CONNECTIONS

The EERI Oral History Series

Henry J. Degenkolb

Stanley Scott
Interviewer

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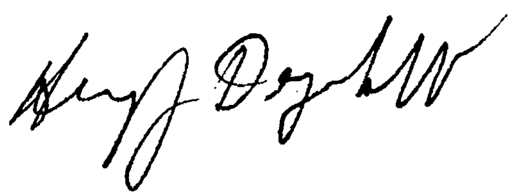

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Earthquake Engineering Research Institute

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Thanks are also due to the children of Henry Degenkolb, in particular Henry's son Paul, who spent hours culling Henry's meticulously cataloged photo collection for pictures *of* Henry rather than *by* Henry. Out of over 30,000 photos in the collection, precious few included Henry himself. Patty Degenkolb Blanton and Virginia Degenkolb Craik also combed family albums to find photographs to contribute to this volume.

The help, encouragement, and editorial feedback of EERI Executive Director Susan K. Tubbesing, the EERI Board of Directors, and Publications Committee Chairperson Gerald Brady were also 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 first volume in *Connections: The EERI Oral History Series.* The Earthquake Engineering Research Institute has initiated this series to preserve some of the rich history 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 to tell. *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, 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 these stories be told in *Connections.*

The oral history interviews on which *Connections* is based were initiated and are being carried out by Stanley Scott, research political scientist at the Institute of Governmental Studies at the University of California at Berkeley. Scott has himself for many years been active in and written on seismic safety policy and earthquake engineering. A member of the Earthquake Engineering 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 the Degenkolb interviews in 1984. The wealth of information obtained from these interviews led him to consider initiating an oral history project on earthquake engineering and seismic safety policy. Oral history interviews involve an interviewee and interviewer in recorded conversational discussions of agreed-upon topics. After transcription, revision, and editing, the interviews and the tapes are placed in the Bancroft Library at the University of California at Berkeley for research purposes and scholarly use. Occasionally, interested professional organizations sponsor publication and wider distribution of interviews, as the Earthquake Engineering Research Institute is doing with *Connections.*

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 been continued on his own, following his retirement in 1989. Modest funding for some expenses has been provided by the National Science Foundation. The John A. Blume Foundation also made a contribution.

The recordings with Henry Degenkolb thus began what has grown into a more extensive program of interviews with earthquake engineers who have been particularly active in 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. The suggestion that the Earthquake Engineering Research Institute publish the Degenkolb interviews, and perhaps others, led to a formal decision that the Earthquake Engineering Research Institute initiate an oral history series, which begins with this volume.

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

Interviews completed or nearing completion include:

John E. Rinne
George W. Housner
William W. Moore
Michael V. Pregnoff
William T. Wheeler

Interviews with several others are in progress.

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Foreword

The recorded interviews on which this book is based did not begin as a formal oral history project, but grew out of discussions that took place during meetings of a committee advising the Association of Bay Area Governments. Henry Degenkolb and I were both members of that committee. Pronounced differences of opinion emerged between Henry and a lawyer member of the committee regarding liability for earthquake damage or injury. Henry argued that for engineered structures, code compliance alone does not give sufficient assurance of adequate earthquake resistance, and that the exercise of sound engineering judgment is also essential. The lawyer argued that code compliance was sufficient to determine liability.

Henry and I agreed to discuss the issue in more detail, and on tape. How could the critical role of engineering judgment be explained more effectively to lawyers and lay persons? When this topic proved too limiting, we expanded the interviews to cover Henry's reflections on the development of earthquake engineering over the years. From January 30, 1984, until May 21, 1986, we met regularly in the library of H.J. Degenkolb Associates on Sansome Street in San Francisco's financial district.

The Degenkolb interviews prompted several associates and me to consider the merits of initiating an oral history project on earthquake engineering and seismic safety policy. These discussions included Willa Baum, Head of the Regional Oral History Project at Bancroft Library, University of California at Berkeley; Harriet Nathan, Institute of Governmental Studies, UC Berkeley; and Robert Olson, VSP Associates, Inc. of Sacramento, CA. Our idea was to use oral history methodology as practiced in the UC Regional Oral History Office, which has been interviewing well-placed participant-observers on major developments in the history of northern California, the west, and the nation since 1954. While the Degenkolb interviews were still in progress, a decision was made to begin the oral history effort, with Henry as advisor. Meanwhile, the interviews with Henry were completed, and the process of editing, correcting, and revising proceeded, although at a relatively slow pace because of his many other activities. One or two more interview sessions were planned to conclude the series, but were never conducted because of Henry's long illness, and his death in 1989.

While the Degenkolb interviews have been edited and reorganized for publication, the gist of the text conforms closely to the language of the interview transcripts. Thanks are due to the staff of H.J. Degenkolb Associates for their careful work in reviewing and checking the manuscript; to Gail H. Shea for editing and reorganizing the material; and to the EERI staff for their support and help, enthusiastically given. I also gratefully acknowledge the contribution of Maria Wolf, my former secretary at the Institute of Governmental Studies, who years ago transcribed those many hours of Degenkolb and other tapes and set up the oral history project files that I have been using ever since. I also owe a special debt of gratitude to Frank McClure, who suggested many fruitful lines of inquiry for the Degenkolb interviews that elicited interesting and valuable responses. Frank thus shares credit for the comprehensive and thorough coverage Henry's interviews achieved.

I hope all who contributed to this project are pleased with the outcome. The Degenkolb recollections provide invaluable background on earthquake engineering history, seismic design theory, and the development of structural engineering. Henry's style, personality, professional leadership, integrity, and intellectual penetration are clearly shown in this book's intimate profile of one of California's great earthquake engineers.

Stanley Scott
Research Political Scientist, Retired
Institute of Governmental Studies
University of California at Berkeley

November 1993

Introduction

Henry Degenkolb began practice as an engineer in 1936, shortly after his graduation from the University of California at Berkeley. He entered the profession at a time when traditional structural design practices (designing for vertical loads only) were just starting to be called into question. The poor performance of many structures in the 1925 Santa Barbara earthquake, and especially the failure of many public schools in the 1933 Long Beach earthquake, caused some of the more forward-looking engineers of the day to think critically about design and construction practices and the influence they have on the way buildings perform under loading—particularly seismic loading. The experiences of older engineers who inspected schools and helped develop standards and criteria for the Field Act became part of Degenkolb's early education.

It was under these engineers that Degenkolb began work on his first job in 1936, designing structures and inspecting construction for the World's Fair that would open in 1939 on Treasure Island in San Francisco Bay. Degenkolb worked for three years on the World's Fair, then went on to work in the offices of many of the early engineers who pioneered advances in structural design and engineering thinking—Henry Brunnier, John Gould, Henry Dewell, L.H. Nishkian, Jessie Rosenwald, Austin Earl, Gus Saph, and others.

In those days, engineering was more of an itinerant profession, with engineers working a few months here and a few months there, wherever there was work, often working at two or three jobs simultaneously. "It was a way of life," Degenkolb said. Along the way, Degenkolb participated in a wood truss testing program sponsored by the timber industry, which was the most comprehensive testing of wood construction and detailing up to that time. He worked for three years designing "any kind of wood thing built" as chief engineer for Summerbell Roof Structures, including glue-laminated truck body parts. He designed the outside forms for concrete ships, ski lifts at Sugar Bowl ski resort, and worked on the Head Tower at Shasta Dam. Working in his own garage he designed experiments that used a car jack to test the deflection characteristics of wood diaphragms in response to loading.

The young Degenkolb was a fast learner and a critical, intuitive thinker. His varied early experience allowed him to observe many design practices, and he incorporated what he considered the best into his own philosophy and practice. He also began what was to become a hallmark of his professional life: investigating earthquake damage and determining what implications it held for improving the design of structures. Degenkolb called it "earthquake chasing," and felt it was the only way to "see the discrepancy between our theories and what actually happens." Perhaps more than any other aspect of his practice, earthquake chasing enabled him to develop innovations and contribute significantly to advances in the way structures are designed and built.

Degenkolb joined John Gould as chief engineer in 1946. Ten years later the two became partners, forming Gould and Degenkolb, Engineers. After Gould's death in 1961, Degenkolb continued the firm as H.J. Degenkolb and Associates.

Degenkolb felt that engineers must design and build for toughness and ductility, and that these concepts must be incorporated in building codes and standards. This commitment led him to devote a great deal of his professional time to pro bono public service. Degenkolb was active in and consulted on most of the major seismic safety issues of the past forty years, including the Hospital Act, the LNG Seismic Safety Review Panel, the President's Task Force on Earthquake Hazards Reduction, the Seismic Safety Commission, and many more. He was active in many professional organizations, including the Structural Engineers Association of California, the Earthquake Engineering Research Institute, the American Society of Civil Engineers, the Seismological Society of America, and was a member of the National Academy of Engineers. He authored 26 papers and publications and received numerous professional awards and honors, including the ASCE Ernest E. Howard Award in 1967 for preeminence in earthquake engineering.

Through the years, Degenkolb became internationally known. His innovations, insights, and hard work have affected lives around the world by making buildings structurally safer and public policies and building codes stronger. He believed in bringing younger engineers along—mentoring them—so that the profession he loved would continue to advance.

Henry Degenkolb died in December 1989. He leaves behind a rich legacy of innovative engineering practice and principles, as well as a profession that was significantly advanced through his intuition, observation, practice, and love.

Gail H. Shea
Editor, H.J. Degenkolb Oral History

Chapter 1

Early Days

"I've never known a time since I was a kid that I wasn't going to be an engineer."

Scott: What got you interested in engineering?

Degenkolb: I've never known a time since I was a kid that I wasn't going to be an engineer. I was going to be an engineer since I was 3 or 4 years old. I never even thought about it.

Scott: Were members of your family engineers?

Degenkolb: No. I was the oldest. My father was a minister. I have two brothers, though, who also became engineers.

Scott: Do you know what got you interested? Did your parents buy you a tinker toy set at one time?

Degenkolb: I remember once when I was about 4 or $4^{1}/2$, and I was with my grandparents on a farm up in Wisconsin, and I remember the harness shop. Boy, I was playing around with rivets and straps. I tried to put the harness on the dog and got bit. I had no idea what the harness was for. But I always liked mechanical things. I never knew anything else. Becoming an engineer was not a conscious decision.

Awareness of Seismic Design

Scott: When did you first become aware of seismic design as a significant issue? Can you trace the development of your activity in earthquake engineering?

Degenkolb: Our awareness of seismic safety really started with our actual work. We had nothing on it in school [Degenkolb graduated from the University of California at Berkeley in 1936]. At least I didn't, and I don't think Les Graham did at Stanford. Les and I started together over at the [1939 World's] Fair.[1] We worked there with John Gould, who had been in charge of setting up the Appendix A, that's Title 21, after the Long Beach earthquake in 1933 and the Field Act. John had just come from the Division of Architecture and I would guess that maybe a third or half, or maybe even more of those involved in the Fair—of the senior engineers—had also come from Sacramento. I remember Stan King had worked in Sacramento. [Al] Paquette had, Pres Jones had. So they were all very conscious of earthquake concerns—though wind resistance governed most of the design in wood at that time—and as a result we were sort of brought up with it [seismic safety]. Lateral forces and details relating to that were important. Then that followed through into private practice, where I worked for a lot of these engineers, and of course they were concerned about earthquakes.

Experience in a Dozen Offices

Degenkolb: In my day there wasn't enough work to keep an office like this going. You'd only have one or two men, and then when you got a job you'd hire five or six more, and then have ten men, or whatever. So I had the advantage of building up my experience in many offices. I look back now and say it was an advantage, although in those days it seemed horrible. You got paid by the hour, with no overtime, no vacation. You finished a job in one to three months, and about a dozen of us draftsmen and engineers were floating around from office to office. In the Depression and the early war years there wasn't enough work to keep a staff.

Fortunately we kept busy, although it was nerve-wracking at times. While I wasn't out of work, I'd always wonder about it. But I had the advantage of working under all these people. I saw how [L.H.] Nishkian did things, how [Henry] Brunnier did things, how [John] Gould did things. I had discussions about designing with all of them, and with people like Gus Saph. I think that was a hell of an advantage, because out of that I could pick what, based on my experience and background, I considered the best of each office's practice. I worked in about a dozen offices. You did what the boss wanted, and different bosses had different ideas. I got exposed to lots of different approaches and theories. I think it was a tremendous advantage. I think all the old-timers did that.

Scott: What was your first job?

Degenkolb: My first job was the World's Fair '36-'39. I did the analysis—six months out of school—on the Tower of the Sun. I did the analysis on the big main arches, North Square Court. I got involved in a lot of it.

1. The Structural Engineers Association of Northern California (SEAONC) recommended two recent university graduates, Henry Degenkolb from Cal and Leslie Graham from Stanford, to work under the engineers preparing the World's Fair of 1939 on Treasure Island in the San Francisco Bay.

John Gould and L.H. Nishkian

Scott: Would you talk a little about the early days, how you got started, your eventual partner, John Gould, what was going on in engineering when you started out?

Degenkolb: Let's start with John. John came from Switzerland in 1923 and spent some time in New York as an engineer. He had graduated in Switzerland. He came out to the west coast, and in 1925 joined L. H. Nishkian's office. Evidently they did quite a few things—I know they used to do theaters—the Fox and Paramount Theaters in Oakland. This would be in the latter '20s, up to the Depression. Nishkian was, at the time, an advocate for the flexible first story. They also did a lot of work for the Capital Company, which was the construction arm of the Bank of America. Since the bank made loans, they got quite a bit of work that way.

The Depression, the Field Act, and the Bridges

Degenkolb: That was up to the onset of the Depression. Then in succession we had the Depression, the Long Beach earthquake of 1933, the building of the two big bridges, and the construction work for the World's Fair. Each of these had a major influence on structural engineers in California, and especially in the [San Francisco] Bay Area.

When the Depression came, most of the engineers who were employed in most offices had to go. There was no way to pay them, there were no jobs coming in. Then the Long Beach earthquake occurred, and frankly, that was a gold mine for the structural engineers. They had been out of work, and here the schools were shown to be so bad that they all had to be examined—at least in districts where the school boards were concerned about them. The review of existing schools was voluntary on the school board's part. The structural engineers had to write the regulations for designing new public schools. We called it Appendix A, now it's Title 21. John [Gould] was the number two or three man up in the State Architect's office[2] and did a lot of the writing of the codes, reviewing of buildings, and also enforcing the codes.

Scott: This was shortly after the Field Act was passed?

Degenkolb: This is immediately after the Field Act's passage.

Scott: Did Gould leave Nishkian to take the job with the Division of Architecture?

Degenkolb: No, I guess he was already out of work before that. Most of the guys I knew and grew up with technically had been out of work, because there were no structural jobs, except for those who were working on the Bay Bridge and the Golden Gate Bridge. Those were the two big jobs going on then. If you weren't on one of those jobs, or working for one of the bridge contractors, things were pretty poor.

Then the Field Act came, and of course the Division of Architecture had to be built up. All this is sort of secondhand background, and I

2. The Division of Architecture, the Office of Architecture and Construction (OAC), and the Office of the State Architect (OSA) all refer to the same State of California office under different names at different times.

don't know the details. I do know that John had a lot to do with the writing of Appendix A—the regulations for the Field Act—and also with enforcing them. Then he was chosen as chief engineer of the San Francisco Bay Exposition Company of Treasure Island. That would be around—I started work there in May 1936, so maybe it was late '35 or so.

Preparing the World's Fair: 1936-1939

Degenkolb: The San Francisco Bay Exposition Company designed the structures for the World's Fair, the filling in of the island. Most of the senior structural engineers who were working on the Exposition had been involved in the schools program.

I remember the stories they would tell of going into places like Berkeley High School and finding the trusses on the verge of failure, so they'd have to prop them up. They'd go to another school that had called them in. Everything would look nice on the outside, but up in the attic they would immediately see the need to start shoring—the basic tying together and all that. So I was steeped in the schools' experience in my first job, because practically everybody, at least the senior engineers, had come from that environment. So we designed the Exposition buildings and some of the buildings for the private exhibits, with their experience in mind.

As an aside—in 1924, when Herbert Hoover was head of the U.S. Department of Commerce, he organized a National Committee on Wood Utilization. A big study was made (it came out in an orange cover, I remember[3]) about the better utilization of wood. It studied all the different types of fastenings that were used in Europe. Out of all of these different fastening systems, they picked a split ring, and something that was called a Baumann connector, which was a forerunner of shear plates. We at the Fair were the first ones to use those [Baumann connectors]. A. C. "Jack" Horner was the guy that founded the Timber Engineering Company and brought those in.

The South Towers—I remember when we designed those, we didn't even know what the connectors were. All we knew was that a pair of them would develop about 12 kips, and then I observed the tests at UC Berkeley, where we developed these [design values] and the spacing and all that. Our common name for the towers during design was "South Towers." They were designed architecturally in a South Pacific style and were later called the Cambodian Towers.

Scott: For the record—what is 12 kips?

Degenkolb: Twelve thousand pounds, working load for stressing. [The connectors were] like a bolt, except they're shear plates or split rings, transferring stress from one piece of wood to another. A pair would transfer twelve thousand pounds of working load, which means you'd have an ultimate load of 35 kips or something like that. Twelve kips is the design load based on working stresses. The factor of safety at ultimate load should be about 3, so this

3. *Modern Connectors for Timber Construction.* Report prepared by the National Committee on Wood Utilization (U.S. Department of Commerce) and the Forest Products Laboratory (Forest Service, U.S. Department of Agriculture). U.S. Government Printing Office, Washington D.C., 1933.

assembly should not fail before reaching an ultimate load of 35 or so kips.

We acted as the local building department for Treasure Island—as part of the city. Rather than having everything come through San Francisco's Bureau of Building Inspection, it came through the Exposition office. Then, later on when they started some of the construction, another fellow and I were in charge of the exhibits. He had the inside exhibits and I had the outside ones. I checked the roller coasters and the airplane rides. We checked everything, just like the building department, except we did it pretty thoroughly.

Scott: Was this a regular checking, a periodic checking or sort of a one-time matter?

Degenkolb: This was periodic. They'd [the private architects and engineers hired to design the structures and displays] submit the drawings, you'd review the drawings and make criticisms, and they'd correct them. Then we'd review the work in the field. We went over every week, and we'd go through the darn buildings when they were putting them up. Just like a competent local building department would do. We were all on salaries. A senior engineer got $400 a month. I think John [Gould] got $500. I got $110 a month. That was good pay in those days.

After the Fair

Scott: That was the beginning of your working career?

Degenkolb: Yes. And I worked there for three years until 1939. Then the Fair didn't go over so well, and they kept it open an extra year. John stayed there. I went to work for a lot of the local engineers. I'm one of the last of the guys that worked like they did in the old days. Engineers didn't have steady jobs. You worked a month here, three months there, six months there, then you floated on to the next job. That was a way of life. Like a construction man, you went where the work was. They didn't have offices like we do now. It was an educational thing, an excellent way to see how different guys do design—different philosophies.

I worked for [Henry] Brunnier for three months on West Mission Junior High School. I forget the sequence after that. I worked for Henry Dewell and Austin Earl on the Head Tower at Shasta Dam. After a few other jobs like that, I worked for Henry S. Howard, who had a joint venture with [Gus] Saph and [Matt] Simonson up in Sugar Bowl, at Soda Springs. I worked under Saph for a few months when he designed the ski lift up in Sugar Bowl. He designed the big building or lodge or whatever it is. That would be the fall of '39.

At that time, the draftsman [at Sugar Bowl] was pretty friendly with ASCE [American Society of Civil Engineers]. ASCE used to have an employment service for engineers, and the draftsman had a friend who was in charge of it. Those two got worried about me not having work. There was a request for designing concrete tanks up at Tacoma for American Smelting and Refining—a big copper plant. I wasn't too interested, but I filled out the forms and they sent them in. Anna and I were married September 9 [1939], and we went up to Anna's folks for Thanksgiving, in Portland. A wire came up there to proceed up to Tacoma for an interview with the chief engineer. They offered me a job with fantastic pay—$250 a month. So I stayed there while the tanks were built. I designed them first, then supervised their construction in the field.

But then I had to come down here and oversee the stringing of the cable for the first Sugar Bowl ski lift. That thing, I understand, is still in operation in the Great Smokies. I've never seen it. I've often wondered if after 45 years it's still working.

Scott: They took it down and moved it to the Great Smokies and cranked it up again?

Degenkolb: The last I heard, a few years ago, that's what they did.

Timber Testing Program

Degenkolb: Then in 1940, I came back down to San Francisco and did the timber test program. The timber people and ASCE, through West Coast Lumbermen's Association, and the San Francisco section of the American Society of Civil Engineers, and the Forest Products Lab in Madison, started a testing project in wood. We had these tremendous timber buildings over on Treasure Island that had been used for three years. Anyway, they made an arrangement with WPA [Works Progress Administration]—with a lot of backing from City Hall. Ralph Wadsworth was San Francisco's chief administrator or head of public works, I think it was head of public works. He was also WPA administrator—or maybe it was one after the other.

It was decided that we should test all the buildings that we could. The timber people raised $10,000. They got a WPA allotment. The university was in back of it, but didn't put any money into it. John [Gould] was the chief technical director, and I was assistant technical director for acquiring specimens and testing them. These were used trusses. We tested about 23 trusses, some 100-odd joints, and plywood, which was fairly new then as a structural material. For a couple of years we gathered these specimens, built a big testing machine, bought some jacks and rams. We tested everything to see how strong it actually was, and then wrote up our own report. A lot of the building code requirements for timber came out of those tests. It was the most comprehensive testing of timber construction up to that time.

Scott: When was that done?

Degenkolb: That would be from June of 1940 up through May of 1942 or so. We finished up about that time.

Scott: Was the testing project done in connection with the war effort, or was it done because the timber people and the engineers thought, "We've got these structures and it would be a good time to learn something?"

Degenkolb: It was separate from the war-related work, and it was just a good time to learn something. I gathered all the specimens. John was nominal head, but I was the guy out in the field all the time, who did the computations and everything else.

We had a committee from ASCE overseeing us. Harold Hammill, one of the consulting engineers, and Henry Dewell, who at the time was head of the State Board of Registration [for Professional Engineers and Land Surveyors].

He had been president of the structurals; he was a very famous engineer. As a matter of fact he was the chief engineer in the 1915 Panama-Pacific Exhibition. He wrote a book on timber design—a very good one that's been out of print for 30-40 years.[4] The other one was Jack Horner—A.C. Horner—who until 1933 had been a building official, and was one of the founders of the Pacific Coast Building Officials Conference (which is now ICBO), which wrote the Uniform Building Code.

This was 1940–41. And I used to work part-time for Gould and also worked on different things as a consulting engineer. John was a consulting engineer. He would design and I would design. We did a lot of Woolworth buildings. Later we worked on Bank of America branches. Did a bunch of stuff like that—whatever came up. During World War II, work slacked off. We finished the timber testing program. I turned down a commission with the Marines—thank god I did—because I wanted to finish up the project. That was in '41. Then things slacked off in '42.

Work at Summerbell

Degenkolb: Up to this time I'd been "pure," I'd always worked with consulting engineers and looked down on materials people. A friend of mine had been chief engineer of Summerbell Roof Structures of Northern California, which designs, manufactures, installs, and sells timber trusses. It was late in 1943, and he was leaving to set up his own office in the city, so his position was vacant and they asked me if I wanted it. I had always looked down on that kind of job. But Christmas was coming with no work in sight, so I became chief engineer of Summerbell and I stayed for three years. It was the Depression and war years, and things in consulting engineering were slow.

Summerbell was a contractor, and I was chief engineer. So I'd design a truss, and they would build it and erect it. Or if some other engineer designed it, we would shop detail it and fabricate it and erect it. We were basically a contractor that specialized in wood.

I was there for three years, during which we designed any kind of wood thing built. Most of the style of trusses that you see that have metal plates—I didn't invent them, but I resurrected the system from the 1800s and I promoted them. I said it was the cheapest way to do things. As a matter of fact, most of those trusses down on Cannery Row, in Monterey [California] are mine. I did the first glue-laminated stuff around this area.

When building was scarce, Summerbell took a contract for furnishing wood truck body parts for Chevys and Studebakers, so I had to devise a system. We had a good purchasing setup for getting lumber out of Oregon, fabricating rough sizes, kiln drying it—we had to design our own kiln—and then fabricating it with all the holes and stuff needed for the truck body parts.

My work at Summerbell lasted about three years, until around May 1945. I could have stayed there as long as I wanted, but it was basi-

4. Dewell, Henry, *Timber Framing*, Dewey Publishing Co., San Francisco, CA, 1918.

cally contracting, doing timber all the time. And I am an engineer, not a contractor.

Designing Concrete Ships

Degenkolb: At that time, which was during World War II, [Bill] Ellison, and later Stan King, who I had worked under at the Fair, were designing the concrete ships that were built here [in California], in National City [southern California], and on the east coast. Actually they were barges, built because steel was short. Stan loved to talk. He was a very good engineer and he twisted my arm, so I designed the outside forms for the concrete ships. At one time I had three jobs—working for Summerbell, working for John Gould, and working for Stan designing concrete ships. Today we frown on moonlighting, but in those days everybody did it in order to get things done. We always had two jobs and quite often three jobs that we would juggle, and everybody knew it.

I had six architects working for me [on the concrete ships]. I would work at night and do some designs, and then they would draw it up. To draw up ship bracing and things like that is very complicated, because you have to match the water lines with the transverse sections or shapes, and they're all curves. It takes a lot of just plain drafting ability. Each one of the six architects had his own private office, but there was no architectural work, so they were working in structural engineering designing the forms.

That's the only time in any of the shipyards that they used the forms a second time. Generally, they built them for the first time and found out everything that was wrong, so then they'd change the forms for the next ship. Ours they used all the way through. I was rather proud of that.

Chapter 2

The Degenkolb Firm

"It also means that we're willing to say 'no' to architects for certain types of designs. If we don't think it's sound and can't convince them to change, we let somebody else do it."

Scott: Would you discuss the development of the Degenkolb firm, which I guess evolved by degrees out of the Gould firm, which you joined in 1946?

Degenkolb: I had been working nights for John [Gould] off and on. He was getting more work and needed somebody, so I joined him in 1946 as chief engineer. There were three of us: John, Tom Treverton (a draftsman), and me. Also a couple of night draftsmen. John had just picked up a job through Aleck Wilson, an architect, doing phone company work—and also Woolworth in those days provided a good portion of our work. Woolworth built and owned their buildings. Nowadays it's all in shopping centers and it's leased. We designed dozens of Woolworth stores and telephone company buildings. We did almost everything for PT&T [Pacific Telephone and Telegraph, now Pacific Telesis] from Bakersfield to the Oregon border—we did about 90% of that work. Another one or two engineers did some of the work once in a while.

John and I used to argue. He'd see things one way—he's Swiss—and I'd see things another way, and we used to argue a lot. He was a good engineer and he was absolutely professional and thorough. He was very active in the Structural Engineers Association [of Northern California (SEAONC)], which was a very small organization at that time.

The Partnership and the Corporation

Degenkolb: So we kept doing jobs, and after a few years [in 1956] I became partners with him and the firm name became Gould and Degenkolb, Engineers. That was about the time we did the Fireman's Fund Building out on California and Laurel [in San Francisco]. It was the main office, but has since been purchased by UCSF. We did a lot of jobs all over.

In most engineering offices of the day, there were one or two principals, and between jobs there'd be just one or two people in the office. Then they'd get a job and they might have five or six hired for the job. That was the traditional old way of doing it. Nishkian tried to keep an even flow of work, so they were more steady. And that's what we've always tried to do. John ran the office more like Nishkian. We didn't take on somebody until we needed them for a while. Don Smith, our draftsman, was just a kid out of the Army when I first met him. He's been a steady employee ever since.

The young ones after World War II, and during the latter part of the war, landed in one office and stayed there. They didn't have the advantages of seeing different design attitudes and procedures. So Loring [Wyllie, now Chairman of the Board of Directors of H.J. Degenkolb Associates] hasn't worked in another office. Tom [Wosser] has, but only briefly. He set up shop down south with a partner for a year or two, then after John died I tried to get him back and succeeded. But most of our young people have never worked in another office. So, to my way of thinking—but nobody else's—I think that's a drawback. They are continuing my prejudices without evaluating them and comparing them to others' practice.

But here we try to have different individuals contribute. Once a month we have a brown bag lunch, and somebody describes a job or some research or something like that. It used to be that nobody would argue with me, nobody would even question me. While that may seem flattering, I don't think it's good for an engineering office. They've been trained now to speak out. They do a little arguing. It takes some discussion. John and I used to fight continually. We were good friends, but when it came to technical matters he had his opinions and I had mine, and the secretary often thought we'd come to blows. I was never bashful about expressing my opinion.

John did promotion. I was never very good at that. Generally, John ran the office—that is, the business, the contacts, the management—and I was the center of the back room. I ran the drafting and the design and everything like that.

Then John died of a heart attack in January of 1961. We had about 12 people then—and things were a little rugged for a while. I bought out his interest. We had a buy/sell agreement between the two of us, and we were a corporation by then, thank god [the corporation was formed in 1958]. If it had been a partnership, it would have been awful. Little things like paying the payroll, writing a check—if we'd been a partnership I couldn't have done it. Everything was ongoing, though, and we just continued to do work.

Woolworth

Degenkolb: About that time, or before that I think, the Woolworth work, while we still did everything they had, they didn't have much to do. Most of the stuff was rearranging counters, which they did themselves. Once in a while, they'd run into a problem and have a truss failure down in Las Vegas or something like that, and they'd call us in. They used to provide the bread and butter jobs. We always had two or three Woolworth jobs—new buildings or major remodelings or leases like the Flood Building. We did the big Woolworth store there, which involved remodeling the first couple of floors and the basement.

Phone Company Work

Degenkolb: Then the phone company was in a big expansion after the war, and we had a lot of phone company jobs. We changed the design, which now is generally the one still being used. They were very hidebound, doing things the old way. They had been using mostly steel. We changed them into concrete jobs. Because for 2-3-4 stories and the type of buildings they were building, concrete structures were much more economical, much more workable and safer buildings.

Scott: You mean economical in the sense of costing less to build?

Degenkolb: Cost less to build, are easier to maintain, safer, more adaptable for installing and maintaining the mechanical systems. The way we built them, they are as safe as or safer than any steel.

Scott: You're talking about an equipment building—would this be a reinforced concrete building you're talking about—of how many stories?

Degenkolb: Four stories, maybe up to six. We did one in Santa Rosa that was 6 stories, but generally in the 2-3-4 story range.

Scott: So their practice up to a point had been steel buildings, and you convinced them that concrete had these merits. When did that happen?

Degenkolb: In the late forties. In the same era when we did Park Merced,[5] which was the first flat plate job without any beams and all that stuff—eleven 13-story buildings (concrete) with a lot of walls. We used walls as columns. That was a real advance: instead of using beams and slabs, we used just slabs—we call it flat plate now. Just envision a bunch of books as partitions or walls and you just have a flat plate on it, where ordinarily you'd have columns and beams and then a plate.

Scott: What would the plate consist of?

Degenkolb: A concrete slab, 7" or 8" thick. Now it's old hat, but in those days.... See, you developed from wood beams and planks to steel beams and concrete slabs. And now hotels up to 13-16 stories are just walls and a plate, a slab. It's sort of evolutionary. We [Gould and Degenkolb, Engineers] did the first flat plate stuff.

5. Park Merced is a large residential complex of eleven 13-story apartments and condominiums, including five garages.

Scott: So the Park Merced and telephone company work would have been after the war?

Degenkolb: Yes, in '46, '50, '55, something like that. The districts of the phone company are generally regulated by how many phone lines there are—the number of telephones. So after the war, for I'd say 5-7 years, the San Francisco office handled everything, as I say, from Bakersfield to the Oregon border. We did the jobs in Eureka, Chico, Bakersfield, Fresno, Sacramento, Watsonville—you name it, wherever.

You don't design telephone company buildings like you design your local store. It's an emergency thing. They have heavy equipment, and you have 30 or 40 pounds per square foot of cable just connecting the equipment. You don't worry about getting the absolute lightest section, you want something that is going to be stiff and doesn't vibrate under the equipment. Because of heat, the equipment needed a lot of HVAC cooling. And now because of security needs, which wasn't a problem in those days, you have very few windows. You want a sturdy equipment building that is dependable.

And certain things become extremely important that ordinarily aren't. For example, the [telephone company] building on Mountain Boulevard in Oakland crosses the Hayward fault. We wrote letters trying to get them to change it, but the cabling layout and the distribution is such that the location is a gamble they can take, even putting it on the fault. In protecting them, we put in the hugest slab, I think it's about 10 feet thick. You always have a cable vault, which is one-story deep and as wide as this room—not quite—where you bring the cable in underground, and then from there it goes up through the main frame for distribution through the equipment. We built that thing so the cable vault would never shear off from the rest of the building. They say you shouldn't build on a fault, but where there are other considerations that make it necessary, then you do all kinds of things. That's one reason why I believe that an average engineer should not be checking a telephone company building.

Generally, you do not have problems with the telephone company trying to chisel the last cent out of a building. They want good buildings. Of course they keep unit costs and compare them with the rest of the country. We have the earthquake problem, so the unit costs out here are usually higher because of earthquake considerations. But that's generally recognized as part of the cost of doing business in a seismic zone. The phone company has always tried to do the right thing.

An Anchoring Issue

Degenkolb: The new electronic switching gear is a different kind of equipment, and they were going to brace it by anchoring to the floor. I said, "You can't do that," while the equipment people over at AT&T were telling them they must. So they sent me and the equipment engineer back to Naperville [Illinois], I guess is the place. They have two labs, and we told them what the earthquake problem was—they, of course, had read about it and all that. We got them interested, and then they did a lot of research. And now they're [the telephone company] probably more cognizant than anybody else.

New Equipment and Bracing

Degenkolb: We're talking [to Pacific Bell] right now about upgrading the [equipment] bracing of some 40 or 50 telephone buildings in California, because they are changing from the old number 5 crossbar, the old switching gear with relays, which was braced in a certain way. It now is being braced in another way because it's different equipment. We're designing the anchorage to the same standards. They [the AT&T engineers] also run equipment tests. AT&T used to do this for Pacific Bell. I don't know the relationships since the company is all broken up, but it used to be that automatically Western Electric furnished everything. Now they buy around from different places. But they've kept the same standards, and the new suppliers are keeping the same standards. That is what the Bell System is insisting on.

Scott: Now when you say the same standards, are you talking about standards, including seismic, or talking specifically about seismic resistance?

Degenkolb: I'm talking specifically about seismic resistance design. In this case, the forerunners of Pacific Bell—AT&T. The home telephone office of Pacific Bell went through the 1906 earthquake. The Bush Street Building came through, but it was gutted by fire, so they are very conscious of the earthquake problem. When Eureka had it's earthquake in 1954, they [telephone company personnel] flew off for a site visit immediately. Same with the Bakersfield earthquake.

In Eureka we [Gould and Degenkolb, Engineers] had designed a new building, which wasn't quite finished at the time [of the earthquake]. This was in the days when you still had telephone operators and they were in an older telephone building, a steel frame. You see, all the cabling goes into the old building, which was a 3-story, steel-framed building with unreinforced brick. And Eureka, thank god, wasn't a strong earthquake, but it did damage the [old] building. Well, they had to keep the telephone operators in there, otherwise they'd have no telephone service. They couldn't go to the new building yet, because the equipment wasn't in, the building wasn't quite finished. So we built a steel cage around the old building so it couldn't fall down. This was to protect the telephone operators. We put columns outside the building, and we put a cage around it. I always thought it was a rather unique solution. It kept them going for a year or so until they could switch over to the new building.

Looking at Earthquake Damage

Degenkolb: Still, I think the biggest thing was in '52, after I'd been designing for earthquakes. I went down to Tehachapi [generally referred to as the Kern County earthquake]. John had also gone down. He was a believer in looking at earthquake damage, as opposed to just believing in your theoretical stuff. So I went down to Tehachapi on my own, over a weekend. Nobody paid our way in those days. John and I were impressed and concerned enough that we also sent several of our designers—Tom Wosser was one. I have a picture of him in the women's prison down there with the broken walls and broken timber. Gordon Dean went, and a couple of the other guys. We just felt the designers should see it. That really set the pattern, because from then on, wherever there was a major earthquake that we could get to, we went. John went down to the '57 earthquake in Mexico City. We made some investigations and did some work in the '57 San Francisco earthquake (Daly City). Karl Steinbrugge went to Chile.

Scott: In other words, that set the pattern of your trying to visit significant damaging earthquakes almost anywhere in the world.

Degenkolb: Well, we didn't have the money to go anywhere in the world, but we went anywhere that we could get to. Then that scope broadened, and as our office became somewhat stronger and bigger, it was worth it to send people over to the Philippines, or Guatemala, or Caracas, or to Alaska. We've recently put out a special report on the 1984 Morgan Hill[6] and 1983 Coalinga[7] earthquakes. You've probably seen them.

Scott: Was the Tehachapi earthquake in 1952 the first one that you saw the results of personally?

Degenkolb: No, when I was a student I drove to Long Beach and saw the damage in '33, but I didn't know what I was looking at.

Scott: I was also thinking about Loring Wyllie's role in the earthquake chasing expeditions, and Tom Wosser's report for the SSC [Seismic Safety Commission].[8] I got to thinking that it must give you a lot of satisfaction to see the kind of leadership.

