it's unaffected by the building vibrations, and you would know then what the input motion was. So we gave the State a lot of advice about where the free field instruments should be put in addition to what money is spent on the building instruments. The City of Los Angeles had its own funding for the instrumentation of buildings that they got from their permit fees. They got so many instrumented buildings that they could not afford to have people out there gathering the readings. The State then decided that they should take over. I was on a committee that went to the Los Angeles City Building Department to talk them into letting the State take over the City program. That was a milestone that was helpful in getting the seismic instrumentation program going. Harry Seed was in at the very start, and he has since passed away. I didn't follow him, but I was appointed to the Seismic Safety Commission shortly after Harry left. I served on the State Board of Mines and Geology before the Seismic Safety Commission appointment. I had input there with regard to the seismic instrumentation that was going on.

Martin Duke and I were on this instrumentation committee at the same time. We would fly to Sacramento and back on meeting days. On one occasion, Marty said that everyone was talking about buildings—but what about the 'lifelines', he called them, the pipelines, roads, and bridges other than structures. They needed seismic input. I said, 'Marty, ASCE is the proper vehicle for that. Give me some info and I'll bring it up at the next board meeting'. I happened to be on the Board of Directors of ASCE at the time. So I brought the subject up at the next board meeting and they appointed a committee. Marty came up with the name for the committee: TCLEE, Technical Committee on Lifeline Earthquake Engineering. We got a committee appointed and Marty was appointed chairman to check out the interest among the members. Well, it caught on like wildfire. A year or two later, the committee became the Technical Council on Lifeline Earthquake Engineering, which is what it is called now. It's quite a group in terms of getting information together for a very important element of earthquake engineering.

Clarence Derrick—a structural engineer who worked as a freelancer with some of the major architects in the early days on the Los Angeles City Hall, Alfred Martin was on that too, and then the L.A. County buildings and the L.A. Civic Center. Clarence could quote you the Bible, he went to Notre Dame, and he got his master's degree in engineering. We got along very well, and Clarence was advising me what to do, what not to do, and how to do it. He made the first model study of a small, shaking multistorey building out of metal members stuck together. There was no split-second photography back then. He had a drop tube in which he dropped a bullet, he had a little contact in the tube that would activate his camera after X thousands of a second. He could set this contact for different timings, so he could take pictures of the shaking at different times. The table would shake back and forth and he'd get pictures showing how the frame bent. He taught as USC for a while, and wrote books. He refused to use the term 'seismic design'. He said it's 'aseismic design'; it's against seismic that we're doing here. Clarence Derrick was a super knowledgeable structural engineer and he was doing some fine leg work on the behaviour of buildings in an earthquake.

2.34 Question: When was the Century City Theme Towers development built?

L. C.—Probably in the early 1970s. That whole square block was dug out. They wanted a lot of parking, we do need cars here. The deepest part was 100 ft below street level. The average was about 90 ft. I thought that the New York World Trade Center excavation probably was larger on account of

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the height of those buildings. But it was only 80 ft? And it was not as big an area. Well when they dug it out after the planes crashed, I felt that ours was bigger.

There was a lot of earth that came out of the Century City project. The Playa Vista project got a lot of it. It was done in a swamp; they raised the grade quite a bit there, and wiped out the wetlands. [*Note*: Playa Vista is a large development in one of the last undeveloped areas in West Los Angeles.]

2.35 Question: Where the Playa Vista housing is now is on infill from the Century City project?

L. C.—It's pretty close to grade but we used a lot of the earth to pre-consolidate the soft material, put fills on top, 15-ft high. They had sand drains back then but they didn't spend that kind of money just to consolidate them. They had years to wait before they built it, and they're still working on it. That's the project we did the original investigation on and then the union boys put money into it and wanted union people running it, so we didn't finish the inspection.

2.36 Question: What about the 62-storey United California Bank building in downtown Los Angeles?

L. C.—We were approached to do the project. However, it turned out that Woodward-Clyde was a customer of the United California Bank in San Francisco. Woodward-Clyde said, 'Wait a minute, why aren't we doing that work because we are customers of your bank, and Crandall is not'. They got brought in to do it. L.T. Evans knew some big financier back in New York. So L. T. wrote to him, 'There's a big building going on here, United California Bank, and they're not considering me for the soils testing'. The financier contacted the people at the bank and said, 'Look I've got several million in your bank and I plan to move it all unless my friend gets a shot at this job'. So the bank dumps Crandall and hires both L.T. Evans and Woodward-Clyde to do this work. L.T. liked mat foundations and Woodward-Clyde liked drilled caissons. Neither would back off from what they wanted. So, the building has both types of foundations. Clair Peck told me later he spent $500,000 extra on that combined foundation. We would have put the building on spread footings.