Degenkolb: That's one knack that I never thought I had, but evidently I do. I've made my share of mistakes, but the one knack I had that I was never trained for, was: I picked good people. I don't know how or what or anything else, but I'll back up the young people we've got. John Gould sort of started this business of looking at earthquakes—he insisted on going out into the field. He was very practical, he was one of the best analysts of the day, but now that's old-fashioned. We've just kept it going that way. It does make me feel good. Tom Wosser, Loring Wyllie, Chris Poland, Gordon Dean, Ted Canon—they're all active in various things and that's good.

Attracting Top-Flight Engineers

Scott: What strategies have you used to establish and keep the Degenkolb firm staffed with top-flight engineers?

Degenkolb: The reason we get top-flight engineers is that we work in cooperation with the universities. Since the universities know us, they often steer their top students to us.

Scott: So when did you establish that relationship with the faculty?

Degenkolb: I started teaching, and was also active in professional organizations, so we just worked through natural contacts. The majority of the people in the professional organizations throughout the world are academics. San Francisco and California are slightly different—the

6. "Special Earthquake Insert, Earthquake of 1984, April 24, 1984 in Central California," in *EERI Newsletter*, Volume 18, number 3. Earthquake Engineering Research Institute, Oakland, CA.
7. *Report on Observations: Earthquake of May 2, 1983, Coalinga, CA.* H.J. Degenkolb Associates, San Francisco, CA, May 1983.
8. Wosser, Thomas D., *Earthquake Safety: Potentially Hazardous Buildings*. Seismic Safety Commission, Sacramento, CA, November 1985.

heavyweights are in private practice, because they are interested in earthquakes. So if you're active in professional organizations, you're dealing with academics. If you are interested in certain things—simulating earthquakes, like at Cal, or if you're on advisory committees—you're working with academics all the time.

For example, Egor Popov, who is teaching over at Cal; and Vit Bertero, also at Berkeley, who was one of my students. Then there is Haresh Shah, and Jim Gere at Stanford—those two just wrote a book on ground shaking, *The Trembling Earth*—I forget the exact name of it.[9] Bob Hanson and some of his people at Michigan, Bob Whitman and some others at MIT, Bill Hall at Illinois. These happen to be the best, the foremost places where they are doing good earthquake research. We work with these people. They know what we like, and if some student wants experience, we're probably the guys they recommend. We don't actually recruit in the formal sense of the word.

The net effect is that when they see somebody who's interested, whom they consider promising and likely to suit us, they will mention our name to the student. Then I'll also generally get a phone call or note from them. So as a rule, we have our choice of top people. I hope it keeps up, and right now I think it is.

A Decision Against Branch Offices

Degenkolb: We had the opportunity to open a branch office. We considered it several times, and always decided against it. It would be like Painless Parker the dentist. It's a professional thing, and we've got to be on top of it. So our clientele shrank and shrank and shrank that way. It grew in other ways. I don't think we've done a Woolworth's job in years, I know in 20 years it's been almost nothing.

Scott: Would you go back to this Painless Parker allusion?

Degenkolb: I'm talking about a lot of branches. Remember the ads, Painless Parker the dentist. You could go into almost city, in California at least, and on the second floor there'd be the big window sign, "Painless Parker, Painless Dentist." Engineering isn't quite that way to me.

Richard Gould went up to the University of Nevada, and we had pretty close ties up there. We did some Nevada work. He was John's son and he was with me for a while—ten years or so—then he went with DeLeuw Cather, and then opened up his own office. But we never wanted to open up a branch office. I still don't. We haven't, we have only one office. Consequently, we've lost a lot of work, like the phone company. You have to have a local address so that they're patronizing local people. But because we had done the original buildings, whenever they got into trouble or got a new set of engineers, they'd call us.

Standards of the Degenkolb Firm

Degenkolb: We've kept growing. More than I'd like. I think the ideal size of a firm would be about 12 to 15 people, and we're about 30. We're busy.

Scott: Has it been at that level for quite a while?

9. Shah, Haresh C. and James M. Gere, *Terra Non Firma*. W.H. Freeman, New York, 1984.

Degenkolb: Yes. We were at 25 for an awful long time, for quite a few years after John died, and then gradually got up to 30. In my opinion it's really too big now, but you face the problem that if you've got good people—and we've got the best—you have to have something for them to grow into. We've got too many good people to be only a 10-man or 20-man outfit. That's one of the inevitable things I guess—if you try to stay small, that's rather selfish, although maybe it's better in a way. If you've got good people coming up, however, you've got to give them some room to grow. Right now we seem to be in a good spot that way. Besides which Tom Wosser is now running the firm, mostly.[10]

Scott: When you mention the figure 30, is that all the employees?

Degenkolb: Yes. There are three secretaries, plus a bookkeeper, a business manager and a librarian for a total of six. Everybody else is involved in production—either engineers, or draftsmen, or young engineers who will be getting their licenses, but just haven't gotten them yet. We have four draftsmen—ordinarily you'd have a lot more, but we do a lot of stuff that doesn't require so much drafting. It requires more engineering.

You see, we've priced ourselves out of business for the average building. We don't do many average buildings any more. We haven't done warehouses for years. We're too expensive.

Scott: Why are you too expensive?

10. This was as of interview date of May, 1986. H.J. Degenkolb Associates now (in 1993) has over 50 employees, including 11 principals. Loring A. Wyllie, Jr. is Chairman of the Board and Chris D. Poland is President.

Degenkolb: What we do now takes more time. For example, on a hospital down at Stanford, a big addition, $50 million or so, we met with the architects. They had us on the team that they'd chosen and we quoted them a fee. They should have discussed that earlier, but they didn't—though we wanted to. In their discussions of the fee with the clients, they neglected to support our fee needs, so they ended up getting another engineering office to do it for about two-thirds of what we would do it for.

Well, we tried to give them a bottom price, but if you do the right studies, with the alternates, detail it properly, observe in the field—it takes time. There's no way with a lower fee that you can give the time, so you have to take the first solution that comes to mind.

As a matter of fact, we've got one job over on the Berkeley campus right now, where another engineer is doing something I think is wrong. It's not necessarily unsafe, but it's going to be way over budget. If they had spent more time studying the problem, which would have required a higher fee, then they'd have a better product. But that's the way things go. Many of these buildings downtown around here, you can get them designed, the structural design, at half what we would charge. There's no question about it. We just don't enter into the competition on that type of thing.

Scott: Is the difference largely related to your professional concerns about the seismic aspects of the design, or is it everything?

Degenkolb: Everything, but seismic is a major portion. It's *all* engineering, all phases of it, like the foundation and everything, but I would say seismic is at least 40 or 50 percent of it. There are a lot of considerations [when designing a building]—and they could be important, or they may not be too important to the public. It could be that other solutions would have been cheaper and safer.

It also means that we're willing to say "no" to architects for certain types of designs. Sometimes the architect wants to do something and other engineers will accept it and carry it out, because that's what the client wants. If we don't think it's sound and can't convince them to change, we let somebody else do it. In quite a few cases, or at least in some cases, we have had the pleasure or opportunity or satisfaction that in three or four years, they would be back—they'll come get us to fix up the building.

Scott: That happens after a little earthquake shake, or just after the passage of time?

Degenkolb: Just time. But thank god there are still clients who want and are willing to pay for good service. We're not kicking.

Designing for Performance: A Matter of Philosophy

Scott: There are also some other angles on design and building performance I know you've thought about, such as excessive vibration. It seems we've had a good illustration of that in the recent Morgan Hill earthquake.

Degenkolb: The Morgan Hill earthquake [of 1984], which was only 7 or 8 seconds long, shook the Santa Clara County office building—this is in the EERI report. The building shook for 80 seconds. Now very probably, that building, which is a steel frame building with perimeter framing, will not collapse even in the worst earthquake. It sure will have a lot more damage, though, because it's going to vibrate. It may vibrate enough that the doors jam and make it hard to get out of. You really can't say, on the basis of that experience, that it's an unsafe building. I understand it was the only building that they evacuated, when people got scared.

It becomes a matter of philosophy. Do you prepare for that [vibration], or do you say, "I saved 2% or 3%, or satisfied the architect's artistic desires, and it's only money that is lost"? And that's on the probability that maybe nothing will happen for 25 or 50 years, so it really doesn't matter. So I can't really complain about somebody doing something like that. But I can't justify it in my own mind for me to do it. I can't blame somebody else for taking the other point of view and doing it. If you can save 2% or 3% of the cost of construction and a damaging earthquake does not occur for 25 to 50 years, who can say that is wrong? Or, if the architect wants to do something spectacular? Same problem.

Scott: You're talking about designing a building like the Santa Clara County Building?

Degenkolb: Right. I can't do it, I wasn't brought up that way. But I can't really point the finger and say, "That's bad." I can't do that.

Scott: Are you saying that the Santa Clara County Building could have been designed to make it less susceptible to that kind of shaking?

Degenkolb: Oh yes. If we'd done it, we would have had a different framing system.

Scott: Specifically with respect to the seismic concern?

Degenkolb: Yes. Some of our buildings downtown—San Francisco has a custom of rather sturdy floors. With some of the newer buildings [designed by other firms], however, the floors vibrate a bit when they are walked on. Pencils rattle and such. Or in a windstorm. I understand with the Hartford Building up here [in San Francisco], the secretaries have to go home in the afternoon during a windstorm. To me, that's a reflection on the design. In my opinion it shouldn't have been that way.

Scott: Is it a matter of the way it's braced, the way it's framed?

Degenkolb: It's framed fairly lightly in a certain way, so it sways more than the average building. That isn't necessarily bad from a safety point of view—it may be, or may not be. But a building like that is not completely serviceable to the owner. So a lot of this gets down to philosophy: I like blue and somebody else likes red. It's not necessarily wrong, but it isn't the way we do it.

Failures and Building Reviews

Scott: To what extent are the builders, or owners, or the persons leasing the structure for the long-term, aware of the implications of this kind of thing?

Degenkolb: I'm not sure. But ever since the experience of the Hartford Building in Boston, where the window panes fell out, and the failures of different types like the roof failure at the Kemper Arena and the interior bridge collapse at the Hyatt Hotel [both in Kansas City, Missouri], and some of the others, there is a group of people who are concerned about our professional activity and will investigate that.

We're finding that, more and more, we are analyzing [existing] buildings for performance, quite often for financial institutions. We've done a lot of it for Bank of America Realty, because they're on the line. They are managing other people's money, buying and selling and managing buildings. We run into a lot of tilt-up stuff, big industrial stuff. Actually, I think many owners may not want the best building in the world. But to protect themselves in case something happens, before a building is bought, they get a review. Often they will spend several hundred thousand dollars to fix it up. In the case of the IRS buildings in southern California, which are leased buildings, the minute they found out about these things [the potential for poor seismic performance], they insisted on retrofitting the buildings, just to preserve the managers from liability.

There is a question whether the individual owner, or the person who occupies it, knows that much about it. There's a lot more awareness now than 20 or 30 years ago. There is a considerable awareness among the financial institutions. I know on one of the big buildings here [in San Francisco], for the construction loan we only had a week to look at it. You can't make any figures in that time, but can just look to see if it is generally right.

I asked a couple of questions, and all of a sudden they got several other engineers, and some guys flew out from New York and they added several hundred tons of steel, just because I said "I don't have time to do it, but I hope you looked at this." All of a sudden they realized they had better consider the implications.

Responsibilities and a Proper Fee

Degenkolb: Now if the engineer had gotten the proper fee to start with, I think he would have investigated that. There's certainly nothing magic about it, but if you don't have enough fee to spend time on these sometimes unusual things, then you're taking chances. Personally, from everything I can read between the lines, I think that was responsible for a good portion of the problems of the Hyatt Hotel in Kansas City. I don't think the owners or the developers were necessarily trying to chisel on the fee, but it is a customary practice of the engineers in that area to do things cheaply and dump responsibilities, which gets down to the amount of time they can spend on a job.

Scott: In that case somebody made a very unfortunate, fatal change, and because of lack of attention it wasn't caught.

Degenkolb: That's right. Even on the original design. When you kill 112 people, that's....[shrugs]. The people who chase earthquakes, instead of reading a report and looking at pictures—they see the damage and the lives lost. That's largely what determines their attitudes. I know when I came back from Alaska, I figured from now on we're designing buildings as if the earthquake is going to happen in another five years, and we're going to have to answer for all the mistakes. It sure stiffens up your back.

Scott: I can understand that. You're going at it two ways. One way is as an engineer, and you're seeing graphically and physically the kinds of structural damage, not reading about it in an article or a book. The other way is as a human being, and you're seeing the implications failures can have to other human beings when an earthquake hits them. It kind of puts everything into focus.

Degenkolb: That's right.

H.J. Degenkolb Associates and Highrises

Scott: Why has the H. J. Degenkolb firm has designed so few highrise buildings in San Francisco?

Degenkolb: Very few of the big local offices or few of the structural consulting offices are doing highrises here, although in past years we've done quite a few of them. It's just that we haven't done any in 10 years or so.

Basically, in the old days [Henry] Brunnier or [Henry] Dewell or one of the big firms would design the structure. They worked for architects. You were expected to deliver quality work. More recently, instead of somebody building a home office, it's now largely done for speculation, and the developer wants the cheapest possible job. So Skidmore, Owings, and Merrill (SOM) is doing most of the large buildings. Hellmuth, Obata, Kassabaum (HOK) is doing some. Generally these outfits, like SOM, have their own engineering departments. Some of the other buildings, like 101 California, are designed by Texas engineers who do cheaper work.

Scott: The Texas engineers would do it cheaper than local engineers?

Degenkolb: Right. The fee is the number one consideration. Number two is differences of structural framing systems. With certain compatible architects, that does not raise a problem. But we did not want to do certain types of buildings. Years and years ago we refused to do one up in Seattle because they wanted to do it a certain way. Their previous engineer wouldn't do it that way. They came to us and we looked at it. We wouldn't do it that way either. They finally got somebody else.

It's fees, basically, and who the architect was. If certain architects were doing those buildings, we would get the job, where with other architects, Brunnier would.

In the older days, we did at least our share of them [highrises]. We had Park Merced, Greenhill Towers, the Bank of California, the International Building. Park Merced was late '40s and early '50s. International Building was early '60s. Bank of Cal was '70. Moffitt Hospital we've just finished. The phone company building would be about 1960 [the Pacific Bell Pine Street headquarters building in San Francisco], the one [highrise for Pacific Bell] in Oakland around that same time. We've done a lot of those buildings for the phone company.

Would You Do Anything Differently?

Scott: Would you do anything differently with your professional life if you could go back and do it again?

Degenkolb: I can answer that one pretty quickly. I don't think I would do things much differently. There might be some minor details I'd change, but I was the extremely fortunate one of my era. I was always interested in being an engineer. I had good schooling at Cal. I fell very fortunately into a damn good job afterwards, under some of the best engineers in the country.

Scott: That was the Treasure Island work?

Degenkolb: Yes, the group working on Treasure Island construction. Then, I was also fortunate in going from job to job and doing research with essentially the best people. It was broad-gauge experience. I don't think I can kick about any of it, though things were tough at times. On that score, there's such a huge element of luck. I'll take a little bit of credit. A few times when I got the lucky breaks I was able to take advantage of them.

Scott: Maybe you had the good judgment to know a lucky opportunity when it was there.

Degenkolb: Sometimes it was shoved down my throat, and there was no other work to do. No, I'm not rich, won't get rich, never had any desire to. I'm comfortable. While I wish I could call a few buildings back, I'm generally comfortable with what we did. Though there were some mistakes made. There are a couple of buildings that I wish we hadn't done. But maybe they'll be torn down before an earthquake comes. That's already happened to several of them.

Scott: Why do you feel that way about a couple of buildings?

Degenkolb: I grew up in the era and trained with engineers who were trained on the load basis—stress. I designed buildings that way. In the old days you did not design by the building code so much as you designed by basic principles. The code generally had basic loads and allowable stresses, and it was up to the engineer to go beyond that. There were rules of thumb in the code, but the code was a very thin document comparatively. Engineers were just supposed to do an engineering job, they were supposed to take care of things, more like the old master builders of the ancient days.

If the code permitted it, we did it very conservatively by the code. We didn't recognize all the interplays that we now recognize. There's a parking structure in San Mateo. It's three blocks long. I already told the San Mateo people—several years ago—that it was conservatively designed in accordance with the ideas of the day, and has better than average reinforcing, but in case of an earthquake on the San Andreas, I expect that parking garage to go.

We've been fortunate in a lot of the telephone company buildings—Eureka, Coalinga, Bakersfield, the Woolworth buildings. But I keep thinking of how we designed those, and they were good designs for the day. Maybe a few of the others designed the same way aren't going to be as good.

Scott: Are you alluding to things that basically you've learned in past years?

Degenkolb: Yes, since [the Alaska earthquake in] '64. The ten commandments weren't given all at once. You see certain clues in '64 that make you raise questions, and you see a lot more in [Caracas in] '67—and that was a big jump. Caracas was the big jump. Then all of a sudden you start questioning a lot of things, and other engineers were questioning things. While in the north we were pretty well convinced before San Fernando, after the San Fernando earthquake in '71, a lot of things became clear. That experience jelled with respect to what you had seen before, and other engineers recognized it. There was the big jump of design from '71 to '73, with respect to ductility. In '71, the San Fernando earthquake occurred, and that caused the change in the '73 Uniform Building Code. We keep on learning. It's a learning process. You don't learn it all at once.

But even before '64 I'd say that we took care of most of the things and did it California style—a lot better than the national style. We always did certain things above the code—certain methods of reinforcing concrete. People I worked with always did it. They had observed earthquakes and did certain things.

But buildings changed. We used to have concrete walls in those days, now we have curtain walls. You don't change your practices until they've been shown to be wrong. Actually, our experience has been very good. We did the high school in Tehachapi, which came through beautifully. We did the Woolworth store, the telephone building down in Bakersfield that came through the '52 earthquakes. We designed the phone company building in Coalinga, which did fine [in the 1983 earthquake]. We designed a bunch of Woolworth stores, and as far south as East Montebello, they had stuff knocked off the shelves in one direction and not in the other [in the 1971 San Fernando earthquake]. That was interesting. And we had—I remember we fixed up a parapet in North Hollywood, pretty close in, and it came through the San Fernando quake all right. So I have nothing that I can say failed or something like that. But there are certain buildings that I know if they're ever tested.... Well, we designed them before we knew better.

A perfect example of such change is the Imperial County Services Building. That was designed 50% higher than the code. It was well-designed for it's day [1968], and the design took care of things very conservatively.

Scott: You didn't design that building, but you're commenting on how it was designed?

Degenkolb: Yes. Because your first reaction when you see something like that is "what did the designer do wrong?" So we got the drawings and the calculations. That building was done carefully, conservatively, in excess of code, and yet look what happened. Well, anyway nobody was killed, although it had to be demolished later.

We learned several things from that, and it's making some changes in the code, but that takes a while, too. As a matter of fact (this brings it to mind) in a conference of structurals, an annual meeting at Coronado, one of the concrete people was talking about how badly the Imperial County building was designed. But it was well-designed, very conservatively, way above national standards, way above California standards at the time and well-inspected. In spite of doing everything right, at the time we didn't know enough, so that something came out wrong. When you get as old as I am, you know we're going to have more of that.

Chapter 3

Pioneers in Earthquake Engineering

"That's their accomplishment – they started a system of design. They were highly professional in going beyond the code to try to do what's right...They were on the edge."

Scott: Would you talk a little bit about how earthquake engineering got started?

Degenkolb: The history of the earthquake stuff in San Francisco really started with the 1906 earthquake. Most of what we know about that [the 1906 earthquake] is in the ASCE *Proceedings*[11] of 1907. That tells us something about [J.D.] Galloway and some of the other engineers. There's also information about the water systems and different things—such as bridges.

Some of the giants in those days that chased earthquakes were Walter Huber, Henry Dewell, Henry Brunnier, Gus Saph (in later days, who was not known for writing but for his encouragement of young engineers), Chris Snyder. I'm forgetting a bunch. They designed in the post-earthquake, post-1906 period.

11. "The Effects of the San Francisco Earthquake of April 18, 1906 on Engineering Constructions," in *Transactions of the American Society of Civil Engineers*, Vol. 59, Paper No. 1056. ASCE, New York, December 1907.

1906-Era Construction

Degenkolb: The 1906 earthquake was really the first one that Americans were subjected to in which there was some engineering content. We hadn't lost any engineered stuff in Charleston [1886], New Madrid [1811 and 1812] or Boston [1755] in the early days. That was before the days of building codes—for strength, at least. They were just built. There were no engineered buildings or structures in those three big earthquakes.

The 1906 earthquake, however, came not long after the tier construction had been started—skeleton steel frame started in Chicago, in the late 1800s—the Homestead Building and some of the others. Out here you had engineers who had designed highrise buildings: the Mills Building, the Fairmont Hotel, Central Tower—which is referred to in books as the Call Building—the Flood Building, a whole bunch of these buildings in steel. Some were still using the old system of bearing brick walls and steel interior frames. But some buildings were using the Chicago system of complete steel frames. The steel carried the weight of the walls, instead of having bearing walls to do it.

The Chicago system and the invention of elevators made highrise buildings possible—the two things coming together. San Francisco had a dozen buildings or more that were in the transitional design or new design with steel—[J.D.] Galloway was one of the engineers, and there were some others. This was engineering done around 1902-04, before the earthquake [in 1906]. The other buildings that came through '06, like the Montgomery Block, the old Custom House, were really in the old style with heavy masonry walls, with some kind of interior floor frames, not too tall, maybe wood interiors—but not of a highrise style. There's an old book by Hool and Kinne[12] that talks about old framing systems.

Scott: The ones that came through the 1906 earthquake were of older construction, lower-rise and pretty massive?

Degenkolb: Yes, but there were also ones [masonry buildings] that *didn't* come through. Where they were well made, they came through fine. Where they were not well made, they collapsed. This contributed to the idea that masonry construction is no good.

Scott: Is the key thing, really, how the building was put together—the design and actual workmanship?

Degenkolb: Yes. And the vast majority of masonry buildings—although the Palace Hotel came through well—apartments, hotels, commercial buildings with 2-3-4 stories were generally pretty poorly tied together. They used poor mortar, and were just thrown together. Actually we have pictures. This is a remarkable book [thumbs through a book by John R. Freeman[13] and opens out a panorama photo]. We have pictures that were taken after the earthquake, but before the fire.

On the types of buildings that engineers designed—steel buildings and that—there was a lot less parapet damage than people think. There was a lot of parapet damage in other

12. Hool, George A. and W.S. Kinne, eds., *Stresses in Framed Structures.* McGraw-Hill, New York, 1923.
13. Freeman, John R., *Earthquake Damage and Earthquake Insurance.* McGraw-Hill, New York, 1932.

types of buildings. Where the steel-framed buildings ran the columns up through the parapet, buildings performed well. Where the parapet wall was just "piled up," they came down.

Early Engineers

Degenkolb: Because of the 1906 earthquake, and the fact that all of these people here—Huber, Dewell, Brunnier, Gus Saph, Chris Snyder, Jessie Rosenwald—were engineers, were practicing engineers (though some of them weren't practicing at the time), they were very interested in the performance of buildings.

J.D. Galloway

Degenkolb: [J.D.] Galloway was the chairman of the committee that wrote the report on the 1906 earthquake for the ASCE *Proceedings* in 1907.[14] Evidently he was a pretty good engineer, because we've done work on some of his buildings—one of them was the original Bank of California, the one on the corner there [corner of California and Sansome Streets, San Francisco, CA, across from the Degenkolb offices]. He was the engineer, and that building was being designed, and possibly being built, at the time of the earthquake, so it was reinforced and made stronger.

Henry Brunnier

Degenkolb: Now, Henry Brunnier came to San Francisco after the earthquake and was active in the reconstruction. He must have been a very young practicing engineer. But he was probably the most respected, politically sound, successful engineer in the area, at least in northern California. He's the one who really started the structural engineers [Structural Engineers Association of Northern California (SEAONC)] and got California organized—or at least he was highly instrumental, probably not him alone, but he's generally given credit for most of the good development we had.

Charles H. Derleth

Degenkolb: Charles Derleth was at that time an associate professor over at Cal, and wrote a very good discussion in that report [the 1906 report, published in 1907 *Proceedings* of ASCE]. He later became, for a long time, dean of engineering at Cal. I'm going to guess starting in 1915 or thereabouts, through...he lasted, I think, through World War II. He was crotchety, looked like a chinaman, an old man. The stories about him are innumerable. Very foulmouthed. In the senior classes at UC he used to give lectures about spring emotions and all that kind of stuff. He was a consultant on both bridges [the Golden Gate Bridge and the San Francisco-Oakland Bay Bridge]. He designed the Carquinez Bridge—the first one, the auto bridge—and was a consultant on the Broadway Tunnel in San Francisco. The Carquinez Bridge was the first time, I think, that they took the suspended span, fabricated it, and lifted it from barges. He was a character, but he was a hell of a good teacher and damn smart.

14. "The Effects of the San Francisco Earthquake of April 18, 1906 on Engineering Constructions," in *Transactions of the American Society of Civil Engineers*, Vol. 59, Paper No. 1056. ASCE, New York, December 1907.

John Freeman

Degenkolb: John Freeman was a unique guy, an insurance man and an engineer. He is known for writing the book *Earthquake Damage and Earthquake Insurance*,[15] which is now out of print. He has a lot of history [in the book]. It's a poorly organized book, but he has written about different earthquakes, up to and through the Santa Barbara earthquake in 1925. It was published about 1932, so it does not include the Long Beach earthquake. It was his drive that got the U.S. Coast and Geodetic Survey started developing [strong motion] instruments. You've probably read something about that in Ralph McLean's or George Housner's histories. Freeman's book isn't the bible anymore, but it's an extremely important book.

Gus Saph

Degenkolb: Gus Saph was a leader in that he had very definite opinions about a lot of engineering matters with earthquake concerns. He used to do William Wurster's structural engineering—Wurster was the architect who became head of architecture at UC Berkeley.

Scott: Saph was consultant to Wurster, Bernardi and Emmons?

Degenkolb: Yes. But even before that, before they had the firm, Wurster was just a struggling young architect, and Saph was his consulting engineer.

For $25 Saph used to look at foundations and excavations of any house, and tell them about their foundations over in Berkeley. For $25! It was a loss, he spent more time on it than that. But he probably learned more about the underground stuff in Berkeley than any other man. I don't know what happened, but then Wurster started getting other engineers. But Saph was a giant. He loved to talk to young people.

Jessie Rosenwald

Degenkolb: All those guys were interested in earthquakes. We all wanted to find out more. As a matter of fact, the first time I gave a course on lateral forces at the University Extension—I believe in illustrating with slides, I believe you can't go by reports alone, you have to see the damage in order to appreciate it—and a lot of slides I took of the earlier days, I took them out of books and stuff, so they were not of the best quality. I was using those in the lectures, and Jessie Rosenwald and some of the other structural engineers took the lectures. You talk about continuing education—these guys were interested! And Jessie was very loud, he was a complainer. I hated to eat a meal with him. Everything was always wrong. He said to me "You have lousy slides. I have better pictures. I'll loan you my negatives." So I have prints of the negatives that Jessie took of the 1925 Santa Barbara earthquake, which are excellent. Here's an engineer taking damn good pictures, which are probably not reproduced any place, except for those that I have reproduced.

Development of the Structurals

Scott: And a lot of those same guys were involved in developing the structurals organization?

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

Degenkolb: That's right. Actually, the development of the structural engineers was more important than ASCE [American Society of Civil Engineers], which was the publishing vehicle. The funny thing is that the structural engineers, when the association [the Structural Engineers Association] was formed, were all civil engineers belonging to ASCE. The structural engineers were the largest division of ASCE.

What happened, in '28, '29, and the preceding years was that ASCE did not accommodate the specialty of structural engineering with regard to earthquakes. ASCE was, and is, a national organization and was interested in technical matters. They did not want to get into local problems. The structural engineers of San Francisco were having problems concerning fees from architects. ASCE, despite prodding, did not want to get involved. So a group of San Francisco structural engineers got together and formed a group called Structural Engineers Association of Northern California (SEAONC) to try to solve their own problems. The development in Los Angeles was taking place at about the same time and for the same reasons, and as a result the Structural Engineers Association of Southern California (SEAOSC) was formed. Down there it was started by a group known as the "dirty dozen"—Steve Barnes, Paul Jeffers, consulting engineers, Ernest Hillman, Ben Benioff. The "dirty dozen" were active in earthquake design concepts.

Henry Brunnier was the active leader up here who started it. At first, membership in SEAONC was for employers only, the principals of the firms. That was prior to '29, and the need for adequate fees was the main goal. However, their outlook expanded and they got involved in technical matters and allowed employees and government engineers to join. After a while, the membership was so diluted that the associations were not active in fees or other matters concerning the private business. As a result, the same groups of structural engineers or their followers started the Consulting Engineers Association of California and invited other disciplines to join—the mechanical and electrical engineers, etc. Their field of activity is the business side—fee, management, insurance, fighting attempts to unionize, legislative, etc.

About that time, in 1927, the ICBO, the International Conference of Building Officials [originally the Pacific Coast Building Officials Conference] was started. Quite a few of the engineers were involved in both SEAOC and ICBO. I first got involved with the structurals, a year out of college [1936]. You had to be a year out of college to join [SEAONC]. Before that you were a junior member and you could become a full member after you were out for a year. As a junior I had been on the publications committee—they want to get you active. Then in 1937, I was assigned to the code committee. I became involved with the codes, and that has lasted all these years. My involvement with codes goes all the way back to that 1937 assignment.

Development of Earthquake Engineering in Japan

Scott: I've heard you say that the Japanese were interested in seismic design even before U.S. engineers were.

Degenkolb: That's right. Modern Japanese seismology or earthquake engineering started with John Milne.[16] I've been trying to think of where I read a biography of him just recently.... He was English. He was over there, I believe, at the time of the big Mino-Owari earthquake. It was in 1891, south of Tokyo. He published his observations in the SSA Bulletin.[17] They call it the Nobe earthquake. Here [looks in an index]: 142,000 buildings destroyed and 7,273 people killed.

As I understand it from the Japanese history, which I've read about some place, because of the deaths and the large amount of damage [in the Nobe earthquake], the Japanese government set up a special committee to study what could be done to see that it did not happen again. That started the earthquake engineering—the consideration of causes and effects and all that—of the modern group, worldwide. You also have ancient things, but in the modern ways of doing it, that would be the beginning. Then they formed this commission of Japanese engineers, architects, and all that, to study earthquake problems and were very concerned with them.

Then we had the 1906 earthquake here, and some of the Japanese engineers were quite interested, and the basic elements of earthquake design were formed then. One of the foremost Japanese engineers, Tachu Naito, had developed some theories as to how to brace buildings.

By the time the Tokyo earthquake of 1923 came along, interest had sort of died, but certain theories had been developed, and Naito was prominent in that. [Kiyoshi] Muto, at some time early in that era, became secretary to the Japanese Earthquake Commission. Of course, the 1923 Tokyo earthquake revived interest. They went on from there with their theories. Naito, as described in Freeman,[18] had designed three buildings in Tokyo that came through without any damage: the Kabuki Theater was one, a bank, and some other building that I forget now.

Then when the 1923 Tokyo earthquake happened, Homer Hadley, the concrete man—his son's got a building right down the street—went over to Tokyo. I never knew him, but he was the PCA [Portland Cement Association] representative, and he went to Japan in 1923, and wrote a report. He was quite active in earthquake design development. He was from the Bay Area. Evidently he was a leader, at least in the concrete phases. The insurance companies took a big interest, which resulted in John R. Freeman's 1932 book.

So the interest of San Francisco engineers can be attributed to 1906, reports from Japan on the quake of '23 and their theories, and then

16. John Milne was a professor in the Imperial College of Engineering, 1876-1895. Milne wrote *Earthquakes and Other Earth Movements*. D. Appleton & Co., New York, 1886. (The Degenkolb library has the 7th edition, rewritten by A. W. Lee, published by Kegan Paul, Trench, Trubner & Co. Ltd., London, 1939.)

17. Milne, John and Comte de Montessus de Ballore, "The Seismological Work of John Milne," *Bulletin of the Seismological Society of America*. Vol. 4, No.1. Seismological Society of America, El Cerrito, CA, March 1914.

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

the '25 earthquake in Santa Barbara. And we have been interested ever since.

When they had their earthquake in 1923 in Tokyo, one of the California engineers went over to see it [the damage], and as a result there were several lectures by Kyojo Suyehiro [based on the Japanese earthquake developments], who was a student of Tachu Naito. You know about the Suyehiro report.[19] The interest was here because the 1906 earthquake was still fresh in their minds. But they brought over Kyojo Suyehiro. See the *Proceedings*, Part II.[20] I don't think that is in the record. In those days, the *Proceedings* were the bulletin that came out monthly, and the worthwhile papers were reprinted in *Transactions*. This probably was not reprinted.

There was a book or paper from the Japanese that was blueprinted and circulated to several of the structural offices. I have never seen it. There was also what I call a preliminary textbook by Naito, which was brought over and blueprinted[21] and was in the engineering offices in San Francisco, but I have never seen that, either.

There's a committee report on earthquakes in the ASCE library that has a lot of information on the Tokyo earthquake, and some history that has never been published. It's four volumes, typewritten, about $1^1/_2$ inches thick. We had it here when we wrote the Separate 66,[22] that's after 1948. I tried to copy it with a Foth Derby camera and the copies were not very good. I tried to get it back again a few years ago, but now it's not allowed out of the library. I've got a microfilm of the whole thing on 35mm film, so we have it for reference anyway. It has a lot of information on things that we don't ordinarily worry about—such as how the sewers performed.

Scott: Performed in the Tokyo earthquake?

Degenkolb: Yes. You'll also find some interesting things in the story in EERI's *Earthquake Spectra*[23] on the history of masonry buildings. For example, the Royal Insurance Building, which is diagonal across from the Engineers' Club on the northwest corner of Pine and Sansome—10-story building, steel framed, and the first known reinforced brick building, built in 1910. I knew some of the stories about it, but I had never seen it written up. It was an insurance company, and used eastern engineers, who were instructed to make it as earthquake-proof as possible. You should read the EERI *Earthquake Spectra*[24] on the history of brick buildings—that is excellent. They also have one of the best things I've seen written on the Turkey earthquake, about a year ago, that killed about 1,300.

19. Suyehiro, Kyojo, "Engineering Seismology: Notes on American Lectures," *Proceedings of the American Society of Civil Engineers*. Vol. 58, No. 4, Part II. ASCE, New York, NY, May 1932.
20. *Proceedings of the American Society of Civil Engineers*, Vol. 58, No. 4, Part II. ASCE, New York, NY, May 1932.
21. Naito, Tachu, *Earthquake Resisting Construction*. "Blueprint" version on file in Earthquake Engineering Research Center (EERC) library, Richmond CA.
22. Anderson, Arthur W., et al., "Lateral Forces of Earthquake and Wind," *Proceedings - Separate 66*,. ASCE, New York, NY, 1951.
23. *Earthquake Spectra*. Vol. 1, No. 1. Earthquake Engineering Research Institute, Oakland, CA, Nov. 1983.
24. Ibid.

Insurance Companies Sponsored Some Early Earthquake Observation

Degenkolb: On another point, the insurance companies got interested [in the performance of buildings and potential earthquake losses], partly as a result of Freeman's book,[25] which was really written to compile the data and pointed to setting a financial basis for earthquake insurance. The impact on business and real estate from [the Santa Barbara earthquake of] 1925, and again in [the Long Beach earthquake of] 1933, with the history of 1906 in back of it, was such that I assume that there was a big concern about investing in California. That's why the Commonwealth Club got interested—a committee of 100 (that jibes with Freeman's book) gathering information and trying to get loss ratios so you could write insurance for earthquakes. The committee intended, really, to dispel the ogre of earthquake damage and set up a statewide committee to write an earthquake code. It was not generally available, although I have a couple of copies of it. It has a little of the history. Also the *Proceedings* of the Commonwealth Club give certain clues [to performance of buildings]. They wrote a code that had two sets of earthquake provisions, one of which was favored in southern California, and the other favored in northern California. They couldn't get together. It was published but never adopted.

Scott: This was largely a response to the 1925 Santa Barbara earthquake?

Degenkolb: Yes. Freeman has nothing about [the Long Beach earthquake of] 1933—the book came out just before the 1933 earthquake. Some place along the line, the Pacific Fire Rating Bureau, which sets the insurance rates for earthquake for all companies, retained Harold Engle. In those days, he chased earthquakes to get damage statistics together for the insurance companies. He was a private engineer, but was looked upon with suspicion by the other engineers because he was also the insurance company man. He wrote the first book on the 1933 Long Beach earthquake—a pamphlet for Pacific Fire Rating Bureau.[26] That gave the basis for how we designed the water towers, which were needed for fire sprinklers. If you had insurance for fire, you had your rates based on this type of thing. Freeman's book keeps coming back from the actual happenings to what the damage ratio is—based on the value of the buildings in the area—and what percentage was damaged by the earthquake. That was the first basis for setting rates for earthquake insurance.

Engle's now deceased. He was quite conservative, and of course the belief [of the structurals] was that insurance companies want everything to be super-safe so they won't have to pay off.

Scott: He was considered excessively conservative?

Degenkolb: Yes. Actually, as it turned out, he was the most right of all the engineers. Most of the research of chasing earthquakes—visiting earthquake sites—was being done by Engle

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

26. Engle, Harold M. and J.E. Shield, *Recommendations to the Board of Fire Underwriters of the Pacific for Earthquake-Resistant Design of Buildings, Structures, and Tank Towers.* Board of Fire Underwriters of the Pacific, San Francisco, CA, 1934.

for the insurance people to gather statistics on damage, and the types of damage, and all that kind of thing. They were interested in lowering losses, just like they are with fire prevention. Then he took on as an apprentice a structural engineer by the name of Karl Steinbrugge.