Comment: You had super soils in that area.

L. C.—It was reasonably good stuff for that area. I was glad when the 73-storey (First Interstate World Center; Figure 5) came on because up until then, the 62-storey was the tallest one. We did all but two of the major buildings downtown using spread footings.

2.37 Question: Before we close, could you run down the names of some members of your staff that you remember being really helpful to make LeRoy Crandall & Associates become a great firm, other than Marshall?

L. C.—The initial partners in June 1954 were Fred Barnes, Leo Hirschfeldt and I. The three of us had all worked at Dames & Moore. They talked me into forming a separate company rather than going to San Diego for the San Diego Testing lab which I had almost promised to do. Shortly after we opened up Russell Weber who'd headed up the engineering at Dames & Moore in the LA office, decided he wanted to leave Dames & Moore and join us. He was a registered professional engineer which Fred Barnes and Leo Hirschfeldt were not. It seemed like a good idea to me to have a backup there. If anything happened to me the company would have a registered guy to operate it. So that

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was the initial nucleus. Seymour Chiu was probably the first engineer and he came from UCLA. Marty Duke would send people who he thought would work out. I think he told Seymour to come see us, and we hired him. Then I think Jimmy Kirkgard was probably next, and he was definitely referred by Marty Duke. Jimmy was very active in the company and we made him an associate very early. Jim McWee became an associate and worked with Russell Weber on the inspections. McWee was good at supervising people outside so he went with Russell Weber running the Inspection Department, which was about half the staff. At that time we had about 40 people, 20 were outsiders, and the other 20 were in the office in the lab and other office stuff like engineering. Perry Maljian is still working for MACTEC part-time. Bob Chieruzzi joined after Perry, and Jim Van Beveren now has his own company.

[*Note*: LeRoy Crandall and Associates merged with Glenn A. Brown and Associates in the early 1970s and two prominent engineering geologists, Glenn A. Brown and Mervyn E. Johhnson joined LC&A as associates.]

Well, it kept them on the team, and they shared in the profits. The only ones that had a stake in the office building we built though were Crandall, Weber, Hirschfieldt and Barnes. They bought and paid for the office building that was rented to the company. Then Law Engineering acquired Crandall but they wanted bigger quarters. We had designed the building to add a second floor if we ever expanded. But they moved to rented space on Grand Central Avenue in Glendale by the former airport in 1985.

2.38 Question: You've been through all of the different parts of geotechnology with your office. What part did you like best? What did you like to pass off to others, and what would say I'll take care of that myself because I enjoy that kind of thing?

L. C.—I guess I was a rat because I passed almost everything off to others. I kept the privilege of reviewing the reports. I think I signed every report up until not too long ago. I actually reviewed every rough draft in the whole office. The signatures were the project engineer, the engineering geologist, and then I co-signed it as the final reviewer. I don't know whether I did any good or not.

3. CONCLUSION

I am not very good at predicting the future, but I will give it a shot. One thing I believe I can say with confidence is that geotechnical engineering is not only here to stay but will be even more important in the future. As our cities and traffic continue to grow, more tall buildings will be needed, together with subterranean parking and subway construction. Also, residential construction will be forced into areas of less desirable construction conditions.

Of particular concern will be the effects on buildings and structures due to ground motions caused by major seismic events. In my opinion, the greatest development in geotechnical engineering in the future will be in the field of earthquake analysis and prediction of foundation behaviour during earthquakes. Geotechnical engineers should have a prominent role in this area.

As is well known, the advent of the computer has greatly changed the practice of all branches of engineering. This is certainly true in geotechnical engineering, and it is likely that further developments will continue to modify the practice. However, I am concerned that engineering judgment tends to be overlooked in the use of computers. I believe engineering judgement is an essential part of good engineering practice, and we must make every effort to develop this ability in our future engineers.

Although there has been a great advance in the development of foundation construction equipment, there probably will continue to be further developments in this area. The continued development of

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equipment and construction techniques will be of great value in geotechnical engineering in the future.

I have no doubts that the future generations of engineers will receive adequate training in their fields as they assume the responsibility for future construction. I hope that the training will include the development of basic judgment as well as computer skills.

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