Karl came from Oregon, he had worked up in Sacramento at the Division of Architecture administering the Field Act for a bit. Then I remember him in the field parties in '52 in the Tehachapi earthquake, examining buildings. He and Don Moran wrote the big book in SSA on the '52 earthquakes.[27] That's where I first ran into him for meetings of any consequence, beyond just knowing him.

I had gone down [to Tehachapi], and I had written, though not in any depth like that, because their work was funded by the insurance people. So they had a 4-5-man party going over the damage—they did it very thoroughly. We went down and saw most of some of the highlights, and I wrote a report in '52 on that, but not nearly as complete as Steinbrugge and Moran. My report appeared in ASCE.[28]

So, whenever there was a damaging earthquake that would affect our type of construction, one that we could learn something from, Harold Engle and Karl went. When Harold got older and retired, he didn't go as much, but Karl did. So Karl has seen more earthquakes than anybody else, and probably, from a structural point of view, I am second, because we took on that policy of visiting earthquake sites. Now quite a few engineers go, which I think is wonderful, because that way we can all see some of the discrepancies between our theories and what actually happens.

Lydik Jacobsen: The First Shaking Table

Degenkolb: Another one that should go on the list [of early engineers], though not a structural engineer, is Lydik Jacobsen—a Stanford mechanical engineer who got interested. He did what I would say was the first, and for years the most authoritative and influential study, on the dynamic analysis of earthquakes. He was active in the structurals from the dynamic point of view and he really made the first shaking table I know of down at Stanford. It was a small railroad car on tracks. You took a heavy pendulum and banged it, and you got an impact load. It went back and forth. And they're using that method [to calculate dynamic response] in some countries now—developing countries. Some of his work relating to earthquakes is published in the Seismological Society *Bulletin*. He did the first studies on the effect of water on bridge piers and wharves, and on tanks.

Scott: What period would be represented by his writing? After 1925?

Degenkolb: It started after the 1906 earthquake. In the older days, I'm going to say—really from the '20s on. But most stuff would be from 1933 on. Jacobsen did an awful lot of work. The point I was starting to make is—this

27. Steinbrugge, Karl V. and Donald F. Moran, "An Engineering Study of the Southern California Earthquake of July 21, 1952 and Its Aftershocks," *Bulletin of the Seismological Society of America.* Vol. 44, No. 2B, Part II. Seismological Society of America, El Cerrito, CA, April, 1954.
28. Degenkolb, Henry J., "Structural Observations of the Kern County Earthquake," in *Transactions of the American Society of Civil Engineers.* Vol. 120, Paper No. 2777. ASCE, New York, 1955.

was one of the first developments in attempting to mathematically determine earthquake forces, although they didn't call it that. Most of our information on earthquake performance was on how the building was designed, as the engineers knew how they were designed—in the customary ways—and their performance in earthquakes. The first earthquake load factors were really based on empirical observation of buildings of known strength as they saw what happened to them [in an earthquake]. It was not mathematically oriented. As a result, rather low factors were used because the engineers neglected the beneficial effects of the architectural clothing.

Discrepancies Between Theory and Observed Damage

Degenkolb: The basic coefficients that got into codes were not derived from a theoretical point of view, but were based on observations of earthquake damage to actual buildings that went through earthquakes, and on what stood up in earthquakes.

Of course, later on in the '40s and '50s, when the theories came in and computers later became available, there was always this big discrepancy between measuring the ground motion for which you should design buildings (or have the elastic theory in those days) vs. what we knew about how buildings performed. And we're still in that mess [the discrepancy between measured ground motion and what g force we use to design buildings]: for example ATC 14[29] and things like that.

Scott: Okay. One train of thought would be to design on the basis of what stands up or falls down in actual earthquakes. You change the coefficients or the codes and the practice appropriately. The other approach is based on ground motion and on working backwards through theories of the mechanics of building behavior to find how a building should be designed to resist earthquakes—using a theory of the dynamics of the shaking process.

Degenkolb: Right. And the twain never met. The end result is there are huge discrepancies between the results of the two approaches. They've been working on reducing the discrepancies, trying to understand more about it for many years. We are just starting a project for ATC [ATC 14],[30] trying to evaluate some of those things.

Scott: Is it a simple discrepancy, with one train of thought telling you to build a structure a lot stronger than the other, or are the differences between the two approaches much more complicated than that?

Degenkolb: It's much more complicated. The results have been off by a factor of at least 5 or 6, not something small like 10% or 15%, but 500% or 600%. We are now getting the differences down closer to 50% to 100%, now that we know more about ductility. But we still have the legacy of the traditional ways we have done things, or of things we *don't* do, that we are trying to overcome. For example, the original engineers that worried about earthquakes were structural engineers. So Huber and Dewell and Nishkian and Brunnier, and all these

29. *ATC 14: Evaluating the Seismic Resistance of Existing Buildings*. Applied Technology Council, Redwood City, CA, 1987.
30. Ibid.

old-timers, including John Gould in our office—my partner—they would look at earthquake damage and have very definite opinions. That's why this area has always been very active or interested in earthquakes.

The Start of Strong Motion Instrumentation

Degenkolb: But when the theories would come in, and with the first crude instruments, they were thinking in terms of 10% or 15%g. Then there is this seismologist from San Diego predicting that when instruments get good enough we're going to measure 300%g. We've already measured one 125%g on the dam down in San Fernando [Pacoima Dam, 4 miles northeast of San Fernando]. And we've measured some others—one measurement in Iran [in 1976] was 167%g, and there are others approaching the 2g range.

In those days California didn't have much voice in code matters or earthquake research. But Freeman was active in that—they did get the Coast and Geodetic Survey to design strong motion instruments and install them and maintain them. That was about 1929. Before that, you had seismographs, but they were too sensitive for strong motions. Frank Ulrich was head of it [Coast and Geodetic Survey] and William Cloud (there is something in the EERI *Newsletter* in February on Cloud[31]). Cloud gave a summary of the history and development of the early days [of instrumentation]. They got a record from the Long Beach earthquake—although not much good. And then of course they got the 1940 El Centro earthquake—the first good record.

31. Leeds, David J., ed., "In Memoriam: William K. Cloud (1910-1984)," *EERI Newsletter*. Vol. 18, No. 2. Earthquake Engineering Research Institute, Oakland, CA, March 1984.

"California Practice": Special Above-Code Details

Degenkolb: Now, the older engineers, based on their observations, they considered certain details important. One was that we always put more ties near the end in concrete columns. We would follow the ACI [American Concrete Institute] code within the bulk of the column, but near the end we always put in extra ties.

Scott: What do you mean by ties?

Degenkolb: I mean containment bars. Wrap-around things. They were square for tied columns, and there were also spirals. Square or spiral containment features. We [in California] always extended our top bars in beams further and ran some steel through. We did the same on the bottom bars. We generally anchored our walls to the floors and roofs more securely. There were a series of things that became, not formally, but generally referred to as the "California practice," which was superior to what was done around the world, and was not in the code. But that was the way...when people saw the failures, those were the things they put in their practice. Those were the things that we did.

There were some other things that we didn't do, but that we should have, when you look at the failures. Buildings change too, so there are reasons for that. We found out from later earthquakes that—while our practice was much better than the eastern practice, and the buildings performed better—in some respects our practice didn't go far enough. For the type of buildings built up through the '30s, they were pretty damn good, even if they didn't have the high coefficients.

Their Accomplishments: A System of Design, Promoting the Profession

Degenkolb: That's their [the early influential engineers'] accomplishment—they started a system of design. The engineers, some of them, were highly professional in going beyond the code to try to do what's right. When the Depression came, of course building stopped. They were also very concerned about the continuance of the profession, because people were not going into structural engineering in the Depression. That's when Les Graham and I got started in '36. And they were really—by example and working in different offices and things like that—trying to promote the continuance of the profession in a decent way.

Actually, I was the youngest of the old guard. I was the kid. I came to work with them as a kid out of college. What happened is that the structural engineers, a young organization in those days, having started in '29, I guess. Gus Saph—dead for many years, all these guys are dead—and some others became concerned that, with the Depression, nobody was being brought into the profession of structural engineering. They set up a committee of structural engineers, and as a result of that, for education, developed our May meeting for the universities. They'd invite seniors in from the universities around here. That's gone on for many years. I was at the first meeting. As a result of that, and the activity of some of the old timers, they made arrangements with the World's Fair for it to hire one guy from Cal, which was me, and one guy from Stanford, Les Graham. This was in 1936. Depression. The structural engineers were very concerned about the progress of the profession. So Les and I had the opportunity—and others since then—of really working with the cream of the profession...a handful of engineers, compared to now. I worked under Henry Dewell, L. H. Nishkian, Henry Brunnier.

Scott: So they were trying to recruit people, even though things were in the doldrums?

Degenkolb: Yes. To make sure that the profession would continue and grow, and grow largely in the right direction. There were some rather poor buildings put up then, just like there are today. But I think a very high percentage—at least the ones I knew about or that we've checked—a high percentage were very honest designs. They were on the edge of the construction industry and [engineering] knowledge. They were doing things to the absolute best of their ability. Codes were much less important than they are now, and they wanted to keep this going. I think when you're an engineer, largely you're concerned with public safety, doing something for the client, and they wanted to preserve that.

But earthquake interest is ingrained in northern California, because of 1906 [San Francisco earthquake] and 1923 [Tokyo earthquake]. And the concern that these people had...they were professionals. An engineer was doing a service, and was responsible for people's lives.

Chapter 4

Growth of the Profession

"The most important decisions that affect either saving money on a building, or getting a decent building, occur in the very preliminary phases of design. What you start out with, what your assumptions are, largely determine."

Scott: A lot was accomplished from those early pioneering days up to the time of World War II. But, of course, a great deal more was still to be done. Would you talk a little about the growth of earthquake engineering in the post-war era?

Degenkolb: Well it's been an interesting 40 years to say the least. It grows. When I look back on it—you know what we do now—to think of a Seismic Safety Commission—compared to the '40s and '50s. EERI developed out of the old Coast and Geodetic Survey advisory group. They [EERI] put on a blast and earthquake conference in southern California in '52. So four years later, in '56, we held the northern California portion of it. It was all one organization with only about 30 members or so at the time. Well, we thought it was a good idea to have a conference maybe every four years, and it was our turn in the north, and we called it the First World Conference on Earthquake Engineering, and frankly we'd have been happy to get two countries attending.

We actually had a dozen Japanese and I think a total of 14 countries or something like that. I mean that is '56, that was sort of the start, and was done on a scale that's now unbelievable, it was so small. The Japanese took over in '60, and really made it a world affair. They put on the Second World Conference [on Earthquake Engineering] and formed the IAEE [International Association for Earthquake Engineering].

International Association for Earthquake Engineering (IAEE)

Scott: So the Japanese figured prominently in developing the international earthquake engineering community?

Tachu Naito

Degenkolb: Oh yes. [Tachu] Naito was an engineer and was probably the foremost man in Japan on the development of earthquake studies. When we were over there in 1960, I believe he wrote something for the Second World Conference on Earthquake Engineering. I believe it was after that—either in New Zealand, which would be '65, or Santiago, which would be '69—there was a session or a conference in his [Naito's] honor.

He was from the Waseda University in Tokyo. If I had to find more about him than just what I've read, mostly in Freeman...the best source would be Umemura, professor emeritus of Tokyo University, the royal university, who is presently the president of the International Association for Earthquake Engineering (IAEE). The present secretary since Minami died is another professor at the University of Tokyo, and had friends at Shimasu. The issue of *Earthquake Spectra*[32] that just came out has our report, which I basically wrote, on the Akita earthquake [of May 3, 1983], and in the acknowledgments his name is linked with Umemura's at the back.

John Minami

Scott: Let's go back—you started to mention Umemura and then mentioned the present secretary and then you mentioned another person.

Degenkolb: The first secretary when they formed the International Association [for Earthquake Engineering] in 1960 was John Minami. He died last spring [1984]. He's Japanese. I think he was born in Seattle of Japanese parents, and he went back to Japan before World War II, taught at Waseda University. He worked with us, he was over at Cal at the time, when we were planning the First World Conference [on Earthquake Engineering] in 1956. Then he returned to Japan again as a professor at Waseda University. When [Kiyoshi] Muto was the first president of IAEE, John was executive secretary. He stayed as executive secretary until he retired from that at the Istanbul conference [Seventh World Conference on Earthquake Engineering, 1980].

32. Bertero, Vitelmo V., W. Gene Corley, Henry J. Degenkolb, et al., "Damage Survey of Nihon-Kai-Chubu, Japan Earthquake of May 26, 1983," *Earthquake Spectra, Vol.1, No.2.* Earthquake Engineering Research Institute, Oakland, CA, February 1985.

Kiyoshi Muto

Degenkolb: Muto was professor emeritus, University of Tokyo. He headed the Japanese delegation that came here in '56. He set up the Muto Institute of Structural Mechanics and has done numerous papers and other things. When he retired from the university he joined Kajima Construction Company, which is one of the largest in Japan. IAEE was his idea more than anyone else's.

The Development of Research

Scott: Would you discuss the post-war development of earthquake engineering in California and the U.S.? You spoke previously about the early work of several pioneers, such as Lydik Jacobsen.

Degenkolb: Up until 1955-60 or thereabouts, your engineers and your materials interests were not interested in earthquakes. In those days we were only one state—out of 48—that was concerned with earthquakes. The California market was too small. What research was done on wood diaphragms—I did a lot in those days—was done as a hobby on models, or something like that.

The first relative tests were done for wind loads at Forest Products Lab (FPL) in Madison.[33] Then H. H. Robertson did a little bit with a steel deck. Steve Barnes did tests down in L.A., and that's got to be the early '50s or thereabouts. But about that time Oregon put a tax on their lumber for research, and one of the biggest boosts we got was when we had the requirements for the design of schools. And, California being the biggest consumer of Oregon lumber, they asked what did we need in research?

So with Oregon money, up in Corvallis we got a series of tests of schools, starting with model tests—15 feet, quarter-scale—for California engineers. That was really the first research development where any appreciable money went into research on earthquake problems, except for those couple of tests that H. H. Robertson did on steel decking. Since then, California has become quite a big consumer of construction materials. Oregon and Washington engineers are following our leads, and Nevada, and so we now have say 10 states out of 50 have an appreciable earthquake problem that's recognized. Theoretically, I know, the figure is 39 states, but practically it's more like only a half dozen that recognize the earthquake problem. We've got people spending money and looking at the problems, but that didn't start till the middle '50s.

I have a jack at home. I used to do experimenting at home as a hobby. Jack Horner and Norman Green, did some model tests that were good—were reported in *Engineering News Record*—that go back to the late '30s. There was a full size test of floors on the Long Beach high school track because of the Long Beach school failures. These tests were all done in school districts—I'm going to say almost by hobbyists—to find out why their schools performed badly. A few engineers were able to scrounge a few hundred dollars—and I mean a *few* hundred dollars, not the hundreds of thousands like we're spending now on certain individual

33. *Strength and Rigidity of Frame Walls*, Forest Products Laboratory, Madison, WI, 1929.

projects—to do some tests. But the important research didn't start till the '50s.

Scott: This testing that was done almost as a hobby, when was that?

Degenkolb: That was really after '33. If you're interested in some of that I'll try to dig some out from the files. The courses I gave, first of all for engineering extension and senior graduate courses over at Cal, were basically for timber design, where I got into diaphragms, and this was right after the end of World War II, I guess.

Scott: 1945-1946?

Degenkolb: Well, I started before that, I guess. It was during the war. Yeah, it was an engineering war training course at the beginning. And then at the request of the building officials in the area, we developed a course on lateral forces in small buildings, in which I presented the research material. But in those days you'd have a little piece of information here and a little piece there. I had mimeographed notes on the diaphragm tests, which were copied all over the place. How you design a building, a little building, generally in wood, for earthquake loads—you had to be a dedicated researcher of everything to find out little pieces of information here and there. And then you had the prejudices of the studies of what we had done over at the timber testing program after the World's Fair.

But we had no consistent research programs to put your fingers on until, as I say, about the middle '50s. Then the plywood association became interested and tested plywood diaphragms—different shapes and details. Other new manufacturers of steel deck saw the market and ran tests on various configurations. Everybody did some kind of testing. Karl Steinbrugge's brother, John, used to work for the state Division of Architecture and assembled a lot of the information on steel decks to determine their strength. John's a structural engineer in southern California and has an office down there, though I think he's partially or practically retired now—Steinbrugge and Neilsen I believe it was.

Applied Technology Council

Degenkolb: I don't know how old ATC [Applied Technology Council] is, maybe 12 or 15 or so years old. The engineers started it. It started in northern California with SEAONC [Structural Engineers Association of Northern California] and then went statewide. The idea was that we [structural engineers] should have a research arm of our own, separate from the universities, through which we could look at more practical problems, the everyday problems. It would be a conduit for getting money from either NSF or private industry, or wherever, to have engineers spend some compensated time, instead of voluntary time, to work on these problems and try to get some solutions. At the time that ATC 3-06 came out, ATC was a very new organization. ATC was really a combination of efforts.

Scott: When you say "looking for a research arm of our own," are you talking about ATC?

Degenkolb: Yes. That is what ATC was created for. If we wanted a practical problem studied—such as how much we could afford deflections for a window, or whether a certain type of detail was really good, or whether you had to put stiffeners in the columns. It's hard, unless you're really in the field and following it—and the average structural engineer, unless he does an awful lot of reading and keeping up, doesn't see much of the affects of ATC. Not as much as we thought we would see. But like anything else, you start off as a small operation and eventually learn to live and keep living and it grows. It's a fact of life.

Research: Theoretical vs. Practical

Scott: So the structurals wanted to have practical problems researched?

Degenkolb: Yes. These were practical things, and at that time the universities sort of looked down on applied research. They wanted to do basic research.

In some of the universities, however, the attitude toward research has changed a lot. I remember Egor Popov, maybe 20 years ago, wanting to test his hysteresis curves for small repeated loads on steel beams. It was looked down upon then as applied research, considered not really up to the standard of the university. The university is supposed to work with equations, high theory, etc.

That attitude has changed somewhat now, largely because of Egor and Vit Bertero. And now Marcy Wang got an award from one of the architectural magazines for studies on the Japanese tests.[34] Barry Goodno is from the University of North Carolina, and for 4-5 years now he's been studying the effect of curtain walls on the response of structures. In short, the general attitude has changed from emphasizing highly theoretical research. While it [theoretical research] may be necessary, it is not the whole picture. Materials research and detail research have even become fashionable, or at least respectable.

Scott: This is in academic circles?

Degenkolb: Yes. Thank god for Cal and Michigan, which are probably the leaders. And Lehigh [Pennsylvania] to a certain extent, but at most of the other universities—the type of research that we wanted was considered below them.

Practical Research

Scott: So the shift to universities being willing to do some of the "practical" work—this quite a recent development?

Degenkolb: That's fairly recent, as I said, largely because of the work of Popov and Bertero. And we got quite a prompt from some of the universities, like the University of Canterbury in Christchurch, New Zealand. They did some original work and have become leaders. The Japanese have also been doing quite a bit of practical research.

In ATC, one of the better things I think they have done is in bridges, and some of the retrofit things, they have been running cooperative exchange programs, trading information. They were represented on the full-scale test, I'm not sure if that was official or unofficial, but at least ATC's primary engineer was a member of the group. We're having more and more

34. Wang, Marcy L, *Nonstructural Element Test Phase: US-Japan Cooperative Research Project on a Full Scale Test Frame.* University of California at Berkeley, Center for Environmental Design Research, Berkeley, CA, 1986.

universities on regular research, having practicing engineers on advisory committees, and things like this. And we're looking at some more practical problems. Also some of the practical problems turned out to be very highly theoretical, raising questions as to why things act the way they do.

The fact that EERI became fashionable is also related [to the growth of practical research]. Instead of just Karl Steinbrugge and me looking at earthquakes, we've got lots of people looking at earthquakes, and it's obvious that the simple computer solutions are not the answer. You need more information.

In the earthquake fields we were geared to, it used to be viewed as a California problem only, and the construction market was too small out here, compared to the rest of the country, and we were considered only so many screwballs. But then California's market became important, and so it became important to do something in earthquake studies. To make tests on walls, concrete, steel decking, things of that nature. As you did more testing, it became important.

Whereas in the '30s, [Lydik] Jacobsen of Stanford, and [R. R.] Martel from Cal Tech, I think were really about the only professors involved in earthquake stuff from an engineering point of view. Even Perry Byerly was reputed to be the first Ph.D. in seismology—so that's also a relatively recent thing.

From those days, things have changed, so now I think every university in the country that has an engineering school and that does even a small amount of research, has an earthquake program going. People are designing all over the world, and that includes earthquake country as well as not. It's become recognized. So you have guys in North Carolina, Texas, Minnesota or Iowa that are doing major earthquake studies. Things have really mushroomed, although in some aspects not always for the better.

Scott: What would you characterize as "not for the better"?

Degenkolb: You've got to understand that this is old age speaking. It used to be that there wasn't much research, and the people who were in it were doing unfashionable work for the love of it, and for their own interest. Now, however, when I look at the NSF grants, earthquake research has become the fashionable thing all over. But the vast majority of it is worthless. I guess in research that's sort of a corollary—you have to do an awful lot of stuff to get 5-10% of good out of it. But to see the concern and research, literally millions of dollars that are going into earthquake research now, and compare that to what it used to be. It is just hard to believe.

You do have some crazy ideas from academics, though. One of them is base isolation—I'm quite dubious about it. They haven't considered all the displacements. They were talking about reducing the response to where the displacement is only 4-6 inches. Hell, El Centro's double amplitude was 9/10 of a meter of ground motion [9/10 of a meter is 3 feet]. Five stations showed single amplitudes of over half a meter. So I think they're overlooking something. We've got so much theory on our records, which are not complete in the long-period, or big-displacement areas. To me it's another reincarnation of the flexible first story. That's my opinion.

Theoretical Research

Scott: Just now you were a little critical of theoretical research. Do you also see value in some of that research?

Degenkolb: Yes—using the shaking tables, the computer. There are only a few shaking tables, but there are code changes as a result of shaking table observations, also a lot of computer stuff, it's fashionable to do risk analysis for earthquakes.

Risk Analysis

Scott: You say risk analysis. Can I ask what you mean? Or does that term cover several different things?

Degenkolb: It's a combination of things. Risk analysis involves first of all the probability of having an earthquake of a certain size. Then it also involves the structural response of a specific building or group of buildings to that earthquake, on a probabilistic basis. You combine those. First is the probability of an earthquake—I'm not talking worldwide, I'm talking about something that will, for example, affect San Francisco. Then comes the probability of failure of a building, or a rating of its performance, in a given earthquake (or range of earthquakes). So it's a combination of the two. I sort of wince when I use the term "risk analysis" because I don't much believe in it. It applies to tools, mathematical tools for dealing with these things, and they far outweigh the data we have available. We have very few data, yet we have whole conferences on them.

Scott: So we are using what we like think of as highly sophisticated mathematical computations and formulas, but the available data is pretty limited?

Degenkolb: Very limited. When dealing with low probability events—earthquakes per year—you have to make an awful lot of estimates to plug into the formula. I happen to believe that instead of going through all this rigmarole, why not just make your estimate? I know I'm partly wrong on that, but that's why I was interested when we were at the conference at the Hilton recently—I was interested in the fuzzy set thing that Chuck Thiel was talking about.[35]

Scott: At the ATC meeting about two months ago? That was when Chuck Thiel talked about fuzzy set theory.

Degenkolb: I've been trying to find out more about fuzzy sets for several years. Purdue [University] is the big one on that, but also Arizona and a few other places. I look at this as junk—because if you don't know anything, you must assume something, and you manipulate it with a lot of mathematics, and then you're supposed to get something useful. I can't quite believe it, but Chuck Thiel made more sense out of some of these things. If you could at least get some of the relationships that he was talk-

35. Thiel, C.C., and A.C. Boissonnade, "Divergence Between Estimated Building Vulnerability and Observed Damage: A Fuzzy Set Theory Reconciliation," in *Proceedings of the Seminar on Earthquake Ground Motion and Building Damage Potential, ATC 10.* Applied Technology Council, Redwood City, CA, 1985.

ing about, maybe there is more to it than I have given it credit for. In my opinion, they have poor data and are trying to get something practical out of it. If you look at the mathematical equations—they're horrendous.

Scott: But with the unfuzzy math, you can get so sophisticated and elaborate that some questionable data entered just about any place can throw your whole outcome very, very far off—you can get totally wrong answers because you made an assumption at some point, but it was twice as big as it should have been, and so it throws the whole thing off.

Degenkolb: That happens all the time. One of the advantages of computers is that if you can do calculations fast and can play with sensitivity, and you can see how important various assumptions are. To me that is very important. It is one of the big advantages of the computer.

Scott: You can run a problem with a lot of different assumptions, and see what happens. Then you start using your own human judgment again, considering how probable the whole thing seems.

Foundations: Assumptions About Stiffness and Yielding

Degenkolb: We have an analysis of highrise buildings, for example. The assumptions for the foundation could completely change the outcome, and unfortunately we don't know much about foundations, in spite of years of research and study of how stiff they are. We know how strong they are generally, but not how stiff, and how this affects the structure above. So literally we do run with the computer, we can run with a bunch of assumptions so that we can pick at least a range of what is probable. That doesn't sound right, but that's essentially what we do, I think.

Scott: You know how strong the foundation is, but you don't know how stiff it is. Can you say a word or two in layman's language to explain the distinction between strong and stiff? I think I understand "strong"—that's basically how much bearing strength it has, how much weight the thing will hold up, thinking only of the force of gravity.

Degenkolb: That's right. I put a footing down and generally know, from tests and experience, how much it will hold on different sorts of ground. That's the strength. But we know it will move—sometimes it moves over a period of time. Generally, there's an elastic or an immediate compression if it moves down, and then there's a future settlement.

Scott: You're talking about the foundation being pushed down into the ground.

Degenkolb: Right. How much of that occurs...there is a much wider variation than in the strength. If you were to drive a pile into the ground, we could test fairly easily how much—like a nail in wood or something like that—how strong that is. Also we have experience over the years about how much that will move. But how much a pile moves will be greatly affected by whether it is supported continuously along its length, or is supported by a hard rock or a hard layer down below, and goes through soft stuff above. Such variations will greatly affect how much the pile moves.

Scott: Moves on down?

Degenkolb: Moves on down with deflection—instantaneous and/or over a period of time. You've got a foundation of any kind and you put a structure on top of it—whether this moves, is very stiff and all loads are taken here, or whether it deflects like this [scribbles a drawing]. This deflects, and that completely changes the analysis up here. The usual assumption is that the foundation is fixed, but very often that is the most dangerous assumption. You'll have a completely different distribution of stresses if there is some yielding.

Scott: In other words when you say, "Assume it's fixed," that means you assume no yielding. Like its an absolute slab and it isn't going to move at all. And that's not realistic.

Degenkolb: That's not realistic. For example, the 6-story steel building we tested over in Japan, and the 7-story concrete building, the Tsukuba building tests at BRI [Building Research Institute]—they were tested on a very heavy concrete foundation that is absolutely as fixed as we can physically make it, because we don't have the opportunity of doing other things. When we test on the shaking table, it is of a fixed condition.

As a matter of fact several years ago when we shook the model building—one that is as high as a building—they built a steel building 6-7 stories, or 4 stories, I don't know. They put a model of it on the shaking table with the weights in here, and one Saturday we went over and they showed us a test of it. They were showing all kinds of uplift in these columns when it was shaking. Several of us asked, "What if we don't anchor a building to the ground and you've got all this tension—what happens to the structure if this column can lift?" This would be true in an actual building. Well they did that. They had to design a fixture. Several months later they tested it, and found the stresses were much lower—had completely changed.

Scott: Let's go through this again.

Degenkolb: You have a big solid plate down here, which may be shaking or fixed, or whatever, so that the building is fastened to that plate. This is similar to a fixed foundation. When the column can lift off, the stresses would be lower. If this were static stress we could tip the thing over.

If the column is not fastened—is just sitting on the ground—then you can move it up and down. As a matter of fact when we look at buildings, even small buildings, after an earthquake, you can often see cracks around right where the footing is. So there is some movement that we don't account for. Traditionally, in the past, we had no means of correcting for that. Now, however, we try to include it. Sometimes this makes it worse, sometimes it makes it easier, but you try to get a range of what happens. When you look at a building after an earthquake—let's talk about a house with a basement. If you walk around the building you will generally see a crack, a little gap there. Maybe it's only an 1/8 of an inch wide, but it shows movement with respect to the ground.

Scott: This is after an earthquake?

Degenkolb: Yes. The hardware store in Tehachapi—I remember they had a beautiful one-story structure. It gave a beautiful performance—it was well-designed and everything else. You could walk around on the floor inside and see little puffs of dust that had come up through the cracks in the floor. That doesn't get written up, because in a way it's not structurally important, except that when we consistently see this, it's telling us something. It is telling us that there is movement between the building and the foundation, and our assumptions and the ways we usually analyze things are not quite right.

Scott: In other words, the assumption is that the building and the foundation it sits on, and to some extent the foundation soil below, all moves as a solid chunk?

Degenkolb: That's right.

Scott: That it moves all together, with no give. You say that's not the way it is in reality?

Degenkolb: That's right.

Scott: Moreover, the difference is of considerable significance in determining the stresses and the forces that will affect the structure itself, particularly in earthquakes?

Degenkolb: Even with ordinary subsidence it will affect the stresses, but this is especially true in an earthquake. So all of our precise figures are really not physically accurate. They don't give a true picture.

They are empirical, in the sense that we have found that if we do certain things with the construction—I'm talking about traditional construction—if you analyze it and build this way it's going to work, even though the stresses calculated are not accurate. Whether that still applies to new construction is another question.

Tilt-Up Design: Not Tied Together

Degenkolb: That's one of the problems with tilt-up design. We really have only had one earthquake experience with tilt-up, and it was bad.

Scott: When was that?

Degenkolb: That was in the '71 San Fernando earthquake. We had other tilt-up walls built like poured-in-place.

Scott: Poured-in-place is different from tilt-up?

Degenkolb: Yes. Anyway those [tilt-up walls built like poured-in-place] have performed well, but they're anchored in the traditional manner. What I mean is, using traditional joist anchors and traditional proportions, and connecting the walls together in the traditional way—lapping steel or welding it instead of using caulking compound—and tying the floors into the walls. They have performed in the traditional manner, which is pretty good.

But we've found new ways of doing things, using fewer anchors, and with each individual piece of wall acting by itself rather than as a long mass. Not tying the building to the footings or to the floor. Typically that is what they're doing in Silicon Valley, but we know from San Fernando that some of those things will fail.

Scott: You're basically saying that they are not tying the various parts of the building, its components, together as well as they used to?

Degenkolb: That's right. That's exactly what I'm saying.

Scott: Then when such a structure is subjected to unusual forces—earthquake shaking and so on, it tends to fall apart.

Degenkolb: That's right. If this was a tilt-up wall [scribbling again], we found out in San Fernando that there were a couple of things wrong. The plywood and the joist were bolted to a wood ledger, but that was not an adequate anchor to hold the wall and keep it from falling out.

It used to be that we had steel straps and bolts to tie it into the joist. Then we had diagonal sheathing and this was all tied together back to the next beams. We really didn't worry—it was inherently tied together. Then we found out that even if this didn't break, the wall or roof would pull apart at this point. What you have is a concrete wall. You have a bolted wood ledger, and then the plywood, then maybe the next joist.

It used to be we would anchor this back to the joist and into the plywood, or into the purlins going the other way with a bolted strap. But you can put a nail down in here and put the nails on 2" or 3" centers—just nail it in here, and then that is in a 2 x 4 or 3 x 4 or 3 x 6, which is bolted here, in turn, and you can make that figure for the forces that are on the wall—earthquake forces. This was permitted until '73, just the way I've showed it, as the anchor. But what happened is that either the nails pulled out of the plywood, because this is only a 1/2" or so, or this piece of wood split. Then this just pulled out, the wood would split, in cross-grain bending. The '73 UBC corrected the cross-grain bending weakness, but did nothing about the nails pulling out.

In that case, it's not attached to the wall. We wouldn't have done that in the old days, but it saves money. We would have had maybe an angle bolted back into the structure back in here, to hold the wall...so it would be an angle, and some structure back into the steel, so even if this wood splits, it's still anchored. Generally 8 feet or something like that over to the next purlin.

Choosing the Right System

Scott: Would you talk a little bit more about the problem of designs that are difficult from the outset, because they are intrinsically harder to make resistant to earthquake forces? From previous conversations with you and others, I know that earthquake engineers are quite concerned about this.

Degenkolb: Very often, as far as earthquake safety is concerned, many of the systems commonly used throughout the country are just automatically bad to start with.

Scott: What do you mean by systems? The basic design?

Degenkolb: The basic design, choice of materials, of ways of supporting the loads. For example, a very, very common thing throughout the country is to have brick walls in a 1- or 2-story building, or steel joists or pre-cast concrete resting without being tied together, or with welded connections that are brittle.

For Chicago, that's probably perfectly good. But when you look at the whole system, the whole method of framing, the materials used, and the details used, and you transport that to California and try to apply earthquake criteria to it, it will probably cost you 10-15% to make it reasonably earthquake resistant. But if *right at the beginning* you make a better choice of materials and systems, you could probably do it for a very small proportion of what it would cost to make the other system earthquake resistant.

The most important decisions that affect either saving money on a building, or getting a decent building, occur in the very preliminary phases of design. What you start out with, what your assumptions are, largely determine. With the right way of doing things, if a system is inherently good, it really doesn't matter whether it's a little stronger or not. But if you weaken it to the point where you permit bad details or poor anchorages, you only save peanuts while increasing the hazard tremendously. That's why it bothers me to weaken the requirements on precast walls, which may shower down on streets. I think it's like almost anything else—if you start off on the right path, it's not hard to do things right.

Scott: Does that mean some basic systems ought to be either outlawed or strenuously discouraged in earthquake country?

Degenkolb: Yes, but you can't quite do it that way, because it's a free country and you can't totally outlaw certain materials. In ATC 3 we have listed some design reduction factors for some types of framing, depending upon the ductility (toughness) of the system. Those systems that have low ductility must pay the penalty of designing for much larger forces, hence they are discouraged from using them. To design for lower forces, you must choose a system that is inherently tough, but this requires details that are not common throughout the United States. Actually, the worst systems are not permitted [under building codes] in California. In addition, for certain occupancies, what we call group D in ATC 3—that is, hospitals, schools, and buildings of very high occupancy—we have outlawed certain methods or materials. Not very many, because first of all, that's not a good way of doing it. There's a better way. We've also put very heavy restrictions on the poor systems, not restrictions, but very high criteria, expensive force levels—trying to do it indirectly. I think, well, since I'm one of the proponents of that, I guess I'm in favor of that.

There are certain systems, very common in most of the country, that are not suitable in California. The way they do bridges in the midwest and the east is on even a lower level than in California before the '71 San Fernando earthquake. We saw what happened to our overpasses and bridges, and since then our systems have changed dramatically for bridges. But they have not changed much in the rest of the country, although where earthquakes are a factor they've written a new code, AASHTO [American Association of State Highway and Transportation Officials] has.

But you can only do that when things are demonstrated to be bad. The Four Seasons [in Anchorage, Alaska] was a lift slab apartment house that collapsed up in Alaska. Before that, however, there had been other earthquakes in which lift slabs didn't perform badly. While they've now got a bad name in some places, we find that in England and Europe they're used an awful lot.

Scott: What is the term?

Degenkolb: "Lift" slabs. They're all poured on the ground and lifted into place. Actually, I would like to outlaw the system, except in special cases. If they are designed and built properly to get adequate safety, it will probably cost much more than the way they're actually doing them in most places. If you want to spend enough money, even a bad system can be made into a less hazardous system, an adequately safe system. But as it costs money, the balance of what you choose changes, and that's often lost sight of. But if you don't have the earthquake problem, as you do not in most parts of the midwest—or don't appreciate the problem and never considered it—they do a lot of things that would be bad here. They also have many failures, for example L'Ambience [Hartford, Connecticut], recently.

We run into that occasionally when an eastern engineer does a job out here. They design certain systems that are familiar to them, and the result is that some jobs are very, very dangerous—I would not want to either live in them or have my office there. Some of the systems like Moffitt Library over at UC, followed the codes at the time they were designed and built. We didn't know then that the systems were weak. Since then, since Caracas in '67, we have found out that this method of construction [lift slab] is not good in earthquakes and has to be reinforced. In this way sometimes the development of more experience from observing earthquake damage changes what is considered "reasonably safe."

Learning As We Go: The Imperial County Services Building

Scott: You learn that a system previously accepted is not as good as you originally thought?

Degenkolb: The system of nonductile concrete frames is not good. That's what happened in Imperial Valley at the County Services Building. That was considered a well-designed building, and the engineer did it very carefully for loads 50% greater than the code required, and yet it had to be abandoned after the 1979 earthquake.

Scott: Was it the soft-story aspect of the building that caused the problem?

Degenkolb: No, by our standards, the way it's usually calculated, it is not considered a soft-story structure because it has a shear transfer under the second floor. But it's an overturning phenomenon, a partial overturning on certain columns, which is not recognized in the '83 Uniform Building Code, but will be. We recognized it in our ad hoc committee work for San Francisco. That was one of the things that was not accepted in the changeover from the old San Francisco code to the UBC.

The Imperial County Services Building loss was mostly, I think, due to the fact that we did not have ductile detailing requirements, and while the engineer went way beyond the code at that time even in his details, we did not then recognize the weaknesses of these details. That came about later. There are, for example, certain buildings that our firm has done that lack the ductile detailing we now know is necessary—fortunately not very many. Most of our buildings, I think, are probably going to perform pretty well, though looking with hindsight at what we did 20 or so years ago, there are some things I wish I hadn't done. The problem is that we learn as we go along.

Scott: The state-of-the-art changes over time.

Degenkolb: State-of-the-art, that's right.

Chapter 5

The Practice of Engineering

"We convinced them [our insurance company] that it's better if we handle everything – the design, complete authority, with all the inspection done through us. We convinced them that it's better to keep something from happening than to worry about who's at fault after it happens."

Degenkolb: Most of the engineering names that you read about nowadays are the big 1,000- or several-thousand-man firms that went the business way. Some of them are good and some of them are bad.

Scott: What do you mean by the business way?

Degenkolb: Enlarging, running it as a business, production-line type of things. What I'm saying is that is they're probably wrong. That's what you think of: the big Kaisers, the big Bechtels, the thousands of people in production-line work. It's no way, generally, for entering or bringing up the profession. Traditionally, that type of outfit robs other offices and doesn't develop people. Then, when things slow down, they dump them all. When you get into the very large offices, it's more of a business than a profession. We've seen some pretty poor work come from some supposedly high-quality offices, or offices that used to be high quality. I don't like to say too much about it, because every older generation looks on the new one and says everything is wrong.

Scott: You mean you represent an older generation of engineers?

Degenkolb: That's right. With families, doctors, any profession, any line of work. The older generation knew what they were doing and the younger one doesn't. You don't know how to separate that feeling from what you observe.

Fees, Competitiveness, Rush

Degenkolb: It all boils down largely to fees, and competitiveness and the rush to do things. It's the same thing that the automobile industry went through some years ago—turn it out cheap, don't worry about the quality. That, of course, has backfired. It's catching up with us. There have been many building failures and the profession has been discussing the problem in conferences and journals. To a large extent we have been through or are going through a phase that is similar to that.

Scott: By that, you mean the competitiveness and rush is beginning to backfire?

Degenkolb: I'm not sure what phase we're in, but certainly the desire for a quality building, at least in the big buildings, seems to be subordinate to the desire to build it quickly and cheaply and get a financial return on it. That was secondary in a lot of the old buildings. It means the [engineering] fees are cheaper, which means you'll have a more competitive engineering group, which can mean less professionalism, more computers, more work-by-the-book rather than thinking, which means less training for the younger people. Whether that's true or not, I'm not sure. I think everybody's biased. I am, anyway.

It's a basic attitude difference. If you're an owner yourself, you want something that will be good and last, with low maintenance—a quality building. But if a builder is going to dump it as soon as possible, he really doesn't care about that. He wants it done as cheaply as possible and as flashy as possible, so it can sell.

Your apartment house owner is involved in all the maintenance and everything else. He wants it to be good. But if it's condos, as soon as they are sold, the developer is out. All they want to do is build and get out. It's an entirely different attitude and it effects every step in design and construction. It affects the choices of architect, engineer, contractor, and the materials that go into it.

Scott: So, if you are a developer, which means you own the building for only a little while, the assumption is that there is not going to be an earthquake during that short time.

Degenkolb: That's right. That gets down to one of the basic reasons why I think there are a lot of failures now. A failure is not necessarily a collapse. Waterproofing is the biggest thing—roofs leak or foundation rot. And with respect to earthquakes, they want the cheapest thing. Anything that passes the code, or that the building department will pass, is okay. If, however, it is done for Standard Oil—I'm just using that for an example—say the headquarters building, or for Bechtel or someone like that—they want a quality building.

Scott: In terms of volume of buildings, and ownership vs. development, are more being built by developers than by actual long-term owners?

Degenkolb: I think more are being built by developers.

Scott: So it's a very important consideration.

Saying "No"

Degenkolb: Right. And the type of engineer that will say "no" to something eventually doesn't get to do certain jobs for certain clients. And there are a lot of engineers now that will take the jobs. As long as it meets the code and doesn't violate the words of the code, they will do whatever the architect wants.

For instance, years and years ago we refused to do a job up in Seattle because they wanted to do it a certain way. Their previous engineer wouldn't do it that way, and we wouldn't either. They found somebody else who would, though.

Scott: Your concerns about the Seattle building, were those related to seismic stresses, or were you concerned about ordinary loading?

Degenkolb: Just ordinary loading. There's been an awful lot of trouble over the years on prestressed concrete, pre-tensioned and post-tensioned, because of the creep factors and everything else. But some people are still doing it.

Scott: On the Seattle building, when was that?

Degenkolb: John was alive, so it was about '55 or so. That's a long time ago.

Scott: Do you still feel those concerns are justified?

Degenkolb: Yes. That Seattle job had one place when you came out of the elevator and stair core, which had adjacent floor spans of 35 feet. From the hall between elevators, you would step onto a floor in the middle of a 70-foot span. In those circumstances, it is almost impossible to make the deflections compatible—to keep the deflections the same—especially on something that has shrinkage or creep like concrete. I understand they do have a step between those two spans. Over the years in those circumstances you can't have an even floor.

Scott: You mean there's a differential, that they actually have to have a step?

Degenkolb: Yes. So I think we were right. I don't think they would do it in that manner today, but that doesn't help now. Except I think engineers are learning that you have to use some judgment and be able to say "no" once in a while.

Structural Failures

Scott: Is that sort of thing still going on, or its equivalent?

Degenkolb: Yes. As a matter of fact that's the reason for the structural-failure seminars and a lot of such discussion. There have been a lot of problems, and not only in that particular way.

I don't know of anything quite like that [Seattle], but you have comparable things now, especially in welding. Wolf Trap [Wolf Trap Farm Park, an outdoor center for the performing arts] in Washington, D.C., is in all the magazines just now. It burned down a couple of years ago. Then they replaced it, and the new structure just opened 3-4 months ago, and already it's shored up because of weld failures in some of the girders that span the auditorium. There's been trouble in several states—Texas, Hawaii, Seattle, largely due to welding.

Scott: Are these new structures where some kind of failure is just beginning to show up?

Degenkolb: Yes. In some of these there were cracking and failures before the structure was finished. We had the same thing on some of the bridges in welding high-strength steel. They stopped one of the bridges across the Columbia River in Portland, I forget the name of it, because of the welding details. There have been a whole rash of failures, and they're still going on.

Scott: Are these failures due to differences in design philosophy, with one philosophy proving better than the other, or is it just failure to do a really good, top-rate workmanlike job on the actual project? Or is it a little of both?

Degenkolb: Most of the ones I can think of are pushing the limits of our knowledge and experience a little further, and not realizing the problems that can result. For example, some minor detail that is no problem on a 100' span, may become very important on a 200' span. Or if you can weld 1" thick steel, just assuming you can do it bigger. But the welding of 4" steel becomes a different problem, in cooling stresses and all that.

Sometimes they're matters of bad design. Sometimes it's bad workmanship. Then they want to cut down on the inspection to save money; well that's no place to save money. One engineer goes by the book and does it cheaper, while another engineer with a higher fee may investigate these things or be more careful about certain details. So it's a matter of fees, of inspection costs, of pushing our knowledge or what we think we know in the field. It's a whole flock of things.

On some of the big ones, like the Hyatt Hotel [the interior bridge failure in Kansas City, Missouri], there is the whole business of quality control, of checking designs, and later of checking shop drawings. Under common midwestern and eastern practice the engineer won't want to see the shop drawings. Shop drawings are considered a detail that is up to the contractor.

Checking: Preventing Failure in the First Place

Degenkolb: In our case, in California practice, at least with the better engineers, we insist on seeing the shop drawings and we check them. We may *say* we don't—we've got a very reasonably worded stamp saying everything is up to the contractor, specifications. But still we spend the time checking it. If we can catch any errors, it just makes a cleaner job. But that is California, or maybe western practice. I've heard and read of fellows in other parts of the country who are just as vehement that they don't need or want that responsibility.

Scott: I can understand their being vehement against it, if they say they don't want the responsibility, and I guess the liability too. But do any of them also maintain that you can get just as good a job done, or that checking the shop drawings wouldn't help at all in getting a cleaner, better, quality-controlled job?

Degenkolb: I don't think anybody would maintain that. They just don't want the responsibility. It's up to others to pick up and do an honest job. The trouble with that approach is that when something happens, everybody is named afterwards in litigation, so they're really not ducking any responsibility. I think the western [California] philosophy is that you try to prevent something from happening in the first place, so you try to control it all the way through. But that's basically one of the reasons why right now we [H.J. Degenkolb Associates] are not working with architects that do a lot of highrises. Well, we recently did Moffitt Hospital in San Francisco, which is 15 stories. That's not really highrise, but it's costly to do it right.

We just turned down a job for a client we've done a fair amount of work for. They were giving us a certain price on another major hospital in the Bay Area. It was about half of what we figured we would need to do it with all the red tape to get through OSHPD [Office of Statewide Health Planning and Development]. But if we can't get it done for the price they want, somebody else will do it. That's what's really happening.

Architects and Engineers: Fees, and Relationship With Owner

Scott: On the cost difference, let me ask you to give a horseback opinion. In terms of costs, the basic engineering fee would be part of it, and I suppose the costs of inspection and that sort of thing. But when you get to different design philosophies—where the cost difference might involve a percentage of the entire cost of the whole construction job—how would you weigh these? How do these cost factors compare in order of magnitude, or are they really not comparable. Do they differ tremendously from job to job?

Degenkolb: Generally the architect's fee will be about 6%, maybe 8%, of the total construction costs. Hospitals, schools, etc., are more—compared, say, to a warehouse. And we say we should get a quarter of the architect's fee, maybe a little less.

Scott: Would that be one-fourth of his 6%?

Degenkolb: Right. The architects maintain it should be more like one-sixth or one-fifth. So let's say the structural engineer gets 1%. Then there are the mechanical, electrical, whatever consultants. Let's say the structural engineer gets 1%. But you can also get the engineering done for as low as $^3/_4$%—and maybe a good engineer will hold out for $1^1/_4$% or $1^1/_2$%. That's the difference in planning—that extra $^1/_4$% or $^1/_2$% of a total job—yet it may save many times that by having a job thought through more thoroughly, having a cleaner job. There have been enough problems that they [architects], more and more—after a few experiences of actually having to pay money out—they prefer the higher quality of service, let's put it that way. To get better advice to start with. You can design a job for almost nothing if you just "single-line" it—give member sizes and make them all oversize, so that you're safe. But that makes for an expensive job later on.

Scott: Describe the engineers' and architects' relationship with respect to fees and responsibilities.

Degenkolb: If it's an architectural job, like on a highrise, the American practice is that out of his fee, the architect pays for his subcontractors, engineers, various structural, mechanical, electrical engineers. So the cheaper the engineer he can get, the more of the fee the architect can keep. I'm told that the English practice is that the owner pays the engineer directly, outside the architect's fee, so it's not filtered through the architect. Architects in the United States traditionally have fought that very hard. They want to be the master builders and do all the controlling. In recent years, that has been changing because of liability. If you hire a subcontractor, you're still liable for everybody working under you. If there are separate contracts with the owner, then you may not have that [liability] problem. If there were structural problems, but the engineer had been hired directly by the owner and not by the architect, the architect could say, "That's not my responsibility."

Scott: Would structural design under a separate contract with the owner be a more direct relationship?

Degenkolb: Yes. Traditionally, Brunnier's office was the only one I know of that could generally get direct fees from the owner. Also, we [H.J. Degenkolb Associates] have in quite a few cases—or we've had arrangements where we play the architect's role insofar as coordinating a job, and then hire or retain the architect to do the architectural work.

Scott: That's interesting. Tell me a little about why those arrangements are different from the standard pattern.

Degenkolb: Generally, on garages, we are the prime contractor because it's mostly structural work. And we don't do architecture, so we hire the architect. On the Oak Knoll Hospital—the Navy hospital—the Navy wanted an engineer in charge.

Scott: That was a decision made somewhere in Navy management, they preferred that?

Degenkolb: They wanted an engineer in charge because they [engineers] can manage the job better. Many architects are maybe artistic, but are not very good management people. On certain jobs, we had the contacts and the owner preferred doing business with us, and then we hired consultants. We're sort of an anomaly in that respect. Many offices don't do that. It's hard to compete with the guy, and then be his client or have him as your client.

Engineering "Different" Designs

Scott: And then I guess part of what you've alluded to is that the architect, or owner, or the builder/developer wants to have more freedom to do something—to have a wider floor span or go higher, or maybe do it with less material cost?

Degenkolb: Well, they want it as cheap as possible, very often. It's fashionable to have these very long spans so you can move your partitions around any way you want. It's cheaper. You could put up sheetrock, or some two-hour fire-resistant floor around the stairs, rather than concrete and a four-hour wall. It's cheaper to use a metal deck and fill, without the underfloor raceway for electrical stuff, and feed everything from the ceiling. Those are cost things that architects might design—all this fancy stuff.

On 101 California—that's a circular building that's got a 21-foot gap—a cylinder that's 50 stories high and it's circular, but not quite circular. One edge of the circle misses the other by about 21 feet. It's an open circle. That costs money, and it also raises problems with the engineer. Can you make a building with that shape reasonably safe?

They'll pay a lot of money to get something that is a little different. Mostly "different" also means expensive. It's the same analogy if they're selling a house. If a builder has some nice kitchen equipment in there, customers may say the heck with going around to see the rest of the house and checking how well it's built. A cheap house can sell nicely if it has a nice kitchen and washer-dryer, all that sort of stuff, rather than a good house without these things.

Scott: In short, some of these things have much more immediate visibility and attractiveness? Sometimes you don't see all the good features?

Degenkolb: Yes. Many clients, maybe most, treat engineering as a commodity. As long as a structural engineer does it, and as long as it meets the code—it has to go through city hall—they're all seen as equal. If they can get the engineering done for $^3/_4$ of a percent... [shrugs].

Scott: In other words, the attitude is, as long as the person who does it, who signs off, is licensed as a structural engineer, and as long as it meets the code, the design is considered okay?

Degenkolb: That's right. You can't legally stop builders from doing anything that the code permits. So first thing, a code should be the best code you can write—up-to-date and with a reasonable balance between economy and safety. Judgment and state-of-the-art practice can't all be written into the code.

Small Firms Not Getting the Big Design Jobs Anymore

Scott: For the future, does it look like most of the engineering will tend to be done by the big firms?

Degenkolb: That is almost the universal prognostication. For the last two years we've been hearing more and more in the professional magazines that the little firms that traditionally did the work are on the way out. My reply to one of those some years ago was, "Well, we'll need some quality firms to fix things up." It is true that most big buildings that you see going up now, most of the tunnels, BART, all this kind of stuff is done by the very large outfits, almost never by the smaller offices any more. There are certain things that can't be done in a small office—a nuclear plant, for example—something extremely large and complex. A power plant cannot be done in a small office, unless you organize a bunch of small offices—by subcontracting. But even the ordinary things are generally being done by the big offices. Like many others, our own focus has shifted. Where we once did almost all new buildings, and a very small amount of problem areas. Now we largely do problem areas and some buildings.

Scott: What do you mean by problem areas?

Degenkolb: When there's a failure, to find the cause of it. When there's a lack of performance, too much leaking, too much sagging, or settling because of foundations. Or a specialty area. We were involved with the rapid transit tunnels in L.A. Very few people are concerned about deep excavations, and the effect on adjoining buildings and buildings over the tunnel.

Scott: These are special problems?

Degenkolb: Yes. I think in the future that role will stay in the realm of the small office. Already the small office has lost—most big buildings you see here are done by SOM [Skidmore, Owings, and Merrill] or HOK [Hellmuth, Obata, and Kassabaum] , or another large office. A lot of the engineering is done by the guys with the branch offices from Texas or elsewhere. Projects are going into the big architectural-engineering offices. They are doing the work, rather than the small ten-man, five-man architectural office.

Scott: Look around at all the construction that's gone on in this city. If you compare a picture of San Francisco's skyline taken 20-25 years ago with one taken last year, it really is quite a phenomenal change. Who designed all of these new structures?

Degenkolb: Skidmore, Owings and Merrill. I would say they've done two-thirds or three-fourths of them. There have been others. [William] Pereira did the Transamerica Pyramid, and Wurster was with Skidmore, Owings and Merrill on the Bank of America Building. Hellmuth, Obata and Kassabaum (HOK) has done some, Philip Johnson-Burgee out of Texas or someplace has done at least three—the Neiman Marcus Building, and one at Kearny and California, and 101 California. They're going for the architects that are famous.

Somebody explained it to me once—when you're doing these things for a big corporation, there's another element in their picking an architect. If they pick a good but a small one, who's not really well-known, they're sticking their necks out. They might get a superb design—in some cases they have—but on the other hand, if they fail, then the people who picked the architect are in the doghouse.

But they can never go wrong picking somebody with a big name like SOM. The result may not be as good, but they can't be criticized, because the firm is so well-known. I think they have a couple of real dogs around town. They just had the AIA convention here last week, and from some of the things I read I guess some of the architects also believe that, although maybe we don't agree on which ones are the dogs.

Then there's [John] Portman, who's done the Embarcadero Center and the Hyatt Regency Hotel. We're doing the excavation for the Portman Hotel at Post and Mason Streets [now the Pan-Pacific Hotel]. If you get somebody of their stature, some of them are good, some are not. I happen to think that Portman is a pretty good engineer or pretty good architect. At least his organization has been pretty careful. They have unusual projects, but they're buildable projects, while some of the others are complicated just for appearances.

Scott: You mean for aesthetic reasons? They want to design a building that looks different, or is on the far-out edge of architectural design, and it may also be hard to build?

Degenkolb: Generally they are hard to build if they are far-out designs. Not always of course, but generally.

Scott: Many or most of these architects you have mentioned are not Bay Area architects? Is that true?

Degenkolb: SOM started in Chicago, but they've got offices all over. They've got a San Francisco office, one in L.A., and one in Portland. The San Francisco office does the work around here. HOK is out of St. Louis, but they have an office here. Philip Johnson-Burgee has an office here. CRS [Claudell, Rowland and Scott] out of Houston is just closing their San Francisco office at the end of the month. Whether they do most of their work at the home office or in their branches, I wouldn't know.

Job Control and Liability

Scott: You spoke earlier about engineers being able to say "no," and about the importance of job review and checking that things are done right. This obviously relates to concerns about failures and also to liability concerns, which have gotten a lot of attention lately. Would you say a little bit about those issues?

Degenkolb: There have been a rash of failures, and so the different organizations of consulting engineers, the American Society of Civil Engineers, etc., are having seminars and making a big deal.

Scott: The November 1983 Santa Barbara workshop was a good example.[36]

Degenkolb: The engineers need to get back in charge of their thing. We've [H.J. Degenkolb Associates] generally taken the position that we have to be in control. Years ago I sold our insurance company on that. What we do on deep excavations is unorthodox. Generally, they say do the design, and you will observe the construction, but keep rather aloof and avoid liability. We convinced them that it's better if we handle everything—the design, complete authority, with all the inspection done through us. We convinced them that it's better to keep something from happening than to worry about who's at fault after it happens.

Scott: When you sold your insurance company on this, does that mean that you got more reasonable premium rates?

Degenkolb: No, they permitted us to do it. Otherwise, if we get into that, while our insurance is okay for certain things, if we do some other phases of the work, our insurance wouldn't cover us. Right now, some offices are facing that. They will practically be out of business because they can't get insurance.

Scott: In other words, you could only do certain parts of the job?

36. Gross, James G. *Summary Notes: Engineering Failures—Their Cause and Prevention. Santa Barbara, CA Workshops of Nov. 6-11, 1983.* Center for Building Technology, National Bureau of Standards, Washington, D.C., 1984.

Degenkolb: And you had to have hands off on other parts, otherwise your liability wouldn't cover you. The similarity is, 10-15 years ago the good foundation engineers would not do residential work—the liability was too large. As a matter of fact, there was a time when none of the standard carriers would carry a geotechnical firm. Their lawsuits were horrendous. And the good firms would not do certain classes of business.

Residential Work and Gresham's Law

Degenkolb: The class of projects that most need competence is residential—housing, condominiums and such stuff—because that's where the biggest chances are taken and the worst things are found.

Scott: You mean the condominium sort of thing?

Degenkolb: Residential, my house. Any fee you can get for doing a house, because a house is of small value, isn't worth the liability that you've accepted for telling them it's a good or bad foundation. You don't know that much about it. The big outfits, the good outfits, refused to do any residential stuff. So there was a class of very poor engineers who were the only ones you could get to do that. It was Gresham's Law of engineering: bad engineering drives out good engineering for the people who need it most. I think that is true of a lot of this other stuff that is going on, and that's resulting in some of the failures. If you compartmentalize everything to limit the liability, you sometimes end up doing things in an expensive way in order to limit your liability, rather than in a rational way. On the other hand, I think, in general, the work is becoming less professional, jobs are being done cheaper, and we are driving out the quality work. I think that is what's happening in many of the large offices. Anyway, as I said before, it will always take some quality offices to fix them up.

Scott: Do you think the recent concern with failures is being reflected in the various activities of the professional associations? There have been a whole bunch of them, but I think of the Santa Barbara workshop a couple of years ago—November 1983, the one I just mentioned.

Degenkolb: That was originally sponsored by NBS [National Bureau of Standards].

Scott: The results of the workshop have gotten a lot of attention around the country, and apparently have been pretty well received by many structurals and professionals.

Degenkolb: Yes, no question. There was a meeting back in Chicago on trying to do with the structurals what the foundation engineers [American Society of Foundation Engineers (ASFE)] did 12-15 years ago. In ASCE, we have this peer review, which is not technical review, it's more of a procedural thing. You have the Seismic Safety Commission pushing for peer review, an actual detailed review of all phases. The failures are causing a reaction, how strong the reaction is, compared with the other forces, I'm not quite sure. At least a lot of people are recognizing the problem.

Scott: You mentioned the foundation engineers a couple of times, and what they did

10-15 years ago. Would it be worthwhile to describe that?

Degenkolb: All right. The first big [geotechnical] firm, the biggest in the world now, is Dames and Moore—Bill Moore and Trent Dames. The other is Woodward-Clyde. Those are the two biggest and they're both in the Bay Area. There are other good ones. There was a period in the days after World War II, when you had some large tract developments. They were the experts, and if you wanted a house done, they would do it, or if you had a developer with a dozen or a hundred houses, they would recommend on the fills, grading, type of piles, etc. That's fine, and I think they always did fairly well on the commercial work.

But they also did a lot of residential work. The residential work practically broke them. They couldn't get insurance because there were so many claims. While you might get $100-$200 to make some recommendations on a house, if anything went wrong or the contractor did something wrong, they [the engineers] would also be named, and the punitive damages would be several hundred thousand to a million dollars. There were some huge mistakes made. Here was a brand new profession dealing with soils and foundation engineering, and geared to industry and commercial type of work. Woodward-Clyde, I know, got tabbed for a lot of these developments on the Bay. Housing, commercial developments, with the buried stream beds with fills over, that have differential settlement. There was Portuguese Bend—down in southern California, the big landslide. This almost broke certain companies. Woodward-Clyde actually split into a lot of little local companies to limit liability.

Insurance

Degenkolb: The various geotechnical firms couldn't get insurance, so they started an "offshore" insurance firm for insuring themselves. They started out with about 22 firms around the country and they were highly successful.

Scott: Woodward-Clyde started it?

Degenkolb: They were one of the founders, and so was Dames and Moore. There was a group of about 20 or so by the time they got in that mess. Their program [requiring loss prevention practices and education within the profession] was highly successful. The basis of their success was really that they faced up to the fact that they were doing a bad job—or a lot of them where—so they straightened up. They made certain minimum office standards, design standards, quality standards, that they had to live up to.

Scott: What was this group?

Degenkolb: American Society of Foundation Engineers, ASFE. That was a new organization. It's really related in a way to ASCE, and it's related to insurance, but it's ASFE. The insurance company was TERRA, based in Bermuda, an offshore company. Although the last I heard with this last go-around with lawsuits, they are in trouble again. But for a long time they had a good insurance record when some structural engineers didn't, which was a reversal of things. One of the reasons I think they succeeded is that there were only a few of them at that time—a couple of dozen, and the organization then grew. You can control a couple of dozen or 50 practitioners. They can get together and say, "These are our standards, and this is the way we're going to do it." They got out a lot of manuals and instructions for training their people in office practices.

You watch your contracts so you don't guarantee everything, which means you don't brag about things if you can't deliver. You tell them exactly what you can and cannot do. Boasting can get you into a lot of trouble. They [the foundation engineers] cleaned their practices up. The structural engineers—there's a 1,000 in northern California alone, 3-4,000 in the state, and 50 states. We'll have to do something like that. That's what ACEC [American Consulting Engineers Council] is trying to start.

CEAC (Consulting Engineers Association of California) is one of the founders of ACEC and is active. They are pushing that now, taking the example from the foundation engineers and pushing that idea to the consulting engineering firms.

The idea is to improve the quality. That's not checking an individual job, but checking practices. Reviewing the quality control in the offices—how do they check the jobs, how do they write their letters, what are their business practices—this sort of thing. It's review of processes and procedures, not of individual projects or the type of engineering. It's done to ensure that there are quality controls in the office, that they are signing the right contracts, not assuming all kinds of extra liability, this type of thing.

This is needed, but should not be mixed up with independent review—the other type of review that the Seismic Safety Commission wants that is similar to that given schools. "I don't care how you do it, but the answers have got to be right because I'm checking the answers."

Scott: A review of the design of a project itself, whereas the review you are talking about is a review of procedures.

Degenkolb: The qualifications of the office.

Scott: Various professions try to handle this. For example the accountants have this kind of thing. They even do a peer review of each other's shops—to see how well their procedures are living up.

Degenkolb: There would be two or three guys from another shop who would come in for a couple of days and review their competitors. It's done on a professional basis. It's not to check individual jobs, but to look at sample reports to see if everything is covered, or whether something is missing, or whether the engineers are licensed, or what the proportion of engineers is to others, for their type of work, the type of contracts used, correspondence, all this. It's very similar to the accountants.

Scott: How would you go about getting more of that into the structural engineering profession?

Degenkolb: Actually, that is starting with the consulting engineers, which includes the structurals. I have considerable hopes, because the consulting engineers of California are fairly strong, I suspect that in California the vast majority of firms—electrical, mechanical, structural—will have peer reviews in the next couple of years.

Mentoring

Scott: It is widely believed that a "mentoring" relationship—in which an older, established professional helps guide the development of a younger person in the field—is an important way of achieving proficiency and transmitting values. Does your experience suggest that this is so? How does the process work?

Degenkolb: Yes, mentoring is important. You have to let people develop. From my point of view, however, this is a management question. You have to work with a student fairly closely. You can't make all of the decisions—that stifles them, even if you would do things slightly differently. As long as theirs is a good way, and has rationality, you have to let them have their head as much as possible.

Scott: Are you talking about a student when he's still a student, or after he's graduated?

Degenkolb: When he's working, after he's graduated. For most students it takes a few months, we used to say six months, before they can produce anything. That isn't true anymore. The quality of people we now have, they are producing early. But you have to watch, because there's a lot more to learn after university schooling—concepts, systems, and all that. You have to strike a balance between letting them learn and progress, and taking over responsibility. Of course, on the other hand, you have to make sure that a good product goes out.

I'm not sure how others do it. I do know of two or three other offices that do it much like we do. I found out years ago that it is almost impossible to pick up an experienced man who is any good. You really had to take somebody out of school and train them in your own way of doing things. That's the way it happened to me, and that's been the only reliable way for our office. We've had a couple of exceptions, where we picked up other people, but that's only two or three cases. It doesn't happen very often. If it's a really good man, the office is going to hang onto to him. We do know that at times Bechtel, for example, when they've got a big job, they'll go around robbing anybody—or least they have in the past.

We had some horrible examples of when we tried to hire, and did hire supposedly experienced people who presumably could turn something out. Well, it didn't come out the way we did things, and it'd be full of errors. We did ourselves more harm than good, because we would have to take the time to correct the work. So we believe the only reliable way is to bring them up in the office. There are several outfits that do that.

There's of course a disadvantage to that. You see when Frank [McClure] and I grew up, there wasn't an office like this. There were small offices, and nobody could afford to keep a stable of young engineers because the workload wasn't that even, so we worked in various offices. They, our various employers, all sort of tried to teach us. In those days they were very conscious of trying to preserve the profession—it was a small group. So we learned in different offices. Nowadays, if you ever let anybody go who is any good, some other office will get him and you'll never see him again. So they only learn just the one phase—our way of doing it. But we are bringing them up, we're doing the old-fashioned mentoring. And some others do it.

In the big offices I think you can't say they are *not* doing it [mentoring], but I think it's more due to chance as to whether they do or don't. That's my belief at least. By "chance" I mean that if the engineer happens to get under a good squad leader, directly under someone, they may have a very sound mentoring setup. But if they get somebody that is all production and not a very good teacher, they don't have any. So I can't say that the large offices are all good or all bad. I can't say that all of the small offices are good either. At least the guys that seem to be the leaders, the offices that are the most active professionally, generally have the young people in the organizations, and they seem to be bringing them up. Eventually, they become part of the firm. There are some firms that don't try, and they're sort of fading out.

Scott: Which ones are fading out?

Degenkolb: The ones that sort of sat on the laurels of the past, had real good men, but didn't develop young engineers. Personally, I feel that's the way Brunnier's office sort of is.

Some of the younger offices have been developing the new generation. Rutherford and Chekene comes to mind, Wildman and Morris and, I think, our office. There are several others, I don't mean to exclude others.

It correlates with the offices that are pretty active in the professional organizations. Those offices are generally trying to do pretty good. That's really not from an altruistic point of view, but rather from a selfish point of view. If you want to continue an office on the same basis and quality of work, you've got to continue to develop quality people. I think the best offices are doing that. It's a natural cycle—I was reading something recently—the starting of an office, the second generation and the third are maybe pretty good, but then there's a decline that sets in unless it's a very unusual office. I don't know. It's interesting, is all I can say.

When I started out, generally, there was an office (a fairly small office) and a partner, and when the originator or his partner died, the office just disappeared. You don't hear of R. S. Chew or any of his descendants. You don't hear of [J.D.] Galloway, who wrote the 1907 report,[37] or Jessie Rosenwald, or any of those old names. When the guy or his immediate partners died, when Walter Huber and Ed Knapic died, the office disappeared.

I was one of the first, I think, to recognize that if the business would mean anything, because everything was tied up in it, it had to have young people, and it had to progress. Brunnier did that. He had an excellent crew. But I don't think that excellent crew, most of whom are now retired, have recruited young people to go beyond that. While that office has extended now 80 years or so, I think the chances are, unless something unusual is happening, it will go the way of the other offices.

37. "The Effects of the San Francisco Earthquake of April 18, 1906 on Engineering Constructions," in *Transactions of the American Society of Civil Engineers*, Vol. 59, Paper No. 1056. ASCE, New York, December 1907.

Chapter 6

Learning from Earthquakes

"Some of us used to argue that you shouldn't really get your structural license until you've chased an earthquake...No matter how much you read the reports, the impact doesn't really strike you until you've seen the damage."

Degenkolb: Some of us used to argue that you shouldn't really get your structural license until you've chased an earthquake. I'll tell you—the difference between reading a report and seeing it—there is no comparison. No matter how much you read the reports, the impact doesn't really strike you until you've seen the damage.

As far as earthquake design is concerned, by far the most important advances have been as a result of observing earthquakes. The codes were changed on certain things after the '52 Bakersfield earthquake. Largely, this had to do with grouted brick wall construction, because of the Arvin High School. One of the influential ones was the '64 Alaska earthquake. There were failures of a lot of the pre-cast stuff, and of some tilt-ups, and lift slab failures at the Four Seasons Building. You then have a big surge of change—the L.A. code, the S.F. code, and the Uniform Building Code. Then next, was an observance of the highrise buildings down in Caracas in '67, and Managua in '72, and San Fernando in '71. I have written papers about our advances.

Important advances really come from our observing something. We have a new method of construction and see how it performs in an earthquake. As a matter of fact, that's one of the problems now—we have new methods of construction, but won't know until the next earthquake comes whether they are really successful or not.

Scott: Can we talk a little about "earthquake chasing" and how you go about doing it? To start off with, let me comment as to how I've tried to think about the subject. You've got the people like yourself and Karl Steinbrugge, etc., who pioneered the field and have been team leaders, and who really know it from the structural side. Then, of course, you've got a variety of other disciplines that must be involved.

Then beyond that, you've got the "nontechnical" social science and policy people who need to learn, need to get insights from their own vantage points. While recognizing their limitations in terms of technical knowledge, it is clear they have roles to play and they can learn something from earthquake site visits.

I don't know how you would like to proceed. Perhaps you can think out loud about the history and theory and practice of site visits and earthquake chasing.

The 1906 San Francisco Earthquake

Degenkolb: The Japanese got started [observing the effects of earthquakes] even before 1906, with help from British and American scientists on the Nobe earthquake in 1891. On the American side, we have the 1906 earthquake, about which a lot has been written, both technically and geologically—the Carnegie report,[38] the engineering report of ASCE,[39] the geological papers, I think USGS. The Himmelwright report[40] was done to promote a certain method of concrete fireproofing. It has information on some of the buildings, and is a very valuable book for source information when you remodel some of the old buildings. After 1906 there was an interest and there were reports—there was considerable interest throughout the country, when you look at the amount of discussion that followed immediately after the San Francisco earthquake.

The 1923 Tokyo Earthquake

Degenkolb: It was in the minds of the engineers up here [northern California]. And in 1923—I'm trying to think of the guy's name [it was Homer Hadley] who went over to Japan—it's in Freeman's book,[41] he was the concrete man—he went to Japan and came back and reported on the 1923 Tokyo earthquake. He

38. *The California Earthquake of April 18, 1906.* Report of the California State Earthquake Investigation Commission, Carnegie Institute of Washington D.C., 1908-1910. One-volume reprint edition issued in 1969.
39. "The Effects of the San Francisco Earthquake of April 18, 1906 on Engineering Constructions," in *Transactions of the American Society of Civil Engineers*, Vol. 59, Paper No. 1056. ASCE, New York, December 1907.
40. Himmelwright, A.L.A., *The San Francisco Earthquake and Fire, 1906*. Roebling Construction Co., New York, 1906.
41. Freeman, John R., *Earthquake Damage and Earthquake Insurance*. McGraw-Hill, New York, 1932.

also provided a lot of the information on the Tokyo earthquake for John R. Freeman. There was a committee then, and there must have been others that went to Tokyo, but I don't recall that right now. There's an unpublished report in the ASCE library—we have a microfilm of that.

The 1925 Santa Barbara Earthquake

Degenkolb: Then we had the Santa Barbara earthquake in 1925. There must have been quite a few who went down to Santa Barbara, including Dewell, Huber, Jessie Rosenwald, that I know of, Mark Falk (he did work on the San Marcus building), and I don't know how many others. It would be in BSSA [*Bulletin of the Seismological Society of America*].

Scott: Those were all Bay Area or northern California engineers?

Degenkolb: Falk came from the south, and during the war (World War I), he came up to San Francisco, so he belonged to both associations, and he died up here. These things (Tokyo and Santa Barbara) kept the interest in earthquake engineering alive. The key leaders of the profession—both north and south—were active and looking at the 1925 Santa Barbara earthquake, and tried to derive whatever lessons they could from it.

The 1933 Long Beach Earthquake

Degenkolb: Then in 1933 we had the Long Beach earthquake, and the same engineers plus a lot of others looked at '33. The state stepped in because of the extensive damage to schools, and the Field Act was passed. The state made a lot of investigations. You also had the brick industry, which had reports made. I'm not sure about some of the others. In 1933, I also knew that Reuben Binder, who used to be chief engineer of Bethlehem Steel, collected a gross amount of material which was never published, and I'm not sure where it is now. At one time they told me it was in the basement of his house. Somebody must have it—Cal Tech would probably know.

Engineers and the Schools

Degenkolb: But after 1933 there were reports. Not only that, but for the first time, the state was involved, because the legislature passed the Field Act and the Riley Act after the '33 [Long Beach] earthquake. As a result of that, there were a lot of engineers employed by the state for the schools, for rehabbing and investigating. The state could not come in and examine or evaluate an unharmed school—that was left up to the local school district. But many of the school districts asked the state to examine their buildings, and once they asked, the districts then had to bring the schools up to certain standards, which was the old Appendix A, written by the state [now Titles 21 and 24]. A lot of the old-timers were involved in that.

Scott: You mentioned that after the '33 earthquake the school districts could invite the state engineers to come in and inspect their undamaged facilities—although the state couldn't come in unilaterally. Did quite a few districts ask them in?

Degenkolb: Quite a few did, not all of them. L.A. couldn't afford to and San Francisco couldn't afford to.

Scott: Because they suspected what they'd find?

Degenkolb: They *knew* what they would find, and the investment in rehabbing or replacing schools would have been so horrendous that—I remember in the '40s in L.A. they were talking about $37 million, which was a lot of money in those days. L.A. went through all kinds of rigmarole trying to get unreinforced brick approved. They proposed certain tests, and if their buildings passed, they could do certain things, but that almost split up the state association [SEAOC]. That was a real hot issue for several years.

Then you finally had the Garrison Act, which made school board members individually responsible if anything happened to their schools if they hadn't brought them up to code. Of course, that in essence meant that all public school buildings had to be inspected and brought up to code.

Scott: After that act, was it still a fairly slow process even then?

Degenkolb: They had five years or something in which to do it. The deadline got extended some, but not too much. None of these things work fast. I think they gave them 3-5 years to start with, and then extensions, but now it's water over the dam.

Scott: It's all been taken care of.

Degenkolb: Yes. But this is only *public* schools. Private schools are still in limbo. Also the universities, especially the University of California, whose investment is so tremendous. And state buildings. While they keep putting it [seismic upgrading] in the proposed budget, it's one of the things that keeps getting cut out.

The 1952 Bakersfield Earthquake

Degenkolb: Then in '52 several of us went down to Bakersfield. Karl Steinbrugge was a young apprentice for Harold Engle. I went down on my own. If you are designing for earthquakes, you want to see what happens. We had a couple of buildings down there, which came through all right.

Degenkolb: We did the gymnasium in Tehachapi, and some of the phone company stuff in Bakersfield, and we did a Woolworth's store in Bakersfield. Those things stick out in my mind. Frank McClure was brought in later by Engle or Karl to go over the housing statistics as to how much was lost in Bakersfield. From there on, Karl, representing the insurance industry, went to all earthquakes of any size—Eureka, Chile, etc.

Scott: When you say any size, you mean virtually anywhere in the world that he could get to, if there was urban structural damage?

Degenkolb: That's right. We don't worry about the earth huts in Iran or Turkey and that kind of thing. In those days we also had sort of a gentleman's unstated agreement that we didn't look at Japanese earthquakes. In those days, we figured it would be an insult to them, because they were competent to examine their own earthquakes. Of course, they came over here to see San Fernando in 1971, and that sort of broke the ice, and so now we go over there too.

In 1952 it was all voluntary [looking at earthquake damage], except for somebody from the school districts and the State Architect's Office and the insurance companies. Then Karl went to Chile with the insurance people—1957, '60 or so—and then of course we had the local one in '57, the San Francisco [Daly City] earthquake, of which Karl made quite a study. Many of us looked around a bit—though not very thoroughly. Up to 1957 or so all of this post-earthquake investigation had been done by structural engineers. Architects weren't interested, except for two architects that I know—George Simonds from Cal, and Walter Wagner from Fresno. Wagner had designed the Bank of Tehachapi and some other buildings, and for several years he chased earthquakes. He had the experience down there, and he was one of the more intelligent architects in that respect.

About a dozen people from the Bay Area went down on their own, and we did a report on the 1952 earthquake,[42] and finally the West Coast Lumbermen's Association in Portland published it for us. And I printed a book of pictures—I'd gotten the negatives from different people. Karl bound a couple of copies in off-binding. So there's the official report, and then there's my bound copy where I have the original prints. I printed all of the pictures in the darkroom.

Scott: So this is a special, limited edition report on the Bakersfield earthquake?

42. *Data on 1952 Kern County Earthquake.* Compiled by 1953 Lateral Force Committee of the Structural Engineers Association of Northern California, Chairman Henry J. Degenkolb. Unpublished copy on file in the H.J. Degenkolb Associates library.

Degenkolb: Again, this is Bakersfield, close to L.A. And yet, I do not know of any L.A. engineers who went to see it. There probably were one or two, but there were a dozen or so from up here who were interested enough to go down there. Nobody subsidized it or anything.

Scott: So there wasn't much southern California activity at the time of the '52 earthquake, even though it was in their backyard?

Degenkolb: That's right. Even in San Fernando, in 1971, I still maintain that there were more northern California than southern California engineers who saw that earthquake. When we wrote the NOAA [National Oceanic and Atmospheric Administration] studies,[43] some of those authors [from southern California] hadn't seen the damage—they had to reconstruct it with pictures and go out and look after they were assigned the buildings. This is a matter of an inheritance of the activity, and of the quality of the professionals in the background. San Francisco had experienced earthquakes, whereas the L.A. area really didn't until '25, and even then Santa Barbara was 100 miles away. It's a matter of inheritance.

The 1964 Alaska Earthquake

Scott: But somehow, the '33 earthquake, which *was* in their backyard, still didn't get them up to the same level of awareness.

43. *San Fernando, California, Earthquake of February 9, 1971.* U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Four volumes. U.S. Government Printing Office, Washington D.C., 1973.

Degenkolb: That's right. It never did. Then in the '64 Alaska earthquake, the next big one, the Structural Engineers Association offered to send two of us—one from northern California and one from southern California—up to Alaska. So we went up there—Pat Brown was governor and his office had called, and we had got in the military establishment [Elmendorf] and they took care of us.

I had found out before, if you ever get into trouble earthquake chasing, if your connections with the fire department are pretty good, a fireman can get in any place. So we were given badges—firemen's badges, and with those we got into any place we wanted. They also offered us a place to sleep—in the firehouse. I ran into Karl [Steinbrugge] up there. He was there for the Coast and Geodetic Survey. There are some wild stories between Karl and [S.T.] Algermissen and us, and a whole lot of other things which are not pertinent here.

But as a result of our observations, a lot of the engineers from California went up there—some from Seattle, because a lot of the Alaskan stuff had been designed out of Seattle. Some were from Portland—the Four Seasons Building was designed by a Portland engineer. Some of the kids later on were saying the registry book of the 1200 L Building or the Mount McKinley Building...[two similar buildings] looked like a roster of California engineers, mostly northern, but from both sides. This was all unorganized site visits and done on their own, just as a matter of interest.

Scott: This brings us up through the '64 Alaska earthquake, with a substantial amount of activity, but still unorganized.

Degenkolb: That's right. You just wandered around on your own and saw what was there. As a matter of fact, that was true up through the Guatemala earthquake in 1976, except for the second team at the Managua earthquake, 1972. It [earthquake investigation] was not an organized activity.

Special Presentations for Engineers

Degenkolb: Related to that, and also stirring up some of the interest, after the Alaska earthquake in the spring of '64 Karl and I organized, and I guess for a couple of years, had closed sessions at the structural engineers' conventions in October. We were very concerned about [discussions of engineering failures] degrading an engineer's reputation, about libel, getting sued, and all that kind of stuff. So none of these things we said were written down, but we'd give confidential talks and the rooms would be absolutely crowded.

Scott: Where did you give those?

Degenkolb: At the [SEAOC] structural conventions. At Yosemite and Coronado. We would analyze the buildings, give the results in the pictures, and all that kind of stuff. Jim Stratta, I remember, presented an analysis of the Four Seasons Building [Anchorage, Alaska]. He went with the steel group—Glen Berg, etc.

Scott: Are you talking solely about the aftermath of the Alaska earthquake?

Degenkolb: Yes, the Alaska earthquake only—the first presentations were in October 1964, then also in October 1965. We spent a lot of time and we had a couple of hour-long sessions, which was mostly Karl and me. Then there was enough interest beyond that, so in

1965 we had more confidential sessions, discussing some of the buildings in more detail and with more analysis. I remember one of the computing firms ran the analysis of the end walls of 1200 L (or Mount McKinley, they're similar buildings). Again, because of the background, there were a lot more northern California engineers. This time there were some southern California engineers, but they were all interested in the sessions.

Reports on the Alaska Earthquake

Degenkolb: In the '64 earthquake in Alaska there are different reports—there's the report that Karl, John Manning and I did, which I think is the definitive one.[44] Then there's the multi-volume National Academy of Science report,[45] and a steel report, and one from the concrete industry, and prestressed concrete.

Scott: Are these all separate reports? Steel, and concrete, and prestressed concrete, etc.? Each dealt particularly with the material they supplied?

Degenkolb: Yes. There was also one for plywood. I can't think of one for masonry, but there might have been. Right now it slips my mind. Of course every one of these reports is extolling how bad the construction was of the buildings that failed, but how good their own buildings were before the earthquake. Some of them were downright, outright lies.

Scott: The main unbiased reports would have been the multi-volume National Academy reports, and the one you and Karl and John Manning did?

Degenkolb: Yes. Our report was published by ESSA, that is Environmental Sciences, now NOAA.

Scott: Just as an aside, with respect to all these reports, at some point could we get a list?

Degenkolb: I have a whole file case of reports, drawings. John Manning got the drawings, as a rule. We would analyze, Karl would write, and then we'd meet, and I would write. This went on—it took a while to get this published. We have a lot of information on that earthquake.

Caracas, Venezuela Earthquake of 1967

Degenkolb: The next big one was the '67 Caracas earthquake. The Caracas earthquake came just before my vacation was supposed to start. It was obvious to me that, while in previous U.S. earthquakes you could do something in three or four days or a week—south of the border it doesn't work that way. It was obvious that if I was to get any information, I would have to stay at least a couple of weeks. The only way to do that was to take my vacation down there. So I called Anna and asked her, instead of our going out with the trailer and camping, would she like to come down there? She would. I talked to Frank McClure, and Frank and

44. Steinbrugge, Karl V., John H. Manning, and Henry J. Degenkolb, "Building Damage in Anchorage," in *The Prince William Sound, Alaska, Earthquake of 1964 and Aftershocks.* Environmental Science Services Administration, Coast and Geodetic Survey, U.S. Department of Commerce, Washington D.C., 1967.
45. *The Great Alaska Earthquake of 1964.* Committee on the Alaska Earthquake, Division of Earth Sciences, National Academy of Science, Washington D.C., 1972.

George Simonds also came. The three of them came together, and that caused some commotion, or at least some raised eyebrows. She came down with two other men and then she went back with me. We had the same stewardess on Pan Am.

Down there we had actual collapses of 10-12 story buildings, and you didn't have sloppy design in some of them. You had competent engineers. There were also some poor designs and some bad construction—that is another story. So I sent a wire to [southern California engineers] Steve Barnes and Roy Johnston, and the son of this foundation engineer, I can't think of his name [it was L. T. Evans]. I said for the love of Pete, instead of you guys arguing about some of these things, come down and see what actually happens. I sent the structurals' association a wire and those three came down. We showed them around. I even acted as a translator in Spanish, at which I am very lousy. We got some interest.

We had brought down the EERI outline for evaluating the hazard of a damaged building, and the Venezuela group grabbed onto it immediately.

Scott: You mean the EERI methodology—the guide on how to investigate earthquake damage?

Degenkolb: Yes. Once [Paul] Lustgarden found out I had that EERI report sheet, I think in ten minutes they had 50-500 copies out in the field in Caracas. He's a consulting engineer. He used to be the chief engineer of the Venezuelan government, used to be the head of the national Department of Public Works in charge of building designs. Because he belongs to ASCE, he recognized my name, and between that and the Parsons group down there, in Caracas we had access to anything. We had excellent connections in him and a friend of his, who was the contractor on the Maricaibo Bridge, and then later worked on the Orinoco Bridge. These were top-flight engineers.

We actually got involved professionally with several of the buildings, which at first I didn't like. It seems like ambulance chasing, but we were pushed into it.

Scott: So what really started out as your own investigation turned into a consulting deal?

Degenkolb: Yes—ambulance chasing.

Scott: Did that kind of divert you from what you would have preferred to do?

Degenkolb: Oh no, it actually gave us an opportunity to go real thoroughly into details on several buildings. For instance, the Mene Grande Building. Mene Grande Oil is the biggest oil company in Venezuela. They put one of their engineers at our disposal, who served as our representative down there, and then he came up and worked in our office for a few months on that project—analyzing the building and the damage. We went through every joint in the building, most of them had cracks, but could not be seen until you took off the ceiling and really went into it thoroughly. When I go out and lecture, I only show the obvious, spectacular damage. There was a lot more damage.

The 1971 San Fernando Earthquake

Degenkolb: Anyway, the next one was San Fernando—'71. Of course the San Fernando earthquake started people really looking at things. The first time, the mechanicals looked at Alaska, in '64, and they wrote a report.[46] It was published by the Consulting Engineers Association of California, as a benefit to the engineers of California, about the time I was president. It's essentially the same report that is in the National Academy [of Science] publication.

That's really the first case of the Americans looking at earthquake damage to building equipment—at least as related to buildings. There has been some data on water supplies and some on performance of sewers. That information is harder to dig out, but these were generally reports written by the operators and a very few interested engineers. They didn't go around like the structurals, at least I'm not aware of any large reports until after the Managua earthquake.

The 1972 Managua Earthquake

Degenkolb: In the case of Managua in 1972, I was listening to the radio reports on that earthquake, and I decided to go once I heard a tall building had gone down. While the building reported to have collapsed, a hotel, did not, many others did. Anyway, it sounded like something I had better see. So I made arrangements and it turned out that Don Moran and Jack Meehan were going.

46. Ayres, J. Marx, Tseng-Yao Suan, and Frederick Brown, *A Report on the Non-Structural Damage to Buildings: Alaska Earthquake, March 27, 1964.* Consulting Engineers Association of California, Burlingame, CA, 1967.

We sort of informally conferred with the EERI president at the time, Martin Duke. They had been talking about [beginning the EERI] Learning From Earthquakes [project], but in a sense, this was still unstructured. We were really operating on the same basis we always had. You go down with your fingers crossed, hoping to see something and not knowing quite what to do. On the first day my son, Paul, ran into a man, Filadelfo Chamorro, who asked his name and who recognized my name. Chamorro is an engineer down there and pretty well-connected.

So we then saw Managua, and the damage there was interesting enough—and this investigation was unstructured, except that Don Moran was interested in lifelines, so he paid more attention to that. Jack Meehan, of course, from the state, was interested in schools and hospitals. He spent more time on the hospitals than we did. We went together on a lot of things and split up on others.

One thing in this earthquake that was different was that different people went and looked at different things, and saw things that would have been missed if only one person had gone. There's an advantage to having several different observers looking. Redundancy of observation is good.

There was enough damage that the four of us recommended that a second team go down and investigate specific buildings in more detail. Some 20 guys or so went down. Martin Duke was very interested. He and Don Moran were co-principals of the EERI Learning From Earthquakes project, supported by NSF. A year after the earthquake, Chris Rojahn, working with the Coast and Geodetic Survey, and Somoza [a Managua engineer and president of the National Emergency Committee of Nicaragua] arranged a joint conference in San Francisco and Managua on the results of that.[47]

Scott: You mean they had conferences in both places?

Degenkolb: Yes. One here, then adjourned and went down there. They chartered a plane, their engineers came up here, and a bunch of us from here went down there. There were a lot of people analyzing a lot of the buildings—good ones and bad ones—in detail.

Scott: How long after the earthquake was that?

Degenkolb: I was going to say it was a year, but the Managua earthquake was in December 1972, so it's got to be more than a year—a year and a quarter or so. It was around summertime. It produced a two-volume proceedings. Chris Rojahn was in charge of that.

Scott: Was that an EERI report?

The 1976 Guatemala Earthquake

Degenkolb: Yes. Then from there on things got more structured. The next one was in Guatemala [1976], when we [EERI, Degenkolb president] sent down a first team, mainly structurals. There was enough damage and interest there that we had a second team of 26 people that was supposed to be funded by NSF, but the money ran out so I had to notify everybody that they were on their own. Everybody on the team but one went on their own, whereas at first they had expected to be recompensed for their travel fees.

Coordinating Investigations

Degenkolb: In Managua we had seen interest from [Filadelfo] Chamorro from Nicaragua, Franz Sauter from Costa Rica, and two engineers from Canada.

By this time, through EERI and the IAEE [International Association of Earthquake Engineering] we'd had requests [from other engineers] to let them know if we were sending a team. And so for the four years I was president of EERI, we would send out EERI teams. I would also have a list of people I'd had contacts with who wanted to see earthquakes. So the Canadian engineers had a contact man, and there was Franz Sauter, and Fil Chamorro. It turned out after the second Philippines earthquake [in 1970] that tsunami-watch people of Honolulu were interested. [Three Philippine earthquakes—the third had a tsunami.]

The EERI plan calls for having an exploratory reconnaissance team as early as possible, and then if the earthquake is worth the effort, if the lessons to be learned are worth the effort, having a follow-up team for more detailed study of individual buildings. I think this is probably as good a way as you're going to do it. [Degenkolb later added a note to the transcript: Unfortunately, this is *not* the way detailed follow-up investigation is going.

So after we [EERI, Degenkolb president] had made a decision to go to an earthquake, I would put together the teams. Then, in addi-

47. *Managua, Nicaragua Earthquake of December 23, 1972: Proceedings of the EERI Conference, November 29-30, 1973.* 2 Vols. Earthquake Engineering Research Institute, Oakland, CA, 1973.

tion, I would phone all these different people and tell them we were going.

Scott: So you'd call these others, such as the Canadian engineers, and those in Central America, and the Hawaii tsunami people—they all had indicated they wanted to know if you guys felt the earthquake was worth visiting?

Degenkolb: Yes. That's what happened. We had the Canadians, the tsunami guy...there were two Philippine earthquakes that we went to, and Peru. The first Philippine earthquake, Jim Stratta went on his own, I forget all the details. Anyway everyone wants to go, until you ask them to go.

Scott: You mean they want to be on the blue ribbon list, but when an earthquake hits and it's inconvenient...?

Degenkolb: That's right. At one point, I called Bob Hamilton, who was head of earthquake studies back in Reston, Virginia [USGS]. I didn't know it at the time, but for a while you could not send a California government engineer out of the state to chase an earthquake. One of the engineers (under [Governor] Jerry Brown) who was in Guatemala, went on his own money, and they wouldn't reimburse him. So they graciously gave him the time off. They couldn't pay for his traveling expenses, but they paid him for his time on the basis that he would write a report. There were times when the federal government would not permit the USGS geologists to go out of the country, and yet we're a leading nation!

Finally, with Argentina [in 1977], Bob Hamilton stuck his neck out—he's a damn good man—and he got two guys [from USGS] going down with the [EERI] team. He got arrangements set up so in case something like that happens again, they had an automatic allocation of money, so they could leave without going through six weeks' worth of red tape.

Actually, however, it's pretty well set now, and there is good cooperation. At the recent Chile earthquake, Loring Wyllie led a joint team for EERI and the National Academy. Procedures have now been worked out that activate both the structural engineers and EERI. The minute an earthquake happens, something is done. For example, EERI assembled teams or coordinated information on both the [1984] Morgan Hill and [1983] Coalinga earthquakes. And the structurals also sent teams—the California structurals [SEAOC, the state organization]. And now we've got the natural sciences, the National Academy of Science's Research Council, the materials interests, all working with EERI.

In the past, it has been northern Californians who were more active, but in recent years the young southern California engineers, especially, have shown more interest. For example, we had Greg Brandow, George Brandow's son, lead a group for the El Centro earthquake [1979].

Get In Quick...Also At Various Stages

Scott: Would you talk about the timing of earthquake site visits? I guess you want to get some people there as soon as possible, as well as later for follow-up. How has this been handled?

Degenkolb: In any damaging earthquake of whatever magnitude, you really should have a team go as soon as possible after the earthquake to observe any evidence and see the actual conditions before things are cleaned up, before they are working on the buildings and fixing them up.

Scott: That has to be done fast, in the very early days?

Degenkolb: Yes, as quick as they can. The disadvantage of such early observation is that in any collapses, there is so much debris that you can't see what is going on, what caused the collapses. You can, however, make surmises sometimes.

There should be another team that goes in, sometime after the first, when some of the debris is cleaned off, but before they start to fix up things, or at the part of the fix-up stage when you can still tell what they're fixing. And then, ideally, there should also be one or two follow-up visits later on. For example, in Mexico City, the buildings fell over, and we needed information on how they fell and all that. Ted Canon and Bob Hanson went down before I did, and while workers had cleaned up a lot of the debris that fell onto the highway, they still had the ceilings and the exterior walls up, and they only got glimpses of the key damage. Then when we went, six weeks after the earthquake, and they were taking some of the top floors off. They had reinforced some of the buckled members. The exterior walls, which we thought had been damaged, but evidently hadn't been damaged much, had been taken off. So there was light, you could see the structural members. They had taken down the partitions. So in any one visit you may just get a glimpse of the damage, and it really takes a coordinated effort to get the full picture.

Follow-up: Sending in a Second Team

Scott: Managua was the first time you used the second-team approach, which means it's really an in-depth treatment of the whole thing, I would assume.

Degenkolb: Yes. Different people were assigned different buildings and they were to go into those in depth. While they could look at all the stuff in general, they were to concentrate on specified buildings such as Enaluf (power building), or the Banco de America Building or the Banco Central—there were dozens. These papers were later written up in the proceedings of the conference,[48] which as I indicated before was held half up here and half down in Managua.

Then we did the same thing with the Guatemala team. A group of eight or nine went down there first. It was an interesting earthquake, so they needed to have a follow-up. So we organized, if I remember, a team of 22. That was the one I mentioned earlier as starting out so that it would be paid with NSF funds, but that didn't pan out, so everybody went anyway, on their own. We had foundation engineers and geologists who were interested in liquefaction.

On that one [the Guatemala earthquake] we made a deal with the government when we first

48. *Managua, Nicaragua Earthquake of December 23, 1972: Proceedings of the EERI Conference, November 29-30, 1973.* 2 Vols. Earthquake Engineering Research Institute, Oakland, CA, 1973.

got down there. We had a meeting with the ministries, and they were very business-like, compared to the other people. We needed access, of course. They wanted five things: they wanted our opinions on a water plant that was under construction, on the cathedral, on the bridges all the way to the Atlantic coast, on a hospital, which had failed, and there was one other, but I forget it. So we wrote a report on each one of those, and in the meantime they gave us complete support. Loring [Wyllie] and bridge man Jim Gates [from Caltrans] or someone else—they took, I think, the first car that went from Guatemala City, which is near the Pacific coast, all the way over to the Atlantic coast, looking at all the bridges.

Teamwork and Coordinated Writing

Degenkolb: Loring [Wyllie] and I went through the cathedral in great detail. Vic Bertero, I remember, had three or four along with him and went through the hospitals. We also looked at all the other things too, but these were the things we concentrated on. There were a lot of advantages—first of all, when the reports came out, while there were different points of view represented, there were not the gross misstatements that have been made in the past.

Scott: When you say advantages, you mean of this team approach?

Degenkolb: Of the team effort, and coordinating the report writing. There's always an advantage in several people looking at something rather than one, no matter how smart you are or think you are, two or three people can see a lot more than one person. Just the discussion, and looking at the evidence from different points of view as to what was the cause of failure.

Scott: The interpretation of the evidence.

Degenkolb: Yes. It's much more effective to have a couple or several people look at it. The biggest concern has always been on the smaller fragmented things—can you get in [to the site]? The steel and concrete people seemingly have an advantage, because there are steel people on location in most of the countries that they deal with, and they can call them and ask them to act as host. If you're unbiased—like the structurals or EERI—you don't have that. But as it really has turned out in every one of the earthquakes, for one reason or another, we've had no trouble. As a matter of fact, we've had full cooperation in practically everything.

Scott: You didn't need the special entree of the steel or concrete people?

Degenkolb: Right. EERI carries a lot of weight just because of past activities, with members in all the countries we have dealt with. Like in the Philippines [1970], and Argentina [1977], we have dealt with the governments or the engineering societies. EERI is well enough known that we've had no trouble.

It [coordinating the report writing] is just a clearer, nicer setup, for the engineers who don't go, and for the general public—in contrast to this business of writing reports where you almost come to diametrically opposite statements.

Scott: You mean viewing the same earthquake, maybe even the same buildings, and coming to very different conclusions?

Degenkolb: The same building. One says how wonderfully it performed, except for these minor details, and the other says it had to be wrecked because it was damaged so badly. It becomes a question of who you believe. By getting a combined report, we're not squelching different opinions, but at least you have a basic report where the facts are given, and sometimes interpretation, but not necessarily all interpretation.

When Karl [Steinbrugge] and I did the '64 earthquake in Alaska,[49] we did not do very much interpretation. On the Four Seasons Building, we gave two theories. There were two people with two different schools of thought as to why it failed, the sequence of failures. So we gave both of them, with all the facts, and we had practically everything. Other engineers could make up their minds. That has been unique, a success.

Scott: Frank McClure's[50] next question is on the role of materials interests—steel, concrete, wood, etc.—in post-earthquake investigations.

Degenkolb: Frank knows darn well whose reports favored which materials, and that the reports were used to sell different materials—to the extent that they were downright lies. I think that has generally, essentially been eliminated, through EERI when I was president.

Scott: You mean the practice of the materials interest groups?

Degenkolb: Writing their own self-serving reports. They were notorious in the '64 Alaska earthquake and the '67 Caracas earthquake. They were bad. They were a little bit that way on some of the others—Managua, for instance.

But by that time, we tried to circulate the idea [to the materials people] through EERI: if you're going to send somebody, do it as a team. And like the last Chile earthquake, or the Guatemala earthquake, on the second team I made sure that we had steel men, we had concrete men, we had timber men. We had everybody on the second team. We had 22 or 23 people.

Scott: What do you mean when you say timber men and concrete men?

Degenkolb: Their representatives, or people who are favored by them.

Scott: Technical people who were identified with that industry in some way or other?

Degenkolb: Yes. We had representatives of practically everybody. Since that time generally there's been a combined team, and a report comes out. There's always discussions and reports and things like that. But at least we don't have the blatant errors or deliberate downplaying of one thing, and playing other things up higher.

Scott: And that was done basically through EERI?

49. Steinbrugge, Karl V., John H. Manning, and Henry J. Degenkolb, "Building Damage in Anchorage," in *The Prince William Sound, Alaska, Earthquake of 1964 and Aftershocks*. Environmental Science Services Administration, Coast and Geodetic Survey, U.S. Department of Commerce, Washington D.C., 1967.

50. Frank McClure suggested several questions and lines of inquiry used by Scott in his interviews with Degenkolb.

Degenkolb: Yes, during my presidency.

Scott: Did you come in with that as your platform or your own idea? I know you don't run for EERI on platforms, but did you have this in the back of your mind as something you'd like to deal with?

Degenkolb: Not as a conscious forethought. It was a thought, however, as the earthquakes came with their individual problems. So now at least you've got larger representation, different guys working together, without all the competition. Instead of having a lot of competing reports, each saying how good their own material is, you have a more uniform thing where everything is reported. Everything is reported, and from different points of view.

Scott: You mean all the observations and the significant kinds of damage or effects, are reported.

Degenkolb: Yes, regardless of material or anything else. The team members just work together: when you're working together on something and you have discussions on the site, you tend to agree. Even if you have different points of view, there's the evidence. So far that seems to work. That's the best way.

The 1985 Mexico City Earthquake

Degenkolb: The lessons in the Mexico City earthquake are, the vast majority of them, lessons we've also seen in every other earthquake, or in most of them. Some of the more spectacular things don't really apply to our style of construction. The steel in the towers for example—we don't do it that way. The early buildings, up to the construction of the Latino-Americano Tower, used imported steel—rolled sections that they got from the United States. They tell me that's the last building built that way. The newer ones are made from Mexican steel, and they can't roll big sections, so they use thin plates and angles and build up the sections. Consequently, the details they used are not those that mean much here.

There were concrete failures of nonductile concrete. Most of those buildings were 20-30 years old. They were built the way we would have designed them in that era, so I don't think there's too much new to be learned there, because they failed in the same way ours did. Most of the lessons from Mexico City were just exaggerations or confirmations of what we've seen in previous earthquakes.

Kinds of Damage

Scott: There were more extreme examples of damage or larger numbers of examples?

Degenkolb: Both more examples and more extreme examples. The experience with friction piles is the one thing that may be new. I don't think that has occurred to anybody before this, at least I don't think it is in the literature. They have the infill walls, with concrete stuff failing in the old ways.

Most of this was known 20-30 years ago, under different codes. We have rocking on the foundations, with the gaps showing around the bases of the buildings, around the foundations. We have large areas of settlement, and differential settlement.

We have the first-floor problem. While everyone recognizes the soft-floor problem, we really don't know quite how to quantify what the triggering limit is—what change in stiffness or strength, or how much change compared to the other stories, should trigger the requirement of a special design, or, when you have a special design, how much more resistant it should be. The code is essentially silent on that. This leaves it up to the engineer to do the best he can with soft stories. There has been talk among some of the younger engineers of trying to forbid them entirely, but that would never go over politically with the architects and the planners and others.

A New Problem: Friction Piles

Degenkolb: The Mexico City experience has reemphasized several problems, and turned up some that are almost new. One new problem is with friction piles—the possibility that as friction piles have repeated cyclic loads placed on them, the clays or whatever they are imbedded in become sensitive or lose their friction in some manner, and therefore the piles either settle or pull out. Whatever the case, they just don't take the load. To the best of my knowledge, that is a new lesson to come out of this earthquake.

Scott: The use of friction piles—that is not peculiar to Mexico, or to Mexico City, is it?

Degenkolb: No, they are used around the world.

Scott: They are used where the bottom is way down?

Degenkolb: Where the really good soil is way down. You try to use some slightly bearing layers part-way down that have enough friction. It's somewhat like driving a spike in balsa wood. You can drive it halfway in and it will carry quite a bit of load. But of course it won't carry as much load as if you could have put it all the way through the balsa wood down to a steel plate. In this case, supposedly—it's a consideration we've never really faced before—if you keep vibrating the spike in the balsa wood, it loses it's friction and it's bearing strength. That is a presumption, though we don't know it for sure.

Scott: Something happens in the soil or sand, or whatever the piles are embedded in?

Degenkolb: Right. That is a new lesson from Mexico City.

Rocking and Pounding

Degenkolb: Another lesson involves rocking and pounding. We have always known that buildings rock. We don't pay much attention to it in our analyses because we don't have the necessary information. Ordinarily, we think that rocking reduces the stresses on a building. But in Mexico City, the rocking was so pronounced that it had two effects—pounding and the P-delta effect.

The obvious effect is the pounding. The deformation of a fixed-base building can be calculated as so much for any given earthquake. If you separate your buildings by that amount, or maybe twice that amount, supposedly the buildings won't bang together. But if in addition to the anticipated deformation, the building also rocks on its base, you will get a lot of banging. That very obviously happened in Mexico City. I wouldn't say that is really new, but Mexico City certainly provided exaggerated examples of the effects of rocking.

We generally assume that a lot of rocking reduces the stresses on buildings. Probably it does reduce the direct stresses from side loadings, lateral loadings. However, the secondary stress when the building is off-base—which is the P-delta effect—would be greatly increased. And that, I think, had a lot to do with some of the column failures, and maybe the failures of some of the tops of the buildings. It would take some analysis to see how it works.

For example, Nuevo Leon was one of the larger apartment buildings in Mexico that collapsed. It was on poor soil, was leaning, had been underpinned twice.

Scott: It was leaning before the earthquake?

Degenkolb: Yes. They had used tension piles to pull it back into vertical position, so it was straight. When the recent earthquake came, the common belief was that it was a jinxed building, that the foundations were no good. It collapsed, and was believed to be the government's fault. Well, I went over there and have pictures of the foundation—the underpinnings and what they had built underneath it—that was uncracked and in good condition. So what failed was the building above that. It undoubtedly rocked more, and so took more stresses than a building on better ground.

We assume our building to be fixed on the ground, and that any deformations take place in the building above that. The theoretical studies I've seen only indicate a small amount of rocking, according to any of the theories we're used to using. But I know from observation that there is more ground movement around the building than the theory shows. I mentioned the Agua Caliente Bridge piers down in Guatemala City and around Nuevo Leon. There were cracks in the ground, and there was battering against the garage that was about 15 feet away. These buildings did a lot of rocking. This does not cause any primary stresses in the above-ground stuff, but it means a lot of pounding damage—pounding against adjacent buildings—or it effects to a great extent some of the secondary stress like P-delta, which we discussed elsewhere. It increases those quite a bit above what theory calls for.

Scott: The rocking also might affect underground utilities and things of that nature.

Concerns on Soft Ground

Degenkolb: As a matter of fact, that's one of the bigger things that you're really concerned about when you have soft ground, anytime you do underground stuff. Like when we did the airport garage, the first unit, we always had a box outside and flexible connections to all the utilities. You know that the ground will move differently from the building. There was a lawsuit at a sewerage plant down the peninsula [the San Mateo peninsula, south of San Francisco]. It wasn't even in an earthquake. The sewerage plant, by definition, is out in the bay muds that surround San Francisco Bay, it's got to be as low as possible. They brought in these big sewer pipes and just ran them right into the building. Any engineer knows that a building can settle in a case like that. Or if the building is on piles, the ground is going to settle. It's not going to stay the same. So the sewer pipes broke. It's just common sense to expect that, that's not even engineering.

Torsion

Degenkolb: Torsion is another—not lesson, but example—thing we know about, but have neglected. The Pino Suarez steel buildings have all the braces on one wall so the whole thing could rock around that. And that, I think, is a big factor in the collapse of the 21-story building, which knocked down the adjacent 17-story building. I think the Mexico City steel buildings are some of the worst examples of real torsion. The main elements, the stiff elements, were completely lopsided, so you did have a lot of torsion. But even if you made a building completely symmetrical structurally, so that theoretically there would be no torsion, then just from the accidental loadings—i.e., offices or libraries located on one side and not the other, or partitions giving extra strength, or just differences in workmanship—there are always some causes of torsion that you can't avoid.

Long-Period Failures: 6-15 Stories

Degenkolb: Then we have this whole problem of the changing of the dominant periods. At the coastline near the epicenter you have a more normal response spectra. I'm having some response spectra drawn up—for comparison with our regular response spectra.

Scott: Short-period waves, high-frequency motion in contrast to the longer-period motion in Mexico City?

Degenkolb: Yes. In Mexico City the longer-period, medium-height buildings were greatly affected, compared to the type of building that is short and stiff. The vulnerable range was from 6 to 15 stories. The exception was the one 21-story steel building, and that was designed 15 years ago—but with the eccentricity and the type of construction, it is not a very good example. It was not built the way we build our buildings—the bracing was very eccentric with the plan; the columns were thin plates welded in box section, and poorly welded—with the exception of that one steel building, the rest of the long-period failures were in the 6-15 story range. In spite of what everybody says, however, there were also quite a few 1-to-2-story buildings that failed. In general I think that was just poor workmanship or poor layout. Usually, with long-period motion you'd have the big buildings go down, but with a lot of little buildings around them undamaged. You would come to some places, however, where little buildings were damaged.

You'll always have anomalies. We had that in Alaska. The big buildings failed, but when you looked at the houses, glasses, windows, chimneys that didn't fail, a little elementary school with all the stuff that the kids do in kindergarten on the windows, the little knickknacks didn't even fall off the shelves, and yet next door you'd have big failures.

Collapse of a Steel Building

Scott: You mentioned the steel building that collapsed. You said it was the first time we'd seen that.

Degenkolb: Yes. Multistory steel construction has had an excellent record in earthquakes. We had buildings up to 19 stories in San Francisco in 1906, and a bunch at 12-14 stories. We had them up to 100 feet in Tokyo, and we had some in '33 in Long Beach. But we've never had a failure of a multistory steel tier building. The closest steel building to fail was the Tokyo Kaikan in '23, which was a 5-story building. In Freeman's book[51] they said it was very lightly braced, way below Japanese and American standards.

In Mexico City, for the first time, we have a 21-story building that collapsed onto a 14-story building. Pino Suarez was actually five towers—a 14, three 21s and another 14. The end 21-story building, one of the three center ones, collapsed onto the 14-story building and both collapsed. They fell onto the freeway, incidentally, and blocked it. They had been built privately, designed in 1971, then sold to the government.

All of the buildings [in the Pino Suarez complex], even those that remained standing, had buckles in the same locations on a couple of columns at about the fourth floor, around piso/3, piso/4. As I say, the one completely fell on the other. When the columns buckled, the fillet welds just came apart: it was like unzipping. Once you get a little crack, those pieces start buckling, and the crack just continues. This was typical in the buildings we went through. They also had buckled columns that didn't come down. They tell me that the one that we finally went through was leaning several meters when Bob Hanson and the others went in earlier. Evidently, it got straightened up, and they had reinforced the columns by the time we went. But the bracing was highly eccentric. All the longitudinal bracing was against one wall and two X-braces in the other direction were off-center, so you had a lot of torsion.

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

The Structure a Success, the Building a Failure

Degenkolb: They had some steel framed buildings that came through beautifully. They had—I generally don't like it—a double T (prestressed) 2-story parking garage of a kind that ordinarily performs badly, but came through beautifully. They had huge ground motions with settlements and that kind of thing. The thing that impressed me was that they had a lot of 7- and 8-story buildings, or about that height, where from what I could see, the structure was still in good shape, uncracked. They chipped some of the columns to examine the reinforcing, and it had spiral reinforcement according to our ductile concrete standards. Yet the buildings were a total wreck. They were standing, the structure perfect, but all the windows, partitions, mechanical equipment, everything gone, everything down.

Scott: You mean the structure itself was okay?

Degenkolb: Yes. But there was so much motion that the infill walls, the windows, the partitions, everything came down. A mess. And yet, from what I could see looking at the columns, there was no structural problem. The structure was a success, but the building was a failure. It couldn't be used. It makes you sick.

The Distance Factor and Long-Wave Motion

Scott: I'd like to talk about the distance factor and the long-period motion. The short-period motion dies out fairly quickly as you move away from the epicenter, doesn't it?

Degenkolb: Yes, the high-frequency short-period waves attenuate much faster than the long waves. That we know. That's old attenuation stuff. The question has been asked but never answered in a way that I can understand definitely: does the energy from the strong motion near the source get transferred into a different wave length? We've never had a decent answer on that. But I compared Mexico City and the source records for this earthquake with response spectra of other earthquakes. In the Mexico earthquake, near the source there was no bulge in the response spectrum at the 2- and 3-second period that did the damage in Mexico City, which means to me that the energy must have been transformed in some way. That is, the energy at different periods actually changed, to increase that with longer periods.

The Response Spectra: A Geophysical Puzzle

Scott: What are the Fourier response spectra?

Degenkolb: It's a mathematical thing that shows the content of the various frequencies of vibrations of any erratic ground motions.[52] In this case [Mexico] they did get instrumental readings near the epicenter.

An array of instruments was being installed near the epicenter at the time of the earthquake, but was not complete. When the response spectra of those nearby instruments were compared with the records obtained in Mexico City, a marked difference was noted. The local record was rich in short-frequency motion (1/4 to 1/2 second periods), but had little energy in the 2 or 3-second range. As is well known, the short-period motion attenuates rapidly over distances, and so little of that motion was seen in Mexico City. The records in Mexico City were devoid of short-period motion, but had a strong energy release in the 2 or 2-1/2-second range. This indicates that some of the energy of the short-range motion near the source was transformed to long-period energy in Mexico City. Anyway, the recordings in Mexico City on the soft ground showed a very high proportion of long-period motion in the overall motion. We knew from observation that long-distance effects occurred, and had never paid much attention to instrumental readings, because generally we didn't have instrumental readings. At the time of the '52 Bakersfield earthquake, I think there were only 60 strong motion instruments in the whole United States. Now we have about 600 in California alone.

Anyway, previously I never really bothered. But Cal Tech has been taking all the records, giving them numbers, digitizing them and getting all the various responses. So I went back to see what was available for '52, and ran into two [response spectra] that showed exactly the same thing as was shown recently in Mexico City—a sort of instrumental proof of what we see.

Scott: This was from the Bakersfield earthquake in '52? Now would you just go through

52. The Fourier spectrum is a method of determining what frequencies dominate the ground motion, that is, where it is strongest and where it is weakest.

this again—where was that earthquake centered?

Degenkolb: On the White Wolf fault, which is near Wheeler Ridge, Taft [near Bakersfield]. The closest record was Taft, the Taft record is often used—for shaking tables or for analysis or something, but is generally beefed up because Taft is a fairly weak record. It was only around 25%g, but they generally beef it up to 50% or so acceleration [for design, evaluation, and use in testing on shaking tables]. So they had the Taft record, and I remembered that Martin Duke had done some studies about a free field and a building—North Hollywood Storage—so I looked at the response at the North Hollywood site and I was comparing it to the original of Taft. Incidentally, I ran into one at Santa Barbara where the instrument was in the courthouse basement. The Taft record does not show anything in the long-period range, the Santa Barbara record showed a peak at around 2 seconds. North Hollywood showed a peak at 3 seconds. I'm just confirming what has again been found in Mexico City recently, although much more dramatically: that ground motion changes with distance, and certain types of soil amplify it.

On attenuation, the question always comes up—many of us have asked it over the years—is it just a matter of filtering out the rapid motion, whereas the long waves just don't attenuate so much? These records tend to prove that the long waves were not present near the epicenter, so as the waves go through the ground, they must change frequency in some way. I don't know enough about vibration characteristics to know how, but seemingly it is not just a filtering out of some stuff, while what remains goes on.

What remains also changes, or the stuff that attenuates must change, to give the forces noted. Because some of the velocity spectra—that's one way of measuring the response—the velocity spectra at those periods farther away are higher than the velocity spectra of those periods at the source. So there is actually more energy there than started out. It has to come from some place, so the short periods have to be changed in some way. I don't know what it is.

Scott: I guess Bruce Bolt was referring to this, at least in part, in his EERI luncheon talk last week [week of January 7, 1986]. He referred to this or some similar phenomenon and said sort of pensively, "But that seems to go against the laws of thermodynamics."

Degenkolb: It should be Bruce or Tom McEvilly or somebody like that—they're the ones to figure something like this out, not me. But a lot of us engineers always had this question about the long-period motion, whether it is just a filtering process, or whether there's an actual change of energy. It seemed pretty clear from these and the other records that there is a change.

Parallels With California's Central Valley

Scott: In terms of local California situations, you mentioned special concern about Sacramento, being on poor ground and 80 miles from the San Andreas fault.

Degenkolb: You might have similar effects in other valley towns. As I mentioned, we saw that in '52 [Bakersfield] and the damage in downtown Los Angeles. Also in the '54 Dixie Valley [Nevada] quake, the '64 Alaska quake, and the '57 earthquake in Mexico City. It is not an unknown thing, but the Mexico City earthquake just gave us more graphic illustrations of it—I've been digging out some records, like the '52 earthquake, and the record of '64 that was taken in Anchorage. They didn't get the record of the mainshock, it was mainly of aftershocks. They show exactly the same effect as happened in Mexico City.

Scott: You mean long-distance effects—50 miles to 200-300 miles away from the epicenter?

Degenkolb: That's right. Well, it brings up the whole idea that if you were to have a real break on the San Andreas opposite Fresno, for example, where with irrigation you have somewhat similar conditions—the key being the presence of buildings that will respond to those long-period motions—you might get some of the same effects. We didn't see it in 1906, but as we go to higher structures, these effects become more pronounced, more noticeable.

That's one thing that I think merits further study around here. If you think of the Owens Valley [1872] earthquake, and the San Francisco in 1906, if you get a repeat of any of those, highrise buildings in the [California's Central] valley, or portions of the valley, may experience the same [long distance] effects we had in Mexico City. I do know, for example, that in Sacramento you have a high water table and weak ground—most of the buildings are on piles—and it's a long way down to rock. The Dixie Valley, Nevada earthquake caused enough sloshing in the reservoir in Sacramento that it knocked out some of the columns and the baffles—and that's a long way, about 200 miles! This was caused by very long-period motion, probably 3 or 4 seconds, or something like that.

It would be worthwhile, I think, to have some future investigation just to see what would be likely to happen to highrise buildings there. Of course, there weren't any highrises there at the time of the previous big earthquakes, so there was nothing there to be damaged.

Learning From Successive Earthquakes

An Example: Piles, and ATC 3

Scott: Would you talk a little bit about how it sometimes takes more than one earthquake to come up with the best interpretation of the evidence and its significance?

Degenkolb: We are so conditioned by our upbringing, our education, and our experience, that it is sometimes unbelievable what one can look at and not see. For example, piles. I used the illustration [at a talk I gave] the other night in Phoenix. We recognize that bending in concrete is going to have ties to contain the concrete in order for it to be ductile, prevent shear failure. We have to make it a ductile failure, so it will still carry the load and take large deformations. We've gone into this ever since the [1967] Caracas earthquake, which was the first one really to hit highrises that then collapsed. We had to do this for columns and beams. Then San Fernando really brought the lesson home so that California engineers could see it. So the codes were changed.

Below the pile cap, however, we just sort of treated the foundations as a unit, they're separated from the buildings—they support the buildings—footings and all. The piles themselves are taking just as much bending as the columns up above, but we had never bothered to reinforce them for that. We reinforced them the way we've always reinforced piles.

So when we wrote ATC 3, it suddenly struck me and some of the others—I wrote the foundation chapter, or at least the first draft. Different guys write the first drafts of different sections, and then we would argue it out. Anyway, above the pile cap, the concrete has to be contained in order to act in a ductile way. But if the piles are also taking bending, you have to do it *below* the pile cap too. It's logical when you think about it. So we thought about it, and put it in the code. And I'll tell you what—all hell broke lose. I was called everything from... well [shrugs].

Scott: In other words, they didn't believe it was necessary below the ground.

Degenkolb: That's right. They were quoting tests from over at Cal. Shortly, I found some data over in Japan and I found out some of the failures in '71 in San Fernando, where the overpasses had failed. All of a sudden, the New Zealanders have some tests on it, and it's in ATC 3, everybody accepts it. It will be in the Uniform Code one of these days when they get around to it.

Scott: You're saying it took a while.

An Example: Confining Concrete Columns

Degenkolb: To recognize it. We are so used to doing things the usual way. It's a drafting thing, the typical details. In preparing drawings, we usually schedule the reinforcing and show typical details. You show beam reinforcing without the column, and column reinforcing without the beam, so the column is shown starting on top of the foundation or beam and extending to the bottom of the beam above. You put the ties in the column up to the underside of the beam, and you do it also above the beam, because generally in the region between you have beams in both directions, and the concrete is automatically confined. In the old days that was all right, generally, because you had a poured concrete wall next to it and the wall helped contain it.

But when they take the wall away in order to get a clean moment frame, you do the usual thing and don't recognize that the conditions have changed. You look at it, and then finally up in Anchorage recognize that it is stupid. The impact doesn't hit you until you see it again, and then all of a sudden you realize that those bars aren't constrained at all—they can buckle and pull out. Here hundreds of engineers are looking at it and not seeing it.

Scott: What are you talking about right now? Is this the open first story kind of thing?

Degenkolb: This was on the second story. But the first story is similar. For instance, there was a beam of the Anchorage control tower, and you could see that the column bar just peeled off and there was nothing holding the column bars into the concrete. You look at that and say, how stupid, but the full impact of it doesn't hit you until you see, like in Caracas, in the Mene Grande Building, how some bars buckled at the joint.

"...I've Seen That Before"

Degenkolb: All of a sudden, you think "I've seen that type of thing before." There are so many things like that, where, once you say a key word, you automatically recognize what happened, and why you shouldn't do it again, or what should be changed. You never thought of it before, yet it's all simple stuff. You're so conditioned. We're conditioned to think of everything elastically. Our whole college education, our analysis, the computer stuff—is all elastic. But in reality it isn't—it's nonlinear. The simplest thing you look at in any earthquake is not elastic.

Scott: I guess what you're saying is you're conditioned to think of the materials as behaving in these ways, then when you come to an instance where they don't behave that way, it takes a while to see it and realize what's happening. Maybe you don't see it at first, but the light dawns, after seeing the damage again?

Degenkolb: Yes, and once you see it, it's so simple, you're embarrassed that you didn't think of it 20 years before. But we're so conditioned on certain things, that it's hard to break out of the shell and think differently. For example, when we looked at the failure of the airport tower in Anchorage, Alaska, we didn't really recognize the failure—we knew it was bad design but the import of how it related to our "good" work did not fully hit home. You look at it but you don't put it in the context of the code the way you should. But when you see a similar failure—say in Caracas—then all of a sudden it strikes you what is omitted in the code as to why it failed. It hits you—"I've seen that failure before." You go back over your old slides and realize that you've seen it maybe a couple of times before, but didn't fully recognize it. There are so many lessons where all you have to do is think about it a little and you know what the problem is.

The Increase in Interest: Tremendous Strides

Scott: A lot more people are interested in chasing earthquakes now, aren't they? When did this change begin?

Degenkolb: I figure probably the biggest change [the increase in interest by engineers and the scientific community] came about after the Managua earthquake [1972]. For the scientific community, the '64 earthquake in Alaska had a tremendous impact. Alaska did not affect the average layman much, but it certainly affected the scientific community. That's when Frank Press was very strongly promoting the idea that we should try to predict earthquakes, and it got to be a big push. We engineers tagged along, and fortunately we did. The geologists really wanted to squeeze us out, but it worked out okay. Unfortunately, however, they haven't been able to predict anything on earthquakes, and whatever progress we've made has been through the engineering element—so, in short, it worked out all right.

While Caracas was too far away to increase the awareness of the average guy, Managua made an impression. By that time, the television stations and media were interested. And of course the Guatemala earthquake [1976], and the big one in San Fernando [1971]. Gradually, from a scientific and engineering point of view, interest picked up. Karl Steinbrugge and myself and our office, and Frank McClure was another. Once in a while there would be another engineer or two who would chase earthquakes.

Now our biggest problem I think is to keep them away, because there are too many investigations—they overload things. In a way that is good, not because overloading is good, but because of the interest shown, the willingness, the funding and the report writing, I think it is absolutely marvelous. But you can overwhelm small communities with the numbers of research workers.

The increase in interest has largely come about through EERI. I think EERI has been a very powerful force for this. Now you've not only got some of the engineers from the National Academy on the structural, we've also got economists, sociologists, and are getting a whole range of human behavior people. All of this, I think, is important. We've made tremendous strides.

A Summing Up

Scott: I guess you'd say that earthquakes are much more carefully and methodically studied?

Degenkolb: Or more in-depth, and by more people. I think the most important thing is more people, because I think we did a lot of these older earthquakes just as methodically, maybe even more so, but there were only a few of us. Now, automatically there are 20 guys who want to go, and we pick seven, or if it's some place that is easy to get to, the town is overrun with them. That really started with the Alaska earthquake more than anything. Then Caracas, after Karl and I and another guy went down, and Bob Hanson. That one [Caracas, Venezuela, 1967] was an eye-opener on so many things on concrete. That was when I phoned some of the engineers in Los Angeles. It was always northern California that went to earthquakes. Southern California never did. So in that one I phoned and they sent some engineers down. I think personally I may be prejudiced, but I think that the idea is to get more engineers seeing the actual damage. Seeing it in the field is a lot different than reading about it, and I think this has had a major effect on the shift.

Scott: You've got more educated eyes looking over the damage immediately after the earthquake.

Degenkolb: More people to give reports. I personally credit that for a large portion of the change. Whether that's true or not, I don't know. There are several reasons, but EERI is one—in getting different groups to go on a cooperative basis, getting a lot of data, getting the information and the reports out quickly, instead of three years later when it's all cold (used to be anyway). Getting something out within a few months while it's still hot news.

Scott: They're doing pretty well now, don't you think?

Degenkolb: Oh yeah. EERI has always been pretty good on that.

Increasing Sophistication of Investigators

Scott: The growing awareness of people making earthquake visits has no doubt had a major influence. Would you comment a little more on the learning process and how it has changed?

Degenkolb: In the old days of investigating earthquakes, one of the answers always seemed to be "the workmanship is no good, it's lousy, it's not the engineer's fault, it's just the bad people in the field." Well, that alleged reason sort of diminishes in light of new findings. But the American point of view, the California point of view, has tended to be that anybody designing buildings for earthquake, except for us [in California], doesn't know what they're doing. The images are of guys still using five gallon cans for mixing concrete...you know the old stories and stereotypes of the '50s and before.

Well, they had engineers down there in Caracas every bit as good as ours. While they have some lousy construction, they also have construction that is as good as any of ours. That's one of the reasons I wanted—several of us wanted—to get some other engineers down there, so they couldn't say we were biased. We wanted them to see for themselves, to see the quality of the work, and the types of failures.

Scott: In other words, even though it was good-quality work and good design for its day, there was still damage. Thus engineers from a so-called advanced place like California could learn lessons from down there—by observing what looked like quality construction, and seeing what happened to some of it.

Degenkolb: Yes. Actually *most* of the lessons are from foreign countries because that's where most of the earthquakes are. If you're talking about the bad construction in the southern Philippines, that's one thing. You can learn something from it, but not so much. But if damage happens to good-quality buildings in Ecuador or Peru or Caracas, that can tell you something. Of course the junk will also fail, just like the junk that fails here. But you also have failures of good-quality construction, like our own Imperial County Services Building [El Centro, CA] failure. It was of excellent design, superior for its day, with good-quality workmanship, and yet look at the earthquake damage. That's the point that has to be gotten across—that there's something wrong with the procedures some place.

So that's about where we are today. Earthquake chasing is fashionable and there are lots of papers on earthquakes. It's now become much more formalized.

We Learn From Every Earthquake

Degenkolb: I think you can see we have learned lessons from every earthquake. You'd think we've learned so much already that by now there wouldn't be anything more to learn, but that's not true. Sometimes it doesn't dawn till the second or third earthquake. First of all, our processes of building change, so that our old concepts of what's right and wrong—which are largely empirical in spite of all the theory—may not apply when the conditions change, and so there is room for new lessons.

Scott: Lessons regarding new designs and new materials?

Degenkolb: New materials. For example, we have always thought of masonry or concrete exterior walls. But we have gone through a cycle where we have the metal curtain walls and certain required fire ratings. Fire ratings used to require three or four hours of fire resistance, which could only be accomplished with concrete or masonry construction. Right now there's a big push on for doing them with plastic. I'm very much opposed to it, but several buildings have been built that way, and there's one in town [San Francisco] that has been built with plastic on one face, which I think is a mistake, though I'm not sure.

But we're always entering into new ways of doing things. We had ways of doing elevators, and using the old hydraulic system, etc. These things worked pretty well in an earthquake. Then we got the high-speed electric elevators and the counterweights, and found out from Alaska and San Fernando and Managua that the counterweights didn't hold and broke some of the rail guides, and cables shifted and got tangled, and so forth, so we're correcting that. So there'll always be some new things coming up. For example, we worked on Embarcadero Center [San Francisco]—the elevators were taken care of, the hoists and the guide rails and counterweights. But then you go up into the machine room, and find that all the electronic gear isn't anchored. They never did it before—you don't think about these things. All you have to do is keep your mind open, and that is difficult.

Chapter 7

Ductility

"Ductility can save you where mere strength can't."

Scott: Ductility is a very important concept in earthquake engineering. Would you talk a little about what ductility means, as an engineer uses the term.

Degenkolb: Okay. If we have two columns and a beam and they just rest on each other, if you put on a side load, the beam's going to move over. After a certain amount of movement, it becomes unstable and it's going to fall down [Degenkolb begins drawing, see Figure 1]. That is nonductile, and it's essentially very brittle, like a piece of glass.

Now we can go to the next level and I'll add a couple of weak knee braces and weld them—make it all steel and welding, just a little bit of welding (Figure 2). Once a weld begins to break, it breaks quickly and will fail. This design will take a certain load, but once the weld holding those weak knee braces is broken, it will fall down. Figure 2 has a lot more strength than Figure 1. Now let's say we have steel beams and we weld this connection up or bolt this connection up, so there won't be any failure in the corners (Figure 3). When we put a load on that, it may bend way over (Figure 4), but it will take a lot of deformation before it goes. As a matter of fact, you probably couldn't make that fall down. It would just bend and bend and bend, and hold up the load until it would come down within a couple feet of the ground. Now *this* is ductile, although it is no

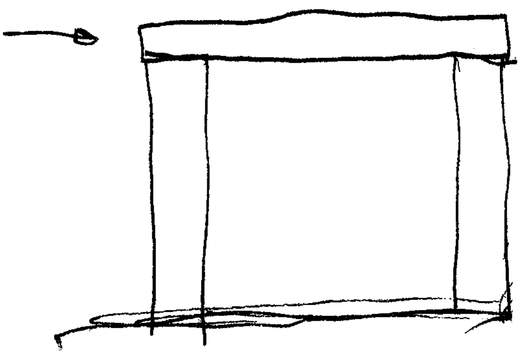


Figure 1

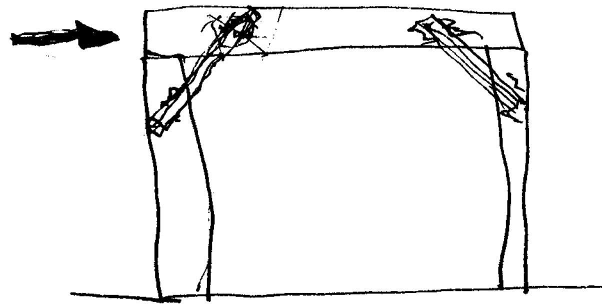


Figure 2

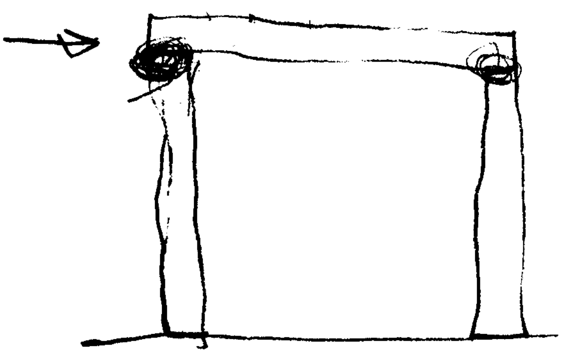


Figure 3

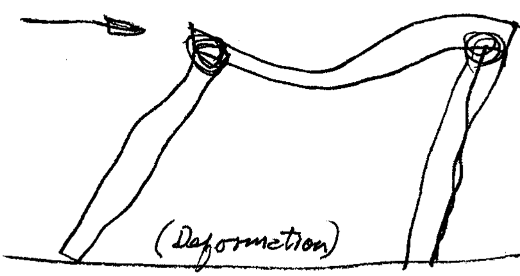


Figure 4

stronger than Figure 1 as far as vertical load is concerned.

Scott: So ductility is the ability to resist and move, without collapse.

Degenkolb: That's essentially it—to deform and still hang together. But this can be quite flexible. This is diagrammatic (we don't quite do it this way) but let's take the same beam and columns, weld the corners up so that we have the same as we have in Figure 3, and now let's put a couple of braces in here or a concrete wall or even a brick wall (Figure 5). Now for the weaker loads, this is much more rigid than Figure 3 and will not deform. But if we ever get a real big earthquake and this all cracks up and shatters, or these cross-members buckle or break or whatever, then we still have the reserve of Figure 3, and Figure 5 will not come down and collapse. I've got to think of a better explanation, but at least that illustrates what we're trying to get at.

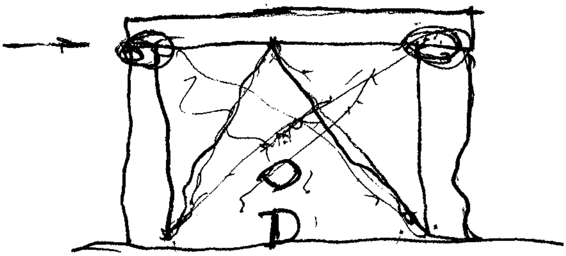


Figure 5

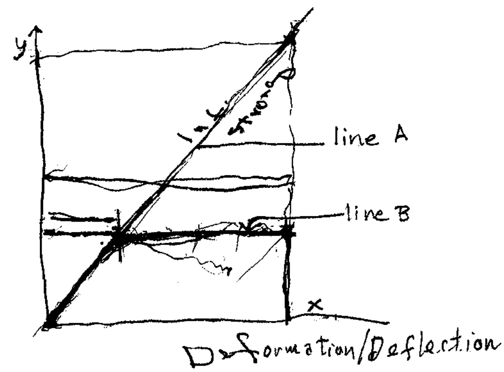


Figure 6

Codes Emphasize Strength

Degenkolb: Present codes almost exclusively emphasize the strength of a structure, because that's what we do for most things. You have a certain known wind load, you have the weight of a truck on a bridge, or people, or furniture, or stacks in a library. You've got certain loads and you provide the strength for them. For wind loads, Figure 2 is probably the cheapest way to put in the strength required by the horizontal load.

If the earthquake is an unknown large load, larger than we can design for now, theoretically if you make this strong enough and you can estimate how strong the earthquake forces will be, you could make these knee braces (Figure 2) strong enough to take the earthquake load. However, that would make everything so costly, and we might get an even bigger earthquake than estimated, so Figure 2 is not a very viable design, although it would probably be accepted in the code if you met the coefficients. In ATC 3, we tried to recognize different systems like this, like in Figures 3 and 5, so that even if it's overloaded more than you anticipated, or if the horizontal load is so great that you can't handle it in the elastic range—the strength range—it will still hang together and not collapse. It may be damaged, it may be cracked, but it will still stand. That's what we call ductility.

Ductility and the Stress-Strain Curve

Degenkolb: Now technically, this (Figure 4) is deformation and this (Figure 5) is strength, and let's say we have a stress-strain curve (Figure 6). If you put a 100 lbs. on a beam and it will deflect 1", and you put 200 lbs. it will deflect 2". The stress-strain curve for an elastic thing is a straight line—if you remove the load, you essentially remove the deformation. (If it is nonlinear it will be a curve like it is with concrete.)

Now for a given earthquake, if you had a structure of infinitely strong material, an infinitely strong system, you would have a strength demand something like this (Figure 6, Line A), and you have a certain deformation. If we don't have an infinitely strong material, but have an elastic, plastic material, we have ductility and let's say the material had a yield strength—it was only this strong (Figure 6, Line B). Newmark and some Chinese guy (I forget his name) back in '60 or so wrote a paper for single mass systems in which they proved for single mass systems that if it's an elasto-plastic system, that it's acting elastically to a certain point, then from there on it hangs together, but it pulls like a piece of taffy. It maintains its strength and keeps deforming [see flattened part of curve, Figure 6]. The ductility is the ratio of this dimension to this one—of x to y, in Figure 6.

The curve for a piece of glass has no horizontal portion—it goes up the diagonal portion to the point where it breaks. A piece of steel or a piece of taffy will go up the curve to a certain strength, then it will keep stretching without falling apart. The next earthquake may make a higher demand, so there is a big question as to what the ductility ratio should be—whether it should be, say, 4, 5, or 10. That is, in essence, what the R values are measuring in ATC 3—Table 3B, I think it is.[53]

That's the engineering explanation of ductility. It boils down to the ratio of x to y (in Figure 6). Now the problem is that none of the materials follow the *theoretical* elasto-plastic curve exactly. Steel comes closest. Other materials have less ductility, some materials have almost none. Then we complicate the matter when we consider cycles of motion. In the second cycle of motion, the material will not be as strong as before, and the curve drops down. That's the degrading strength, the degrading hysteresis curve. If it [the earthquake motion] keeps on going in more cycles, it gets weaker. But that's the basic idea of ductility. [See Figures 13 and 14 in Chapter 8 for hysteresis loops for steel and reinforced concrete.]

53. ATC 3-06, Tentative Provisions for the Development of Seismic Regulations for Buildings. Applied Technology Council, Redwood City, CA, 1978.

Ductility Can Save You

Degenkolb: Now, ductility can save you where mere strength can't. The way we've been taught and the custom of the engineering practice is that in most of our stuff we don't calculate the shrinkage stresses in concrete, temperature stresses, foundation settlement, different deformations, because it has not been important in the types of structures we have known in the past.

With some of the new structures, however, ductility *is* that important, and the thing that saves the structures is being well tied together with ductile materials, so it can adjust. A big mat foundation, I think of the Franklin Street telephone exchange over in Oakland, I think that the center of the mats probably settled over the years a couple or three inches, compared to the edges. And the elastic stresses of that much differential settlement would be out of this world, the building theoretically couldn't stand up. But it adjusts, it follows the curve, which is the result of having a steel frame.

Oh—mentioning the steel frame. We measure the intensity of stress in tension by taking the total force on a member and divide by the cross-sectioned area. This is true for uniform sections like a rod or a plate, but may not be true where there is a change in section, or a

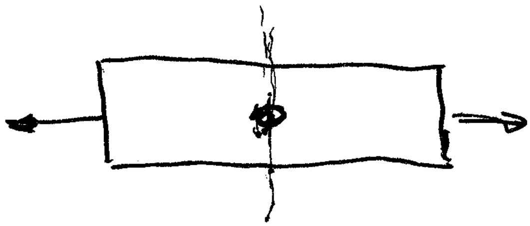


Figure 7

bend. If you take a plate of steel and pull it apart, you get a certain stress per unit area. Now put a tiny hole in the plate, so small that it has a negligible effect on the area (Figure 7). In the elastic range, however, the flow of stresses around the hole creates a point where the unit stress is three times the average stress, and you would think it would fail at a third of the force needed to pull apart an unpenetrated plate. But because of the ductility in the steel, that overloaded area stretches out a bit and the stress evens out and we have no appreciable loss of load (Figure 6). Now if you take a little piece of glass tubing in a chemistry lab and put a little nick in it, that's a stress-raiser that makes it very easy to break—it has no ductility.

In steel, we don't even pay attention to the hole, because steel has the ability to adjust. It flows around so that if this is a very small hole, the strength of the piece of steel with the hole in it will be the same as without it.

Ductility of Systems

Degenkolb: There are other factors involved, because ductility affects not only steel, it affects the details, it affects the framing system. Certain systems are more ductile than others. If this is a rod bracing system in Figure 5 here, the rods will stretch and eventually break at the threads. Incidentally, that happened to us down in Tehachapi. John [Gould] had designed the gymnasium for the high school, and one of the rod bracings in the roof had been threaded with the wrong die—i.e., the threads in the turnbuckle did not match the threads on the rods—and the rods broke. Of course at that time we were sort of embarrassed about it, but the building performed very well. The rest of the system was ductile, even though the member broke. Nowadays we do not like to use threaded rods for this. If you thread a rod and then put a nut on and pull it, these threads are of reduced strength, and also they're stress raisers, and this arrangement has very little energy absorption and it's not very ductile (Figure 8).

Scott: It pulls out?

Degenkolb: It just pulls off. Now what we can do is to up-set thread the rod. We can forge it so as to increase the thread diameter (Figure 8). Then this proportion is such so that when you pull it, it will fail down here, away from the threads. Now this—the body of the rod—will stretch like a piece of taffy and you have not

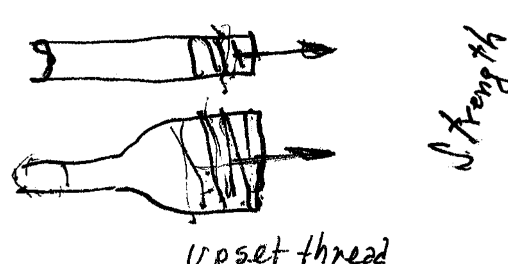


Figure 8

only the larger area but you also have large energy absorption, so if we used rods, we would try in a case like this to use up-set rods. We don't usually use rods for earthquake design. But if you did, like with the old-fashioned water tanks, the high elevated water tanks—in earthquake country we generally see these rods snapped and broken. If you were to build those now—you probably wouldn't, but if you did—and used up-set rods, they would stretch and sag, but they'd still be there. That's ductility. There are different phases—different ways of looking at it.

Scott: Different ways of building ductility into the structure, of designing it in?

Importance of Nonlinear Relationships

Degenkolb: Right. It is most important to understand the basic actions and how things work, and not merely to read what the code says. The code gives you the general levels at which to do things, and from there on you're supposed to apply your knowledge. One of the basic difficulties is our education. We were taught the elastic systems. Now they're getting a little bit better, but in four years of engineering study, or even five years, students are taught only a little bit about nonlinear, plastic systems.

There are peculiar things that happen. For example, when we're dealing in the elastic range we can separate the dead load—the vertical load—from the horizontal load. We can take one stress and calculate it one way, we can put another load on it, can superimpose the two loads, and we'll get the right answer. In linear (elastic) systems you can separate out the various loads, determine the stresses, and they will add up correctly, just as if you had solved a problem considering all of the loads at once. But this is not true for nonlinear (plastic) loadings. They do not add up.

Over in the *nonlinear* range, the loads are not additive because the stresses are not additive. Our whole educational system is based on the traditional elastic system, which you have to know first and is based on strength. But we in earthquake engineering are dealing with nonlinear systems way beyond the elastic range, and things that are automatically taken for granted, that you'd otherwise never even question—such things are no longer true. In undergraduate work, I'm not even sure how many engineering schools do more that mention the nonlinear range. Certainly this topic is not given enough attention to impart a basic understanding of it. The rest of the country is widely believed not to need it. Well, I don't quite agree with that. That understanding is sorely needed in California and other seismic areas where earthquake-resistant design is a necessity. According to the code, if you don't have earthquakes you can design for a certain wind velocity, you can design for a certain size truck, on a strength and elastic basis, and you really do not get into the nonlinear range the way we do in earthquake engineering. So the basic understanding, the background for writing the code, is different.

Scott: When did we begin to realize the importance of the nonlinear relationships, and why did that begin to emerge as more important? Was it related to a better basic awareness of how buildings perform, or was it a matter of our knowing more about earthquake forces, or was it a matter of new designs and materials?

Degenkolb: First of all, it's a gradually evolving thing. I would suppose [Nathan] Newmark, and some of those who dealt with nuclear blast design, may have thought that way on a theoretical basis in the middle '50s, late '50s maybe. I think some of the engineers became more aware of it in the '60s. The older engineers were interpreting what they saw and the performance of things in light of the older style of buildings.

For example, you'll often hear—and I've said it myself—that the steel frame buildings did not come down in San Francisco in 1906. They didn't. Most of the engineers took that as a justification for designing the steel frame at the time for 30 lbs. of wind. That would make the building stand up. Well, it did, with the way they framed things then. The old method provided a large measure of ductility. But the engineer did not have anything to do with the brick walls, and the brick took the load. And he thought the building was successful because of his frame. It didn't collapse—his structure didn't collapse. If the walls fell out he really didn't care. It wasn't his business.

My early experience and education was essentially the same because it was the old-timers—Henry Dewell, Walter Huber and some of these engineers (they were the intelligent ones)—were explaining things on the basis of framing. There must be some loss of transfer force from the ground to the building. Our coefficients are too high, and for the types of buildings they were designing, and the portions of the buildings they were designing, that probably was correct. But in their observations, there were other buildings that failed and they blamed the systems: some were brick buildings. Some of the old-timers went down to Long Beach and explained that certain materials were inherently wrong. They blamed the damage on either bad workmanship or improper design or something like that—poor details. [*Note*: Brick is basically a unitary system connected together by mortar. If the mortar is poor, it is the same as any other system that is poorly tied together. With good mortar and ties, so it acts as a unit, brick can perform quite well.]

Then we sort of evolved, changing things from the old types of systems that we had, some of which performed beautifully. We now no longer have bearing walls, we've got lightweight walls instead of brick walls, we've got curtain walls that are nonstructural. All of a sudden, however, we got the hollow clay tile walls (or unreinforced concrete block or brick) with little strength and no ductile systems to back them up, and so these things were falling down in earthquakes. So you start looking into it more. Then you start appreciating ductility. I would say the revolution in understanding started in the mid-late '50s and gradually progressed.

Education: Many Do Not Understand the Code

Degenkolb: But it also relates to the education. I would say except for one or two places, up until '70 or so, engineering education was essentially and uniformly on the elastic basis. And, I would say, if you take the engineering schools in the U.S. and their undergraduate work, without even knowing the facts, I would guess that in 80% to 90% of the schools, practically everything is still elastic except for the mention of the word "nonlinear." Those are "guess" figures, but I do think that's the way we're trained. The way you are trained influences the way you think later.

Scott: In terms of practice—the education and general practice of the whole profession—it hasn't gotten there yet?

Degenkolb: Yes, that's right. I mean the backgrounds of the engineers that are practicing, even the specialists in earthquakes—I've said 50-60% don't understand our present code. And John Blume, I think, said it was more like 75%. But I'll guarantee that the majority are so steeped in the old training that most of them do not appreciate the background behind the codes. They're thinking in terms of strength to resist known loads. And if our structural engineers are thinking that way, just consider what the civil engineers, and people in other states and countries are doing—except for the few research workers and those engineers that are keeping up.

In California there is a much bigger emphasis on the new ideas. There are texts available, there are teachers available, there are researchers that study these things. The engineers in our office, the young people (we only take them from the master's up, now), they know this material. They probably know it better than I do. But we only get the absolute tops out of the few best universities. If you go down to most of the other universities, especially in other states—the basic understanding of this type of thing is negligible—there isn't much. For me, it's fundamental. There's an interest in it and it's improving.

Scott: What's it going to take to really improve things generally—another generation?

Degenkolb: I think another generation.

Scott: But in California at least we can do some pushing and shoving to help things along the way.

Degenkolb: Yes. In spite of everything I'm saying, just don't forget that California is *the leader*, and by a very wide margin. I still have this lawsuit up north [Degenkolb was hired as an expert witness to review construction and design of a building involved in a lawsuit], one part of it is settled, but I am astounded at the engineering faculty that is involved, at how little understanding they have of this. Some of the expert witnesses were engineering faculty members, and part of the problem was the seismic resistance of a new building. From some statements made, it was obvious that they were still thinking "strong enough," and not ductility.

They were trained, with Ph.D. degrees, in elastic systems. They do a lot of reading in this, but there's a basic leaning skew toward strength, and a tendency to overlook the role of ductility. They use the words, but I can see when I get into discussions and read explanations, that they still don't fully understand it.

Scott: They fall back on basic strength?

Degenkolb: That's right. I mean we've had a few centuries anyway, of thinking about strength as being the main criterion. You don't change that overnight.

Chapter 8

Framing Systems

"We try to make our buildings stiff, with a backup system of a frame, so that there is the combination of stiffness and toughness."

Degenkolb: There are two basic ways of building a building. One, you have columns and floors, and you make the joints all rigid. Under a lateral load, the rigidity of the joints provides the strength against the lateral force—that's a moment frame. The other way of doing it is braced frame—you put braces in some of the elements of the building.

As far as use of the building is concerned, with moment frame all you have is a floor system and columns. You can hang your wall here and put partitions in here, or a ceiling—you have complete freedom. You can put a stair in here. This accommodates the architect's natural desire to have long spans, open spaces, and a lot of glass. The moment frame is cheaper to design. It's more expensive to build, but it's cleaner to the extent that all you have are beams and columns. You can run them on the computer for the sizes, you can do a couple of typical details, and the architect has almost complete freedom as to what he wants to do on the building.

Scott: The moment frame simply consists of vertical members and horizontal members attached to each other at the joints.

Degenkolb: Yes, a rectilinear frame where the joints are rigid, and by the bending of the members they resist the lateral force. It basically takes bigger members, bigger sizes to do all that.

Braced Frames or Shear Walls

Degenkolb: Now if I have an X-braced frame, or if I take this rectilinear frame and pour in concrete walls—shear walls—then I have a much stiffer building. However, I have somewhat less flexibility in arranging things. There will be shear walls around the elevator core and the stairs, and maybe some extra walls outside the building, and the architect has to work around that. All of that has to be detailed. It isn't the type of stuff that can be scheduled—the computer output has to be interpreted, and requires a lot more detailing, so the engineering cost goes up. The architectural cost also goes up because the architect has to work around these things. But it's a safer building. The braced frame or shear wall is a much more rigid system than the moment frame.

Eccentric Braced Frame: Stiff But Very Ductile

Degenkolb: If two members meet at a point, that's a concentrically braced design. It is rigid and one of the members has to fail under side load. When you get up to high loads, you don't have to absorb much energy. If you make it eccentric, this tends to force a lot of deformation right where it absorbs energy, so this gives you the advantages of stiffness and still has the energy absorption elements of the moment frame. We [the Degenkolb firm] were sort of the pioneers in this—and Egor Popov—there have been a lot of tests.

Scott: You mean in developing this eccentric design?

Degenkolb: Yes.

Scott: Why is it called eccentric?

Degenkolb: Eccentricity really just means it doesn't meet at a point—it's not concentric. I guess it came from the old eccentric gear on steam engines, that changes the positions of the intake and exhaust valves. Here's the center of a circle or gear, put the axle rotation from around this point and it's eccentric, and it drives the steam valves back and forth. Eccentric braced frames [EBFs] give you a stiff, but very ductile, structure that absorbs a lot of energy.[54]

One of the criticisms of ATC 3—of course that was written eight years ago—is that we did not include that. I've always taken it as another braced frame, but it's more policy than design. ATC does not include EBFs. It doesn't say you can't design it, but it has requirements of the concentric braced frame. The newer code, the new Blue Book, will have provisions for the eccentric braced frame. The requirements for it will be spelled out. And I think we'll get a new ATC version. There are a lot of people who want it. We [SEAOC] have written the requirements for this so that the beam yields in shear, but it still stays together.

Scott: So, is the key reason or rationale behind the EBF to deliberately get some of the ductility or flexibility of the moment frame?

Degenkolb: To get energy absorption, really, while retaining a good deal of the stiff-

54. Eccentric braced frames are illustrated later in this chapter. See Figures 9 and 10.

ness of the other systems. Moment frame is much more flexible. In addition to that, when the loads are off-center, it tends to tip more.

Damage Repair In Braced Framed Buildings

Scott: Let me ask one more layman's question. Under significant earthquake shaking, like you might expect in L.A. or San Francisco, what happens? You say you get considerable deformation and energy absorption. In a way that's good, that's why you designed that factor into it. But what about that building [the EBF] after it's been shaken by a major earthquake—is it still going to be okay, or are you going to have to go in and patch up those joints?

Degenkolb: You might have to fix up the joints, which would be easy.

Scott: I see. Repair would be relatively easy to do?

Degenkolb: Very easy. As a matter of fact, in both the Japanese test[55] and the model test over in Richmond (I watched them a couple of weeks ago when we shook the 6-story model) you have the steel deck and a little concrete on top. The fear has always been that this was going to be all torn up. Well, in both the scale-model test in Richmond and the full-size test in Tsukuba (Science City), Japan, the cracks were minor, after putting them through a tremendously big earthquake. You could put a rug over it and nobody would know the difference. We tested first of all with concentric braces, the Japanese style. Then we took those braces out in a different panel, so we had fresh material to work with, we did one with eccentric braces. That's the one they tested over at Richmond. [Egor] Popov and some graduate students have been running various combinations of tests on the design—what the stiffener should be, the beams, the spacing, how to calculate the shears, will the ordinary formulas work? They're remarkably good because they're stiff, which prevents this P-delta effect.[56]

Drifts and Deflections

Scott: What about Frank's comment that the actual interstory drifts and deflections in the buildings will be orders of magnitude greater than those calculated from the San Francisco building code procedures. What does he mean by that?

Degenkolb: Traditionally we've used working stresses, knowing that in order to be ductile, a structure would stretch—not fail, but stretch and be deformed during an earthquake. Traditionally, the code says that after you've put the code forces on it, you have to check the damage to partitions and all that kind of thing. In the traditional codes, that was the design deflection, except for any judgment the engineer may use. A few years ago it was required that this calculated deflection must be increased by a factor of about 3 or 4. In actual

55. *Recommendations for a U.S.-Japan Cooperative Research Program Utilizing Large-Scale Testing Facilities.* To be conducted under the auspices of U.J.N.R. Program, U.S.-Japan Planning Group Cooperative, University of California at Berkeley, College of Engineering–Earthquake Engineering Research Center. Publication no. 79/26, Berkeley, CA, 1979.

56. The P-delta effect occurs when a building deflects so far (many feet) that its own weight tries to further tip it over. This can be prevented by making the building stiff.

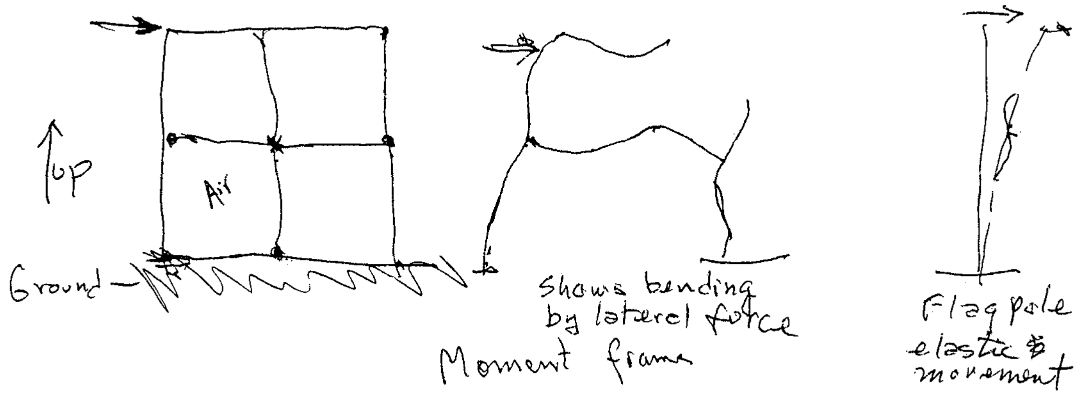


Figure 1

earthquakes, however, we have seen deflections that were much larger than the increased working stress deflection—8 or 10 times as much as the calculated deflection, not just 3 or 4 times. This, of course, means that unless precautions are taken, the contents of the building, such as partitions, and the clothing (curtain walls) will be much more likely to be damaged, or receive more damage. The ATC 3 code tries to account for this larger deflection.

Actually Karl Steinbrugge's book[57] has illustrations of bracing and shear wall systems. It is a summary of all of his writing—I've been using it for some other work. It gathers together an awful lot of stuff. [Looking at a copy of the Steinbrugge book.] The diagram I'm thinking of is on page 92. It is in this general shape [begins drawing]. When we talk about moment frame, it's generally rectilinear, although it can be in other shapes. If you just take some beams and columns and you make rigid joints (Figure 1)—if you put a lateral load on that, because of the stiffness, because of the way these things bend, there's a resistance to bending, a resistance to the lateral force that is trying to push it out of square, as these things are rigid.

Scott: It's pushing back.

Degenkolb: That's right. You're putting a load here (horizontal arrow in Figure 1) and you can see—if it were a flagpole it would bend over like this. But then as you put a horizontal beam in here that prevents this rotation, it puts this kink in it, that kink in turn bends the beams into an S-shape. It's a little difficult to draw because there's a reverse curve. This is moment frame action. It's based on changing a rigid rectangle into a squashed shape. Now if you took that same frame and these were all hinges—if the corner joints were hinges—it would just collapse.

57. Steinbrugge, Karl V., *Earthquakes, Volcanoes, and Tsunamis*, Skandia America Group, New York, 1982.

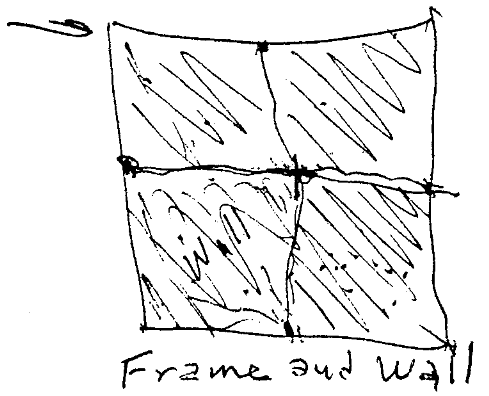


Figure 2

Shear Wall

Degenkolb: But if you take that same frame and fill it with a concrete or masonry wall, even though these joints are hinged (Figure 2) then you can see that the walls prevent it from squashing.

Scott: The shaded area in Figure 2 is filled in with a wall?

Degenkolb: Yes. Now we go one step further and just have the wall without the frame (Figure 3). Just have a solid wall like this. You can see that this is down in the ground pushing—it is a very rigid cantilever out of the ground. This is a shear wall.

Traditionally, in the real old buildings, which used to be the steel buildings—engineers would design a wall like that in Figure 1, moment frame with semi-rigid minor connections designed for a portion of the wind load, or maybe not even designed for wind. But because the buildings were built with infilled walls, masonry, they performed very well (Figure 2).

Scott: In other words the walls added to the resistance?

Degenkolb: Yes. With the advent of the curtain wall this (Figure 1) became the popular way of providing earthquake resistance, because the architect could have nice clean open spaces—the architect didn't have to worry about [interior bearing] walls. He could arrange partitions wherever he wanted and it wouldn't affect the structure. However, the system in Figure 1 is very flexible. In the Morgan Hill earthquake, in the EERI report there was a description of the Santa Clara County office building, which has this system in steel—about a 10-12 story building. The five seconds of shaking caused the building to shake for 87 seconds, because of very low damping. It had a lot of deflection.

Dual System

Degenkolb: Then the opposite plan, ideal for concrete, is to build slabs and walls only (Figure 3). That's the traditional concrete way of doing things. We talk about the dual system,[58] which is the one I've always preferred.

58. A dual system contains shear walls (or braced frames) *and* moment frames. The shear walls provide a great deal of stiffness and will resist all of the lateral load in high winds or moderate earthquakes, and because of the stiffness, will prevent any damage. In a very large earthquake, the shear walls may be damaged and allow the building to move more. It is here that the moment frames come into play, providing the ductility and absorbing more energy without allowing the building to collapse. The damaged shear wall will also absorb energy and increase "damping" as it grinds in response to earthquake motion.

Figure 3

Trying to imitate what happened in 1906 and 1923, and the other earthquakes where we had steel buildings, with the frame plus the wall. The wall will crack in an earthquake. It has to absorb energy if the earthquake is strong enough. Then you have the framing in back of the wall, which provides the rigidity and the final strength to keep the building from collapsing. This design is starting to get much more popular.

Scott: Is it getting popular partly because of recognition of this resistance factor that you're talking about?

Degenkolb: Partly because we've talked a lot about the comparison between the Banco Central [Managua] which was a Figure 1-type building, and the Banco de America [in Managua], which was a shear wall building (Figure 3), and was so much stiffer that it had much less damage.

People in the last 10-15 years are getting much more concerned about the contents of buildings. Another of the big concerns is the attachment—with the change from the masonry walls of the older style buildings, or concrete walls or stone-faced concrete or brick. We've changed to lightweight curtain walls, the precast concrete, which generally is used on moment frame buildings (Figure 1), with the walls just hung on. As this type deflects a lot, the chances are greatly increased that the clothing of the building will fall off.

Nonstructural Walls and "Captive Columns"

Scott: Now a curtain wall is a kind of wall that doesn't really provide much resistance, not the kind of resistance provided by the wall you're showing in Figure 2?

Degenkolb: Right. As a matter of fact, any resistance it gives, since the quantity of resistance is uncertain, may do more harm than good because it may introduce stresses, or changes in the flow of stresses, and cause failure. One example that I used in the Guatemala talks—this has shown up in practically every earthquake—you have a little building on two rows of columns—typically a school. This is a cross section through it, with a roof of some type (Figure 4). In the northern hemisphere, the north side would have all windows and columns, and on the south side, because of the sun, you would have a solid wall up to the slit windows at the top. You've seen these schools all over the state—they're common. The engineer could design that as a building with just the columns and without the wall, and it would be strong enough to take the earthquake. Without the wall, each row of columns (on the north and the south) takes half the load. But

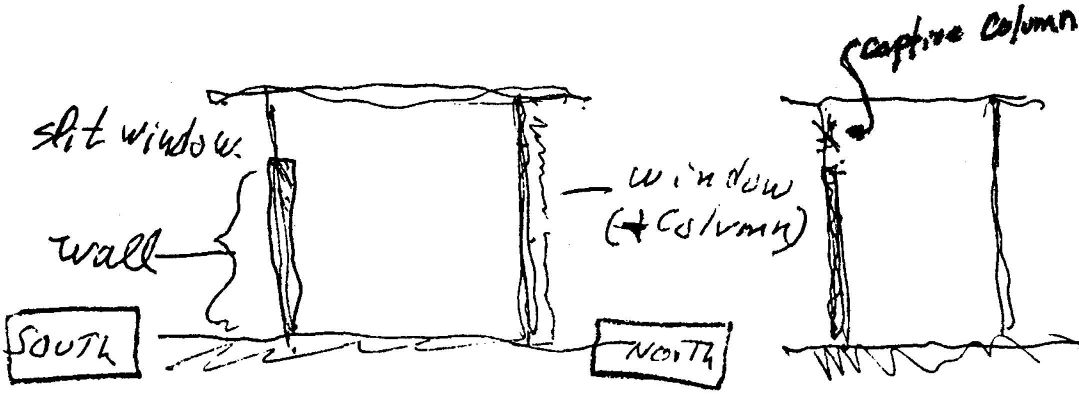


Figure 4

with this wall here, the set of short columns on the south becomes so stiff that it takes all the load, and the north side takes practically nothing. These short columns break. You can see this in every earthquake we've ever chased that had these finger classrooms, like those in South America, in the Mediterranean area, and here.

We call these short columns "captive columns." You undoubtedly can find examples in Karl's [Steinbrugge's] book.[59] If not, you can look at any earthquake report and find the same thing. These always fail. The point I'm getting at in this comparison is that unwanted strength in the wrong place—which may be similar to our precast curtain walls—could do more harm than good. It can change the distribution of the loads and put too much load on something where it shouldn't have gone.

One solution used in Peru—when they reconstructed some of these buildings—was to cut the wall free of the column and put a space around each side—like three or four inches. That way, while you still have a wall for shading from the sun, the columns are free to move equally. In the follow-up earthquake (I forget the years) they were successful. Loring Wyllie has seen those. I think it was at the College of Agriculture, and near Lima, or south of Lima. They have a lot of earthquakes, but there were two successive ones a few years apart that Loring had seen, and talked to the engineers down there. He had seen the effects of freeing this wall up from the columns, and it worked.

The Use of Bracing

Degenkolb: The other thing that we had been talking about is this [drawing Figure 5]: take the same frame—make it two stories—and we can put diagonal braces in there, and that again can take the load because the triangular diagonals keep the rectilinear shape rectangular. The moment frame system allows it to squash. Now, Figure 5 can also be done in vari-

59. Steinbrugge, Karl V., *Earthquakes, Volcanoes, and Tsunamis*, Skandia America Group, New York, 1982.

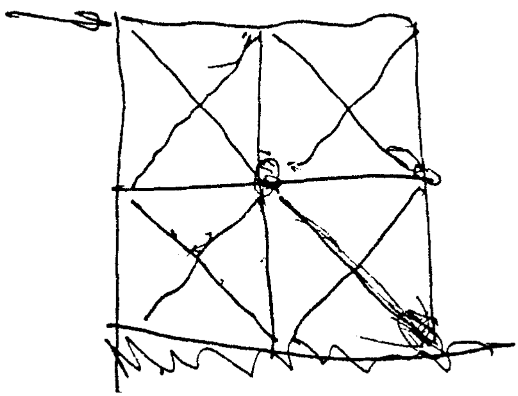


Figure 5

ous shapes. The bracing can be done all in panels just like this. This is then back and forth, in tension or compression bracing as in Figure 6, or Figure 7 fill up the panels with what we call "K- bracing," or chevron bracing. As long as it's triangular and you have adequate connections, then you are resisting the load in a very stiff manner, similar to the wall.

Scott: This is K-bracing (Figure 7)?

Degenkolb: That's K-bracing, or chevron bracing. Figure 8 comes from the K-brace bridge trusses.

Scott: In Figure 8 they are pointing sideways, the apex of the triangle is pointing to the side instead of pointing up.

Degenkolb: Right. Now you'll notice in all of these that I have made the joints all meet at a point, concentrically. That's concentric bracing. Where it has been used, inevitably these braces buckle or pull apart in earthquakes. The Ferry Building [in San Francisco] had this type of bracing [pointing to Figure 5] with wrought iron rods (tension rods) and they pulled out of the joint in here [small circles on Figure 5]. However, in no case of the steel buildings where these braces are used, do I know of a failure.

Stretching and Buckling

Scott: When you say "these braces," are you referring to any of these systems?

Degenkolb: Any of the systems I'm showing. These systems are very stiff. All the lateral load is essentially taken in the braces, and the braces have little or no vertical load. The K-bracing may have a little bit. Generally, with the size of the earthquakes, you find in water tanks and such that the braces are stretched, or buckled.

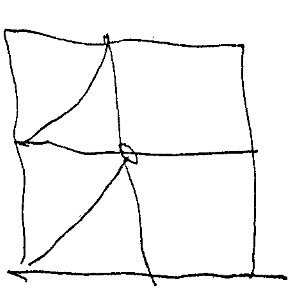


Figure 6

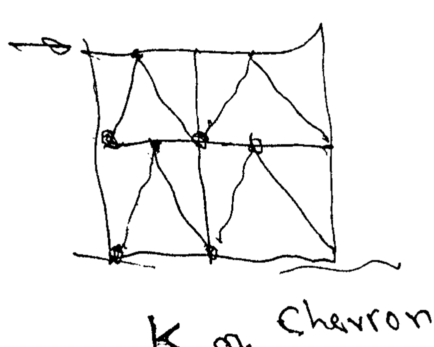


Figure 7

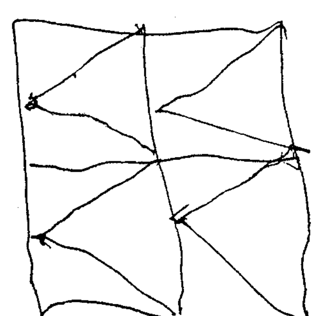


Figure 8

Scott: When you said you didn't know of any failures, do you mean that the buckling may have occurred, or the pulling out may have occurred, but the building did not collapse.

Degenkolb: Yes. Typically, it is like the Ferry Building, which is reputed to have come through the [1906] earthquake beautifully. It's 200 feet tall, and the wrought iron braces that brace the tower section pulled out of the rivets, just tore the connection apart. Then the wall, the facing, which is supposed to be nonstructural, stabilized the building and it stood up. The Call Building [now the Central Tower, 3rd and Market, San Francisco] is reputed to have this kind of bracing (shown in Figure 6). None of the others [in the 1906 San Francisco earthquake] did that I know of.

Typically the "mill" buildings—the big one-story buildings with cranes and a lot of equipment and machinery, or warehouses that are made out of corrugated iron and metal frames—are usually braced with X-bracing (Figure 5). Or if it's heavy, they may have one of the other types. Invariably the X-bracing will be stretched and pulled. Example, on the Olive View Power Building in the San Fernando earthquake. Remember the flat bars that were X-braced. One broke and one was stretched. All right, the X-bracing failed, but the building stood up. It was damaged, of course, but it stood up.

Experimentation With Eccentric Bracing

Degenkolb: There's very little energy absorption when you have these direct connections. You get either direct compression or direct tension. In an endeavor to get around this, we played around some years ago, and Egor Popov has done quite a bit of work. Also Charles Roeder, who got his Ph.D. at Cal and is now teaching at Washington. The system that he [Popov] tested—actually tested a full-sized three-story system—was eccentric bracing like this (Figure 9). In the past we tried to avoid this eccentricity (eccentricity meaning it doesn't meet at a point).

Eccentric bracing is nonconcentric. Concentric means that things meet at a point. With eccentricity there is a certain amount of offset. Now as you put a load on this kind of bracing, it has almost the stiffness of a concentric brace, but it has a little cushion in here where we can engage the girder—if we make that a decent girder—placing it in bending. We can force the girder into the yield range, which absorbs a lot of energy, and has performed excellently in laboratories.

This is what we started out with some years ago, but most of the research has been on a system with K-bracing (Figure 7) and that's what we tested in the 6-story building over in Tsukuba, in Japan. The Japanese tested it with concentric braces and they got a failure at this point. We did our testing with an eccentricity, so that when you put a side load on here [arrow in Figure 9] you can visualize this rotating down into that position, and the other one going up and putting a lot of stress in that link beam [the small circles on Figure 10].

Scott: The link beam that the eccentricity allows for?

Degenkolb: That's right. And we can force this into shear, or take advantage of the bend-

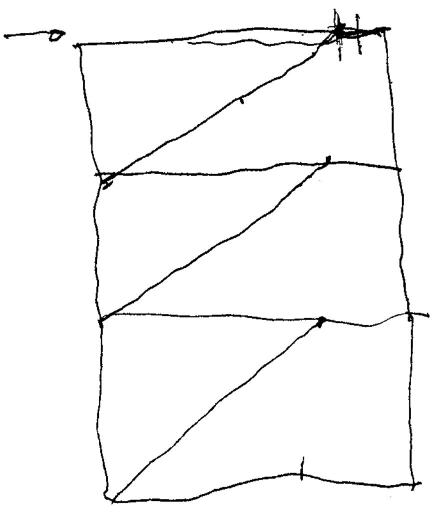


Figure 9

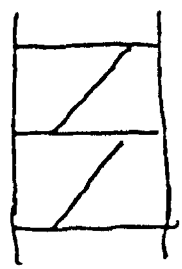


Figure 9A

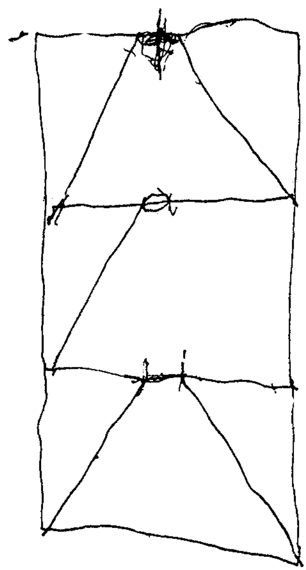


Figure 10

ing in steel, which has huge hysteresis loops that absorb a lot of energy. This is our eccentric bracing (Figure 10), so it has the advantage of approximately the same stiffness as the concentric bracing, depending on how big this link is. And it has energy absorption even greater than the moment frame. Right now it has become all the fashion (Figure 9 or 10).

More Freedom and More Efficient Use of Beams

Scott: Is Figure 10 kind of a development of and a more sophisticated version of Figure 9?

Degenkolb: No. As a matter of design they could be made equal. It just so happens that this (Figure 9A) was the first one tested, and then there's been more testing on this (pointing to K-bracing, Figure 7) although a lot of the information is interchangeable. It basically depends on the configuration. This (Figure 9) allows you to put a doorway or window in here, these others don't. Architecturally, you have a little more freedom.

Scott: It gives you more free open space.

Degenkolb: Yes. But the main structural advantage is that you're using the beams more efficiently. You can absorb a lot of energy, and you still have essentially the stiffness that you have in the concentric braced frames. The stiffness protects the contents and the clothing.

I mentioned one other thing that I'm worried about with Figure 1. This deflects so far that.... This is not generally a problem with the concrete buildings, which are typically a wall type, or the braced buildings. But if the Figure 1-type frame gets so far over [Figure 1 with deflection is shown in Fgure 11], the loads are

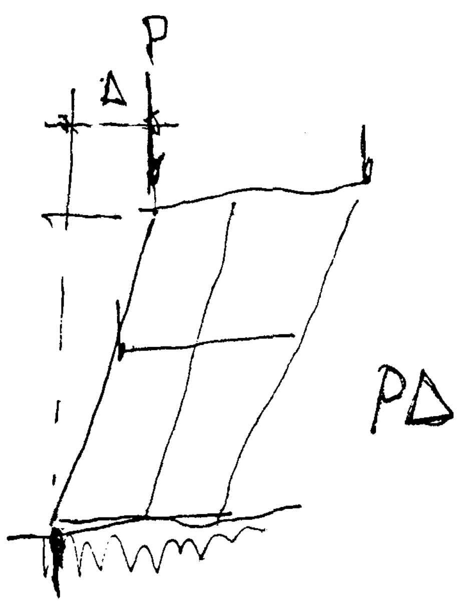


Figure 11

now not over the bases of the columns. We say that this is an eccentricity—we call this delta (Figure 11)i.

Scott: Delta is the measure of the deflection?

Degenkolb: Right. And it means that the vertical load is eccentric with its resistance. You can see if you pushed this too far over, no matter how strong this was, it would collapse down to the ground. This P-delta effect is one of the concerns we have, especially in tall buildings. That's why we have to stiffen them up.

Scott: In P-delta, what is the P?

Degenkolb: "P" is the weight of the load, and the delta is the eccentricity between the application of the load and it's resistance [begins drawing again].

Hysteresis Loops: Steel

Scott: You're doing a stress-strain diagram (Figure 12)?

Degenkolb: Yes. If you stay within the elastic region, within a small fraction of a percent of strain, there's no energy absorbed, there's a little internal friction, but that's all. It's like a watch spring, and just keeps going forever, back and forth. When you go into the plastic range, however, this figure then turns into diagonal lines [drawing] that don't meet.

Scott: Figure 12 now represents cycles of a horizontal force pushing, and then letting it come back.

Degenkolb: This is pushing it, then pushing it on into the plastic range, where it begins to bend. Then it relaxes and bends in the other direction—deforms in the other direction. You release the load and it comes back elastically, up to a point, where then it bends again when you force it. This gets beyond the elastic region. The advantage of it is that the area of this curve, which when it is a straight line is zero, the area of this curve is a function of the work that is performed, or of the energy absorbed, in the building when shaken by the earthquake.

I mentioned the Santa Clara County building [in the 1984 Morgan Hill earthquake]. This deformed only slightly in the elastic range, but it deformed enough that it did a lot of architectural damage. It kept on shaking, just like a watch spring, because it did not absorb any energy. So the building itself at that shaking level was perfectly safe. It moved a lot, but there wasn't enough friction in it or energy absorbed to cause the movement to die down. It was the only building in San Jose that was

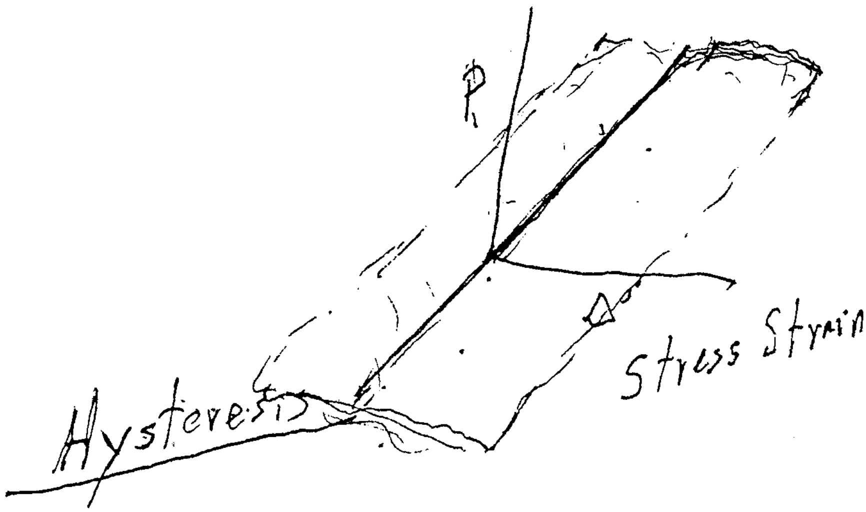


Figure 12

evacuated. It was instrumented, and the motion continued for 87 seconds after the five-second earthquake. That's a lot of wiggling.

Scott: Going back to this hysteresis diagram, when these steel members go through several cycles of the hysteresis loop they don't change all that much from one cycle to the other. What is the significance of that?

Degenkolb: Steel has a very stable hysteresis loop, that is, it can absorb energy without losing stiffness. You've got the molecules working with each other and then you unload it, which goes elastically, then you put the load on it in the other direction until it bends. Then you unload it and put load in the other direction. Steel has the capability to undergo a large number of such cycles on that same curve. You're not harming the steel—you're working it. It's internal friction.

Scott: It is moving back and forth but not deforming, or not much?

Degenkolb: The movement is not damaging it. The steel does deform, but it takes many cycles to cause a fatigue failure. It's like a tin can lid. If you bend it enough times, it will break. But it will undergo a large number of cycles (Figure 13). The diagram shows one hysteresis loop in the beginning. Then we unload it. This is the second loading and it goes around here, and then we do a slightly different but almost exactly the same third loading, and it keeps going around. If you stretch it back and release the load, it will come right back.

Scott: That's where it's in the diagonal part of the curve?

Degenkolb: Yes. But if you bend it far enough to go beyond the yield point, it will go into here (Figure 13, yielding range). Now if

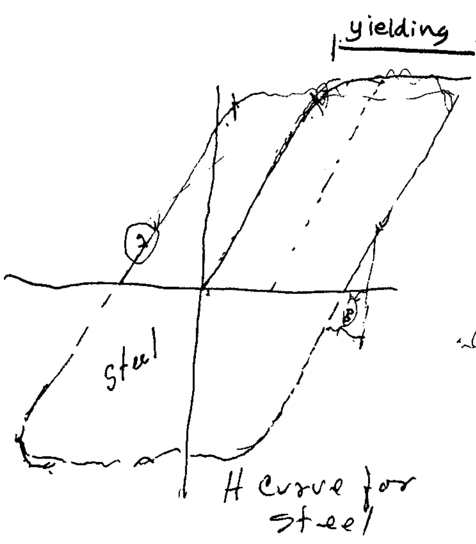


Figure 13

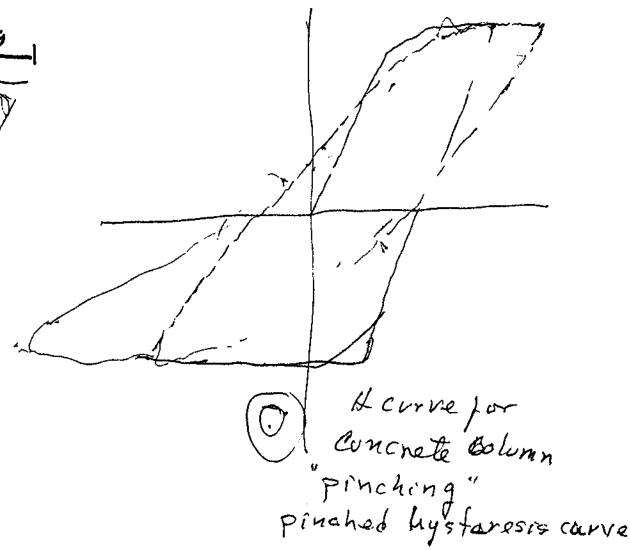


Figure 14

you release it, it will come back down like this. You get these loops only when you pass the yield point.

Scott: In other words, the yield point is about at the top part of the curve in Figures 13 and 14, where the curve flattens out up there at the top.

Degenkolb: That's right. But the structure of the steel has not changed materially. Metallurgists will argue about that, because there is some "cold working."

Hysteresis Loops: Concrete

Degenkolb: Now if we do the same thing to a concrete column, first of all, up to a certain point it's acting like a homogeneous material—elastic. But you'll finally get a point where it will crack, and in that load it will crack in this direction (Figure 15). You get a crack here and the column no longer has the same properties. Then you release this load and it goes the other way. You get a crack going this way when you push it this way. This crack is a little zone of weakness. The easy way to visualize that is to say, once you get this crack, each cycle grinds away and weakens it and weakens it. Now the slope of this hysteresis curve is the measure of the stiffness, and if the concrete gets less stiff, the curve moves ovr this way.

Scott: The loop leans further toward the horizontal.

Degenkolb: Yes, becomes pinched. So the hysteresis curve for concrete will look more like this (Figure 14). You go up to the first cycle and you get a yield. You unload it and you get down to here some place. Then you force it in

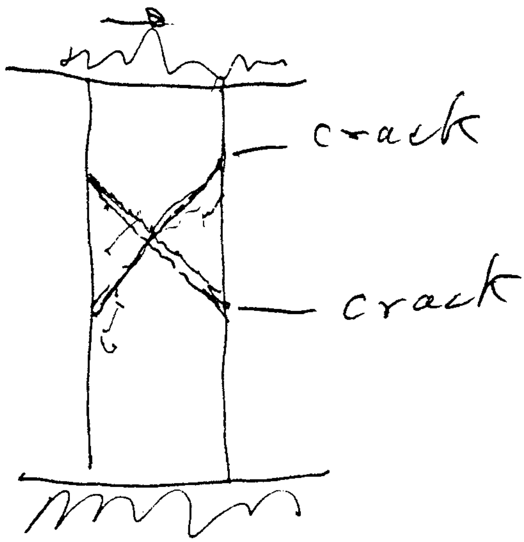


Figure 15

the other direction. So far the curve looks very much like steel. Now you've pushed one direction, and you've pushed the other direction, and you've got two cracks e(Figure 15). It's not as stiff as it was before, which means it lays down a little bit more. It will probably meet that same point of stress again, but over further. Now it may lay down a little further on its way back. It will just keep doing that, laying down further each time. [Figure 13 is the hysteresis diagram for steel, and Figure 15 is an actual cross section of a diagram of a concrete column. Figure 14 is the hysteresis curve for the concrete column with the cracks in it. Figures 13 and 14 show hysteresis curves for steel and concrete, respectively.]

The same thing goes for joints and beams, but it starts getting complicated. Rod-bracing has no stiffness at all until it takes up slack, so it goes right along that horizontal line. In concrete we call that action a "pinched" hysteresis curve. Because it gets pinched, it does not have as much energy absorption as you have in the steel, which is more of a constant hysteresis curve.

Scott: When you say pinched hysteresis, you mean....

Degenkolb: This (Figure 13) is big, but this (Figure 14) gets closer and closer and closer together. This (Figure 14) keeps going further and further out, keeps going further and further out. But they [the loops] come in like this [pointing to the middle of Figure 14], and it's very narrow in between the two. We call that pinching. That's why the concrete column failures look so similar. Because it's this effect. Just imagine you keep grinding the concrete away until you have nothing but the reinforcing bars, which are bulging out. The rod-bracing hysteresis curve is similar to the pinched curve (Figure 14), but has more straight lines.

Concrete Failures

Degenkolb: We saw the Alta Mira Building down in Venezuela. You can see the concrete column reinforcing steel. You lose the concrete in one direction or the other. [Degenkolb refers to Figure 67 in his report on the Venezuela earthquake[60]]. Generally, it's very typical—a typical earthquake [refers to Figures 88, 89, 90 in same report]. It started with the X-cracks and movement back and forth. It keeps grinding until eventually the concrete comes out in powder. Just the reinforcing bar is left. Karl [Steinbrugge] and I used to kid about writing a paper for the seismological *Bulletin* [*Bulletin of the Seismological Society of America*] with nothing but pictures of concrete columns that failed, and have readers guess which earthquake caused the damage. You could interchange the pictures taken in 1925, 1933, 1967, San Fernando, Coalinga. We have them in every earthquake, in San Fernando there were lots of these [concrete column failures].

Containing Concrete Columns

Scott: In terms of what has been learned from this experience with concrete columns, what are the solutions?

Degenkolb: If concrete is contained with very tight spirals (or the equivalent in rectangular sections), it can take very large deformations and has large ductilities. The best example of that is the Olive View Hospital. The big rectangular tied columns underwent essentially the same deformation as the circular columns. The circular columns were still holding the load, although they moved two feet in the earthquake. But the tied columns, the rectangular ones that had the 3/8" bar ties at 18" centers, didn't contain the concrete, and all you have left is a bunch of gravel. That's all in the one building—it's the perfect example.

Scott: The circular columns are wrapped in some fashion?

Degenkolb: Yes. It's a helix. It's something like a piece of 6" or 12" diameter steel pipe that is filled with sand, and then you put a load on it. It would carry a substantial load, as the pipe is containing the sand (Figure 16).

It's the same thing if we take an unreinforced 6" or 12" concrete cylinder, and it fails. But take that same concrete cylinder and wrap it tightly, and it can take a much greater load, 40%-50% greater, until these things burst or break. In addition to this, when you put bending on it, if it is wrapped tightly, that contains the concrete. It supports the reinforcing bars so they don't buckle, and these can take large deformations without failure. This bursting effect is a matter of fact—I was surprised at the Macuto Sheraton Hotel in Venezuela—the biggest failures that I saw at first were these columns. These are columns that are 1.1 meter in diameter [refers again to the Venezuela earthquake report, Figure 22[61]]. Fantastically big columns, well-designed. There are 1/2" bars at 6" centers—one of those was broken in tension. I have a close-up showing where this containment effect had been so stressed that one of the bars pulled apart. But if you have sufficient containment, which depends mostly on the size of the column and the stress in the concrete, you can get a very ductile member, meaning it can deform a lot without failing.

Scott: Now what would enhance that? If you had been designing for this, what would you have done differently with this column?

60. Hanson, Robert D. and Henry J. Degenkolb, *Venezuela Earthquake, July 29, 1967*. American Iron and Steel Institute, New York, 1969.

61. Hansen, Robert and Henry J. Degenkolb, *The Venezuela Earthquake, July 29, 1967*. American Iron and Steel Insitute, New York, 1969.

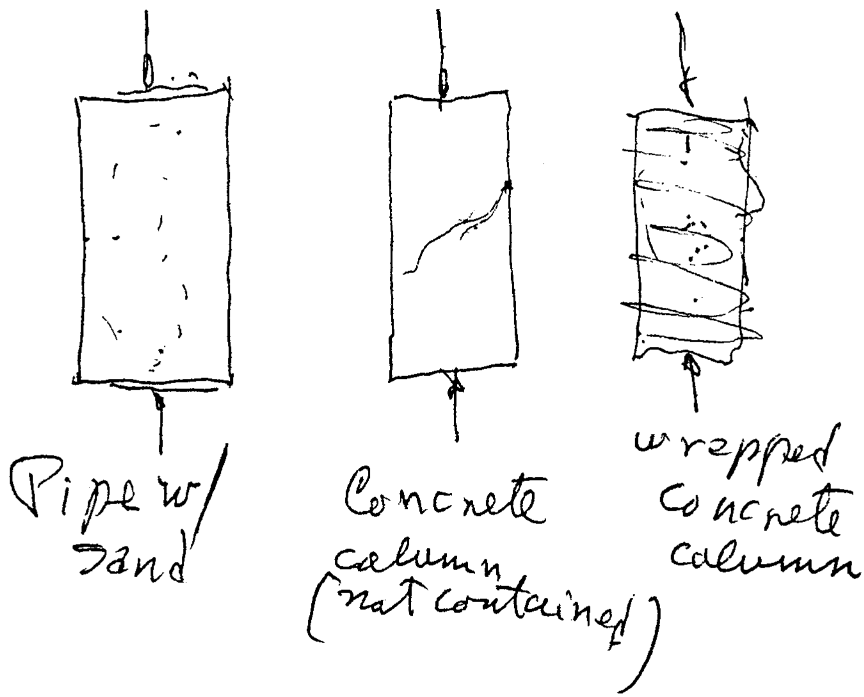


Figure 16

Degenkolb: Nothing with the column. Actually what you have is a rather complicated building with two partial shear walls.

Scott: You would have designed the building somewhat differently to avoid putting that extreme stress on those columns?

Degenkolb: Yes. Although the building did perform well—no one was killed in the building. Two were killed outside. You've got shear walls in the bay from here to here, and here to here, coming all the way down and then changing at this level [refers to Figure 209 in same report], so what you had was—sideways you had a vertical beam tending to bend, putting tremendous overturning stresses on these columns, the circular columns at the bottom (bottom two or three floors). As a matter of fact, we had gone to each one of these columns in the north or south side to see which was the worst. The interior columns were always worse than the exterior columns, although all of them had damage.

To me, it was caused by the rocking of this with large overturning forces. If there were something between, or even if this had not been a shear wall (although I would have had shear walls), you wouldn't have had those large overturning forces. With the offset shear wall on the Imperial County Services Building—you had this big shear wall at the end of the building and it rested on the four columns. Since then we changed the code so that any column of this nature has to be reinforced for a heavier load, and has to have the details of a ductile column regardless.

Scott: But if you'd been doing the whole thing, you would have preferred to do some redesign of the building itself.

Degenkolb: This was done by Paul Lustgarden, the chief engineer for public works [in Venezuela]. And it is a good design. At the time it was designed—until we saw what happened in the earthquake—nobody would find any fault with this building, the Macuto Sheraton Hotel [still referring to the book on the Venezuela earthquake].

This gets into the philosophy of design. We try to make our buildings stiff, with a backup system of a frame, so that there is the combination of stiffness and toughness. The stiffness has a big effect on the contents, and especially the exterior clothing. In that regard Marcy Wang, over in the Cal architecture department, did the studies on the clothing of the steel building that we tested in Tsukuba.[62] She used several variations of different common details that are used for fastening precast elements on buildings—all the stuff you can see—and the results were pretty bad.

Connections for Exterior Walls

Scott: The precast elements—you mean the outside walls?

62. Wang, Marcy L, *Nonstructural Element Test Phase: US-Japan Cooperative Research Project on a Full Scale Test Frame.* University of California at Berkeley, Center for Environmental Design Research, Berkeley, CA, 1986.

Degenkolb: Yes, curtain walls. They look like concrete, or stone sometimes. They're generally panels that are around 5" thick, some people go as low as 4" thick. If it's got a lot of ornate stuff on the face, maybe 6" or so, but generally they're around 5" thick, reinforced, with inserts that the code calls for, and hung around steel.

They [the curtain walls] are fastened and hung on the frame like a picture hanging—a sophisticated picture hanging. The code calls for those connections to remain coherent at certain drift deflection levels—they should be tough. The tests in Tsukuba showed that many of the common connections were not tough. In realistic earthquakes, the connections would have permitted the panels of these moment frame buildings to come off the buildings. They would have fallen off into the streets.

I used to say San Francisco had the toughest ordinance. I always used to say, and I still believe, that if the buildings are done intelligently, and some are, the stuff will not fall into the street. But after seeing her [Marcy L. Wang's] tests and looking at certain details actually used in buildings in the last couple of years, I'm not as confident as I used to be. However, I always said that some would fail.

Scott: You mean it's difficult to hang those things on in a way that gives some real resistance?

Degenkolb: So they can deform, bend around, let the floors move a couple of inches, and still hang there without falling off. I don't think it's really difficult to do it properly, but it's probably expensive. I don't think I have any concerns about any of the buildings that we do (or some of my compatriots), because we've always taken very special care with them. I know that Brunnier spent a whole lot of time on those connections for the Bank of America.

Scott: You mean the Bank of America Building here, in San Francisco—the one that just changed hands?

Degenkolb: Yes. I know that some of the engineers are very conscientious and have spent a lot time to devise connections that are truly ductile and that will hang on properly. And when it is done properly, I think it will hang on all right. But I see an awful lot of this going up recently, and I do not have that same confidence in all of it.

Scott: In other words, the know-how exists, but the need is not understood or not accepted all around. And it's expensive.

Degenkolb: It costs more. And we've weakened our code. It used to be that San Francisco had the toughest code, which was used for years by the Uniform Building Code for the appurtenances that hang onto the frame, such as curtain walls, the precast concrete, and all that. Then last year, when we had the San Francisco building code up for discussion and modernizing, the supervisors elected to use the '79 UBC instead of the building code that the engineers had written. Without knowing it, they weakened the requirements for the curtain walls. A few years before that there had been complaints [from southern California engineers] that the requirements in the Uniform Building Code were very restrictive, very difficult—the connection had to be tough, the anchors had to be anchored around the reinforcing steel, so in case something broke the panel would still be anchored. So the UBC got changed.

At the time we didn't change our San Francisco code. Then last year, in changing to the '79 Uniform Code, our connection requirements were weakened.

Scott: That wasn't done deliberately, it was just an unintended effect?

Degenkolb: Right.

Side Effects: Jammed Doors

Degenkolb: It's a philosophy of moment frame, compared to the dual system, and the effect the flexible moment frame has on contents, on the clothing of the building, and on what's in the streets. One of the effects—which Karl and I have mentioned a few times and I've never heard from anyone else—on the Banco Central [Managua earthquake of 1972] the deformation of the building was such—on the flexible building—that the doors jammed. You could not open the doors to the stairs. That would be a real problem in case of evacuation or something like that. The elevators obviously will not work. You have to use the stairs, and if you can't get into the stair tower, you've got a problem.

Scott: You're stranded, floor-by-floor.

Degenkolb: Right. That's one reason why I got a couple of crowbars at the hardware store and we keep them here at the office. It's one of the things you don't think of. But can you get to the stairs? There were a lot of stairs at the Banco de Central that we couldn't get at—we had to approach them from other floors. There are little things like that.

Scott: I notice that Frank McClure mentions falling glass—glass and other falling hazards. You might say a word or two about glass.

Performance of Glass

Degenkolb: Glass is not an engineering material in the sense that is has a nice reliable strength. Because of its brittleness, it is very subject to variations in detail and workmanship. If they install the glass properly, with the rubber gaskets around, it can take a tremendous beating because the squashing load is absorbed through the rubber gasket (something flexible), and it has performed well. There have been failures in windstorms—not from things hitting the glass but from the deflections—and they find out that there is a little bump left on the edge due to the workmanship, so that the squashing load instead of coming evenly onto the glass, hits one corner or something and starts exploding.

When you have a material, a lot of it, the properties vary—it's just inevitable that you are going to get some variations in workmanship and you're going to have some glass in the streets. And you may have a lot. Again, if it's designed properly, there are certain buildings that I think will have practically no glass damage. Then there are other buildings. I remember there were some tests run on Embarcadero One because those precast panels are two stories high. They have these slit windows. They were put in a testing machine and were able to deform, to my recollection, a couple of inches and the glass stayed in perfectly. It was well-installed. They should have no problem. Between the give in the glass and the panels and the connections, they should be in good shape. But, on the other hand, you can't always be accurate. If you have several thousand panes of glass, some of it is going to go.

Scott: Even with the very best of efforts, at least a little is going to go?

Degenkolb: Right. On some of these buildings, I think a lot of it will go, because they didn't take that much care with the design and installation. As a matter of fact, I'd be worried more about being out in the streets even more than with a brick building.

Scott: You mean worried more about the hazard of falling glass in the street?

Degenkolb: Yes. I'd hate to walk through Chinatown when you look at all the brick and wires and everything else, and you know how it's built. You never think of that too much with the new buildings here in downtown. But with some of these buildings, there's no question in my mind that we will have a lot of glass there, after an earthquake. A piece of glass falling from 15-20 stories is quite a lethal weapon.

Chapter 9

Engineering Judgment

"It's a never-ending problem about code design vs. state-of-the-art design.... It's complicated in that the state-of-the-art varies with who perceives it."

Scott: Would you explain your emphasis on the critical importance in earthquake design of good engineering judgment. In your opinion, the codes alone are not sufficient to ensure earthquake safety?

Degenkolb: No, they're not. One central reason is that engineering, especially earthquake engineering, is a learned profession, as much as medicine, or law, or theology, or even teaching. You could not, for example, write a code of medical practice that gave every detail and would govern everything a doctor does.

There are several reasons why. As the state-of-the-art advances, there's so much background and knowledge required. You need a specialty education for it. Another reason is that the code is generally 10 years in the making. With ATC 3, we've already been at it 8 years or so [at the time of this interview in October, 1985]. It's already out of date. A third reason is that we're a democracy—quite a few engineers could write a much better code, but it will not be an effective law if it can't be enforced because at least a majority of the people that use it don't believe in it. It still represents a consensus, even if things in it are inadequate or wrong, in my or someone else's opinion. The code used to be a consensus of what the experts thought. Now it's not only the experts, but also the people affected: such as real estate interests, or the people who enforce it.

Differences Among Experts

Scott: Why are current state-of-the-art engineering practice and judgment also essential for good results in seismic resistance?

Degenkolb: This gets down to the code being always 10 years or so behind, and right now liability is a major thing if you do something a little different from the code. Generally you try to use the code as a floor—so that you're clear in terms of liability—but you can get into situations of making one member too strong, per the code. One example is Vit Bertero's, he keeps bringing up the requirement of the code as far as overturning on shear walls. We want it to fail in moment and not in shear. By following the code realistically, we're getting a poorer building than if you weaken certain parts of it so that you get failures where you want them.

Scott: To get failures where they do less harm?

Degenkolb: Yes. It's a never-ending problem about code design vs. state-of-the-art design. Part of it is that state-of-the-art hasn't been agreed on, and to get something in the code you have to get it agreed on. To get something in the code, you need agreement of at least a majority of the engineers. That may be different from the state-of-the-art.

It's complicated in that the state-of-the-art varies with who perceives it. If my background was all in concrete, and I'd been working with it for many years and everything has been fine, why should I change? The same thing goes for steel, goes for masonry, goes for wood, because in state-of-the-art practice there are going to be big differences of opinion between the experts, depending on their background, their closeness to the research. There's a hell of a lot of research in materials going on.

Scott: It's the same thing in any profession. You think of the medical profession. Certain kinds of operations are being performed in certain ways and then other groups are doing the same thing in different ways, saying they don't need to do it the old-fashioned way. Two different practices will be followed, and one group will say, "We've got to do this," and the other will say, "No, you don't need to." And that will go on for several years.

Degenkolb: At least in medicine or law you see the results fairly quickly. In individual practices you can see what happens to a patient in a short time. Buildings may go for up to 50 years or more without being tested, which is one of the big reasons why I think it's so important that engineers and architects, or anybody that's involved, go to see what actual earthquakes have done. That's why we chase earthquakes, and why we're pushing so much for other engineers to look at the effects of earthquakes.

Scott: You mean those observations feed right into the state-of-the-art?

Degenkolb: That's right. Then they can see what's going on.

Independent Review for Major Structures

Scott: Are there any realistic forms of protection we could build into the system?

Degenkolb: A code should be the best code you can write—up-to-date and with a reasonable balance between economy and safety. And then the other biggest thing is independent review.

Scott: At least for major structures?

Degenkolb: I believe for any major structure. I would get independent review certainly for anything down to around 3 stories or so, but maybe not to include timber four-plexes. Or call for independent review if the occupant load means that collapse or poor performance could affect substantial numbers of people. Whatever the exact line is.

Scott: Would you include the typical condo?

Degenkolb: Oh yes, they would definitely be independently reviewed, because a lot of people are involved.

Scott: I've heard the following argument raised, and do not know how to evaluate it. The allegation is that independent review at this level, considering the amount of building in California, would cause so much work that there wouldn't be enough good, well-qualified engineers to do the independent reviews. How would you evaluate that argument?

Degenkolb: I would say there might be a shortage of engineers, but that's another problem. I don't think there is now. In certain fields, of course, like computers, there are shortages.

But if you let that argument win, then you're never going to do anything. Supposedly we have local building departments that are doing independent checks now. They are not, however, being done very efficiently. There is not enough money being put into the checking to do it efficiently.

Local Code Enforcement: Legalistic and Not Very Efficient

Scott: You mean that even the good local building departments are maybe not all that effective?

Degenkolb: That's right. Some of them are effective, but the effort is spread too thin. Also if you stay in that business, you get into a very legalistic attitude: this is what the code says, and you must do it and nothing else. If it isn't prohibited, you can do it. Some, a very, very few checkers, might go further. Probably the State Architect with schools and hospitals tends to go further, or will bring up other points, but the vast majority of building officials and checkers see the code as an ordinance, and it's a matter of enforcing the ordinance—for example, 56 miles per hour is dangerous, but 55 is all right.

Engineering isn't that precise, but I can see the attitude developing in friends of mine over the years. Even building departments are now subject to liability laws. Errors, omissions and all this. And I can understand the pressures to stay exactly with the law, and nothing else.

I can even see it in myself. I'm a long-term member of the Board of Examiners—that's the appeals board here in San Francisco, and I know when I first came on—a lot of years ago, I said to myself "I'm an engineer, supposed to think and make judgments regardless of what the code says."

San Francisco Appeals Board Experience

Degenkolb: I was active in the '55 San Francisco code because of things that happened in '48 [passage of the Vensano code]. And one of the important points is to have a strong appeals board. I've always felt that one man should not make the basic decisions, but that it should be a group of experts. So in the '55 code, five people were appointed [to the Board of Examiners]—a structural engineer, an electrical engineer, an architect, a mechanical engineer, a contractor, whatever. The San Francisco charter says a city employee has to live in the city. Well one guy lived in the city—but everybody else lived in the East Bay, or Marin County, and commuted, although they all have offices here. The board members served for about a year, when somebody caught up with it. So they all had to get off. Then the associations nominated me.

I've been on ever since, and I've seen my own attitude change. For example, a common construction in San Francisco is a garage underneath and an apartment house (4-6 apts.) above. The parking garage on the ground floor must have a fire separation from the living units above. This can be done in several ways—sprinklers, one-hour ceiling and penetration for ducts, plumbing, and all that. If someone wants to provide the protection in a slightly different way, no matter how logical the request, if you give an exception to that one guy, because it's reasonable in his case, within two months there will be six other guys coming in with almost the same requests—but everyone will be just a little further off. Finally, you get down to the point where there is not a gray area between safety and economy—it's a black line. On this side it's ok, but not on the other. I see in myself over the years, how your attitudes change. Eventually, you are sticking exactly to that line, with no variation.

When I was first on the board—I was chairman for many years—we were in a cycle where sheetrock was coming in. Every manufacturer was coming in, and everybody had a slightly different way of doing things to gain their two-hour wall or their one-hour wall. There's a vast gap between the real good ones and the real bad ones. Where do you draw the line in-between?

Instead of being a two-hour wall, say it lasted one hour and 59 1/2 minutes, and then the temperature got a little higher so it didn't quite meet the fire resistance test. A half minute isn't really that important, and it involves only one spot in a big wall. It isn't that black and white. What happens is the sheetrock—the nails that hold it brand into the wall, and probably 2 seconds after the two hours the whole wall will come in. It would fall off the studs, if you've ever watched a fire test. So we had additional criteria that we never really accepted, and that industry fought against, requiring that no more than a certain percentage of the stuff could fall off. But it gets very, very difficult to enforce this on just fire. We just had a reversal on some attitudes, because of the supervisors adopting the Uniform Code, instead of the San Francisco code.

For the first time since 1955, last fall [1983] when the San Francisco Chamber of Commerce code committee went up to the Board of Supervisors, we lost 6-5. They went for the new Uniform Building Code—instead of ATC 3-06, which we had adapted for San Francisco—under political pressure by the contractors on a couple of the supervisors. The Uniform Building Code has weakened requirements on attachments of curtain walls, precast walls on the outside of the building. By adopting the new Uniform Building Code, we [the City of San Francisco] will be reducing our requirements for attachment of curtain walls, and of precast elements, on the outside of a building. Reducing them, I think, to a dangerous level.

Just face it, we can't do structural things in earthquake country that they can do in Chicago. It is more expensive to make a ductile connection that can absorb movement and still hang together without falling off. Whereas, in the midwest and east, they can do welded connections that are pretty brittle, and the contention some years ago from down south [southern California] was that we [in northern California] have overkill. Again, I think that's a matter of opinion on our precast, but at least till just last fall, San Francisco had always taken the engineers' word. Since 1955 at least, San Francisco has accepted what the engineers said almost without question.

We may argue with the building department, but the building department staff are engineers, and we can argue on a technical level. For enforcement reasons, they may prefer things one way or another. I'll call that an intelligent argument, without political pressures. But when it gets to the supervisors, in this case we [structural engineers] and the building department both lost.

I was on the ASCE-SEAONC ad hoc committee. As a matter of fact, I appeared before a supervisor's committee, then I went to Europe, so I did not attend one of the key meetings. But I wrote a position paper for the San Francisco Chamber of Commerce, which then later the structural engineers adopted and sent to the supervisors. And we even got concurrence from the concrete industry. We got concurrence from everybody—building owners and managers, real estate people, everybody except the contractors. They have a bug about uniformity, and they had enough political pressure with a couple of the supervisors, and it's hard to argue that the newest Uniform Building Code '82 is not the latest thing.

Scott: By definition it's supposed to be the latest thing.

Degenkolb: They argued that the '82 UBC is '82, whereas ATC 3-06 is seven years old. If it's not good enough for the rest of the state, why should we do it here? So we lost that one. So certain things we believed were okay are now no longer considered okay.

Both Stricter and More Lenient

Scott: You mean now, here in San Francisco, in some ways things are stricter than they need be? Is that what you're saying?

Degenkolb: I'm saying that we're different. In certain things we're stricter, and on certain things we are more lenient.

Scott: More lenient on what points?

Degenkolb: Some of the more lenient things? Typically we allow one extra floor of wood construction, one more than the Uniform Code, and considering the quality of our fire department, and the compactness of the city, I think it's pretty good. But the supervisors did not understand that.

At the next Board [of Examiners] meeting we're going to have several requests for exceptions. They want to go by the old code and get one more floor of wood construction without sprinkling the entire building. If they had filed six days earlier they could have done that, but they filed six days too late. I don't know what's going to happen. But that's the challenge of following the code exactly.

Coming back to the condos—with that attitude, as long as I meet the letter of the code, forget the intent and everything else. As long as the words of the code are complied with, it's okay—even if the results won't stand up.

Scott: Following the words of the code and the letter of the law.

Degenkolb: That's right. And it's not helped by the possible liability of the building official, and the detailed requirements of the code.

Scott: Not helped?

Degenkolb: Not helped. Take for example an equipment building—this is something we have been involved with over the years—the telephone company buildings, equipment buildings. You'll always have a cable vault, where the underground cables come in, and then they go up the building, through cable slots, and some of these are 15-16-17 stories, though most of them are 3-4-5-story buildings. So they come under the requirements for fire sprinklers.

We did most of the buildings from Bakersfield to the Oregon border, up through the '50s or so, during the big [Pacific Telephone & Telegraph (PT&T)] expansion after the war. When we were doing most of these jobs, we always fought against sprinklers in the cable vault, because the water would do more harm than good to the electrical contents. Life safety was not involved.

With the creation of the districts, we've [H.J. Degenkolb Associates] lost a lot of that work. Except that when they get into trouble, we go all over the place for them. Anyway, I kept getting notices that they [PT&T] have been accepting sprinklers in the cable vaults, because that is what the code requires. Well, we never intended that. So between the liability of the building official, and a specific code requirement, you have a loss of judgment there. If they want to put on a Halon system that doesn't affect electrical, that's fine. I don't care about that. The sprinklers, however, are bad in this case, and you have to get an exception to the code to put in a Halon system instead of sprinklers.

Scott: What is the Halon system?

Degenkolb: Oh, that's a gas—it's an automatic thing—it's a gas that will smother the fire. It is very efficient and also quite expensive. But in a case like this, cost doesn't matter.

Scott: It doesn't damage the cables the way that water does?

Degenkolb: No, it doesn't. That's the advantage, the key thing. It used to be that the equipment in a phone company building would be worth five, six times the cost of the building. Then when they got the ESS [electronic switching system] equipment, the solid state, the cost of the equipment rose to maybe a hundred times the cost of the building. And in evaluating old buildings, our policy sort of changed 10-15 years ago. It used to be that if a building stood up without harm to the occupants or equipment, that was sufficient. Now, with the contents so much more valuable, the required standards are higher. And a few people have become conscious of the value of what was going to be put in the building—which may be 100 times the value of the building. We, along with some of the telephone company engineers, said "You don't pack a jewel in a cardboard box." When the cost is that much out of line, we had better put up a damn good building.

Judgment and Independent Review

Scott: Is there some feasible combination of complying with the code language *and* of independent review?

Degenkolb: That is one of the reasons I believe in independent review. When we do a review—as we often do—we can say that a project meets the code, but not the intent of the law, or that the experience of previous earthquakes—and one example is tilt-up buildings—is such that even though the design meets the letter of the law, we consider it no good and it shouldn't be used. Independent review can give such judgments where the usual building official can't. Some, however, stick their necks out. Some building officials do a damn good job.

Scott: This is a question of giving more protection than the code provides.

Degenkolb: That's right.

Scott: Independent reviewers would tend to give more protection than the code where judgment or experience seem to call for it, or to be a bit lenient in situations where strict enforcement of the letter of the code does not seem essential?

Degenkolb: That's right. If you, as a building official, make a mistake and are going to be sued, you're one guy who is making a decision, and you're a city employee and very vulnerable. But if you pass it on to the so-called board of experts—there are five of them [on the San Francisco Board of Examiners]—they can make a decision, and override you or whatever, but you've got some real protection. You can still be sued and all that, but they've got a much tougher job to prove that you were biased.

Scott: You have a much better defense if you've got the backup of the board members.

Degenkolb: That's especially true if you have independent review by—let's say it's a quick review by two or three people, which is quite often—no, not quite often, but at least occasionally done on very important projects.

Scott: A quick review, you say?

Degenkolb: Not a review by one person or one office, but maybe by two or three offices. When we remodeled the Flood Building—we did it for Woolworth, way back when—the owner then had another office to review our work, because he was the owner, and Woolworth was just a lessee. Henry Brunnier's office did the review. Ed Zacher is from that office, and Charlie de Maria and Herb Lyell. In a review like this, they can discuss points with you: "Maybe this wasn't the best decision," or "You could spend a little more money here and do this," or "We really don't care about this." You work together with the reviewers. I think that type of review greatly improves design decisions. It brings the design questions back to engineering, instead of just a matter of reading the code.

Scott: So there's some interchange between the original design engineers and the ones doing the independent review? A kind of constructive discussion goes on.

Degenkolb: That's right. We have that quite often. We review buildings for different clients—some of them back east, or in the midwest. Sometimes these reviews are of the drawings, before the project is built, or of the building before it's finished. Because of the financing—the money may be from out of the country—the Bank of America is really acting for the clients. The State Employees' Association is another group that requires an independent review for their pension investments. Some of these are big deals. Generally, or almost invariably, the design engineer is very glad to get a review.

Of course there are some engineers who don't want it, I'll grant you that. They don't want anyone looking over their shoulders. I guess most young engineers are like that—I was. But as you get older you see things and....

Scott: You learn how to accept criticism.

Degenkolb: You also learn the value of it—I think that's more important than acceptance. You learn the value of it. You have someone else's opinion, and on important projects, especially, it's worth it.

Scott: The kind of independent review you've just talked about with a firm, or two or three, looking over plans and discussing them with the original engineering firm—how would you compare and contrast that with the kind of independent review that, say a local board of examiners gives?

The Designer Mentality vs. the Checker Mentality

Degenkolb: The S.F. Board of Examiners really does not get into that kind of detail. When an exception is requested, or a denial is appealed, or approval of a new material being asked, the review is done only for that one point. A true independent review is what the state does on public schools and hospitals. A very thorough review. Some building departments will send out plans for outside review—when they don't have the expertise in the office. Generally, that type of review is more valuable than one by someone who reviews plans all the time. An engineer whose primary job is not reviewing still has the engineering attitude.

Scott: He has his own practice—is that what you are saying?

Degenkolb: That's right, he has his own practice.

Scott: He or his firm does drawings, makes the calculations, conducts field site inspections. Whereas the other guy tends more just to review plans that others do?

Degenkolb: That's right. It results in a different attitude. When you are always a plan checker you have one point of view. If you are both a checker and a designer there's less tendency to be so legalistic, because you see both sides of the fence. Some of the best reviews of our drawings have been of the second type, where the guy has done a thorough job of going over our drawings, looking at them the way a designer looks at drawings.

Scott: The designer mentality vs. the checker mentality.

Degenkolb: Yes, that's what I'm saying. I'm not sure how important it is, but anyway it's something I feel.

Field Act Administration

Scott: The attitude difference sounds like it could be important. But the administration of the Field Act, almost by definition, is checking. It would take a radical change in the whole system for it to be different.

Degenkolb: I wouldn't change that, because it's working pretty well. You have a history there. When it was first set up, practically every checker had been a designer, so you had an engineering point of view. That lasted for 20–25 years I would guess. We admittedly have had problems with the state getting into the checking attitude. But first of all the design background has helped, and second, working with organizations that have watchdog committees. And they've also generally been fortunate in their top management—Fred Cheeseborough, Don Jephcott. Considering everything, I think we've been very fortunate.

There are some things that perhaps should be changed but they're comparatively minor. As long as the system is working, I wouldn't screw around with it. It's a statewide organization, as compared to an individual jurisdiction like S.F., L.A., San Diego or Sacramento. There are schools and hospitals being checked all over the state. ASCE, and the structurals, especially, have worked very closely with them. If there are many complaints coming in about too much checking or bad interpretations, there will be a committee operating on that. There will be meetings and fights and everything else. I've been in a few of them myself in years past. So there is something of a self-regulating, self-checking system.

Scott: Is this built into the Field Act administration partly because some pretty good people started it?

Degenkolb: That's what I think. It's a tradition. As one example, there's no appeal board on the structural safety section, instead there is an advisory committee of the State Architect. As a matter of fact, Loring Wyllie is on it, and I think we have a meeting tomorrow. I know of only one case over all the years where the advisory committee's recommendation was not followed. There may have been others but.... While it has no force of law—it's only an advisory committee, not an appeal board—but in effect, the State Architect just swallowed and accepted its [the advisory committee's] recommendations.

The case that I know of where they did not accept the advisory committee recommendations was on the brick schools in L.A., back whenever it was, probably 20 years or more ago. They were supposed to bring up the schools to safety, and L.A. had all these unsafe brick schools. They were considering all kinds of ways of trying to rehabilitate them without ruining them, so the investment was fantastic. There were tests run and all that, and there was a lot of pressure on the state that they should accept them, but they didn't. There was a big fight about that.

Scott: The State Architect did not accept the brick schools. Just because they were brick?

Degenkolb: No. The tests were not very intelligent. They were political tests, more than anything else. I think the State Architect was right in this case. They wouldn't have been safe for use as schools, and that is the intent of the law. But it took a lot of guts for the State Architect's people to fight the profession on that. That's what it really boiled down to.

The Los Angeles Hazardous Building Ordinance

Degenkolb: We've come such a long way from when I started out that it's hard to think of going much further, frankly. There's a long ways to go yet, but things are an awful lot better than they used to be. Right now, I think one of our biggest weaknesses—and I have mixed feelings about that also—is in the research and the knowledge of the engineers.

For example, while the L.A. hazardous building ordinance[63] may have been a very brave step, I have a lot of doubts in my mind as to its real effectiveness, if they get a big earthquake. Some of the engineering attitudes, the popular ones, I believe are wrong.

Scott: You're talking about the L.A. city hazardous buildings ordinance?

Degenkolb: Yes. Statistically, they will have certainly done a lot of good. They will improve a lot of marginal buildings. It's the same as the parapet ordinance. I've always had mixed feelings about that. Statistically, by doing something on all parapets, you're going to reduce some numbers of deaths and injuries. But I'm concerned about the building that is brought up to the hazardous buildings code [like that in Los Angeles] (which is less than current code), or in which some mistakes are made, or whatever, and the parapet still falls down. Some are certainly are going fall, even though they've been fixed up. It's inevitable. In certain situations like that you don't know what's good or bad, all you do is the best you can.

Scott: Well, let me ask about the hazardous buildings ordinance itself, rather than the parapets per se. Are you concerned that some of those structures might collapse, even though fixed up under that ordinance?

Degenkolb: In order to make the ordinance palatable, they watered it way down so that you didn't have to do very much. In order to get something done that is good, I just hope it wasn't watered down too much. A few of the

63. The Los Angeles hazardous building ordinance (Chapter 88, Earthquake Hazard Reduction in Existing Buildings) established minimum standards for seismic performance for unreinforced masonry buildings, procedures for their identification, and a schedule by which they must be seismically upgraded.

engineers pushed that program very hard. I have a very high respect for them and their attitudes, and if they do the fixing up, I'm sure it will be a good job.

There are a couple of others [engineers] that are very well known and very vocal that I have very little respect for. And if they do it, they're going to do it by the book and I don't anticipate the outcome. It gets down to the engineers' training and traditions. We were trained to think in terms of loads and stresses, and known loads of some factor. When you're dealing with earthquake forces, all of a sudden those standards are shot. Instead you have to deal in deformations and dynamic processes.

Scott: In other words engineers are trained to deal with vertical loads.

Degenkolb: And even in wind, we're dealing with a known load. You can design—there are unusual situations where that's not true—but with an average house, average building, even the average large office building, you're dealing with the maximum wind you can get—100 mph or 200 mph or whatever it is, and you can design for that. With earthquakes, the stronger you make a structure, the more load it's going to see, so strength is not the only factor, instead it's the ductility, it's the toughness, the stability.

By making it stronger, in some cases you're making it more hazardous. And even for some of our California engineers, this whole concept is different from our training. A full bookshelf weighs so many pounds, or a floor does, and you can always design for that. But an earthquake's different. As to the ability of some engineers to think in those terms, I'm skeptical about it from past experience. We've checked buildings, we've checked some drawings and designs, and I can see the old habits coming through—"Well, it's strong enough." They're designing something for strength and not for ductility. It's the way we were all trained.

Scott: Let me ask a question or two more about the L.A. ordinance. The idea of the ordinance and of building rehabilitation is one of the things the SSC [Seismic Safety Commission] is pushing for adoption by as many jurisdictions as possible. And yet you're saying that those codes, such as the L.A. ordinance, have to be watered down at least to some extent. Of course that's the basic theory of the rehabilitation ordinance: to have something below the current full code. But maybe the code requirements get dropped down too far. Then when some of the engineers who are not that alert to seismic safety requirements do the design for the rehabilitation of one of the hazardous buildings, you can still wind up with a building that's hazardous to life. Is that the case?

Degenkolb: That is right. I'm concerned about what the public's reaction will be after an earthquake. "I've had my building reinforced," and they think it's earthquake-proof now. Then something happens.

Judgment

Scott: They'll think: "We've been betrayed!"

Degenkolb: That's exactly it. Or we get complacent about it. Coupled with the code as it is, or any common professional ethic, if you're reinforcing a building, you'll do it to the extent necessary. But there's a big feeling among structurals, that as long as they can meet the minimum standards of the code, they'll do it as cheaply as possible, regardless of anything else. Instead of considering the likely effects of a failure and asking whether they should go a little beyond the code because of other possible weaknesses.

Scott: That would be using judgment?

Degenkolb: Using judgment in a beneficial way. We just did interviews, in connection with an ATC program [ATC 13], and I was rather shocked that the majority of the engineers consider that if they have to reinforce a building they would take it just up to the minimum code and nothing else. That's all the law requires. Doing only that, even when they see an obvious weakness that you can recognize, I have trouble with that.

Scott: Tell me about the survey.

Degenkolb: I don't know the results. One of the things that we [several members of the Degenkolb firm] are doing is a research project for ATC [ATC 13]. Part of it was to determine the actual state of the practice. So they made up a questionnaire, which they sent out to I don't know how many engineers, and they interviewed some. Just in conversation with one of the fellows that did it [the interviewing], they're saying that out of 10 or 15 there are only two engineers who did it like we did. Six would do it just to the bare minimum of the code, regardless. A few others would look at a little bit of the consequences of failure, and do what they thought necessary. There were different shades of it, and I was surprised that in California a high percentage would be satisfied with the bare minimum of the code.

Scott: That fraction was much too large?

Degenkolb: It surprised me how large it was. I don't know who was involved or who they asked or anything else.

Scott: Is going to be published? If so, where?

Degenkolb: It will be published. ATC will publish it.[64] I don't know when. Sometime next year I would guess.

Scott: Was this with respect to any code, or specifically a Los Angeles-type code?

Degenkolb: No, this was *any* code. It related to the state of the practice in designing for earthquakes for the rehabilitation of buildings. Some of the stuff related to how far do you go in leaving a building alone. There are a lot of buildings which, while they wouldn't strictly meet the code, have an inherent strength that you don't measure by a code, and probably you do more harm than good by trying to fix them. It gets all mixed up in some of these matters. It isn't something that you can quantify very well, and I've been stewing about it some, especially since Chris Poland mentioned the matter to me.

If Explained to Owners Properly

Degenkolb: But what really bothered me was the number or the percentage of the group that would do the minimum—and without much thought, I would say. In a sense, of course, that is what most owners want. Although I think if it's put to them properly, most owners would rather spend a $100 and

64. *ATC-13: Earthquake Damage Evaluation for California.* Applied Technology Council, Redwood City, CA, 1985.

get a halfway decent job than spend $50 and not get anything.

Scott: Or get something that meets the code but is still unsafe?

Degenkolb: I've generally found that if you can explain it to them, the majority of owners will try to do something positive and productive, rather than just try to evade things.

Scott: Who would explain it to them? Presumably it would be the engineers working with them.

Degenkolb: This is one of our biggest problems in working for architects. If we can deal directly with the prime client, we generally don't have much trouble. But if we have to explain our concerns to the architect, and have the architect then explain them to the client, most of the time it will not get over. It's filtered. The information doesn't get to the client, so the client wants the bare minimum, and that's all that's done.

Hazards in Newer Structures

Scott: Talking about hazardous buildings ordinances, like the L.A. ordinance, brings up another matter the [Seismic Safety] Commission is going to be pushing—that is, Tom Wosser's subcommittee report, which is in the mill and will come out soon.[65] It's been hung up in the Commission's word processor backlog. As you know, basically it is a critique of present buildings, of newer types of buildings.

65. Seismic Safety Commission, *Earthquake Safety: Potentially Hazardous Buildings*. Sacramento, CA, November 1985.

Degenkolb: That's another fact—there's been so much emphasis on the unreinforced brick—many of which performed very well in past earthquakes *if* they were properly built. Because of the emphasis on unreinforced masonry, we lose sight of the types of buildings [nonductile reinforced concrete frames, soft stories, pre-cast concrete and tilt-ups, irregular plans] we saw in Mexico City on television. Many of them are being built now—relatively new, or brand new.

Some of the newest buildings are the worst. We [H.J. Degenkolb Associates] have just been reviewing one. One of the Bay Area cities has hired us, and there is a 17-story building done by a reasonably good office, and I'm a little perturbed by some of the practices that I know are common, or even better-than-average, that have been used in this building.

They're considered structural engineers, so they do *only* the structural engineering. They're not interested in partitions. Their fee doesn't cover the partitions, exterior clothing, a lot of the other stuff. Competition means that you have to do things cheaper, which means you spend less time and confine your work to certain essentials, and do not look at other things. I think one of the things that will suffer is the falling hazards.

Scott: Do you mean things falling off the building exterior?

Degenkolb: Falling off the exterior, falling inside of buildings, equipment turning over, essential equipment made inoperative. Elevators, which are nonstructural, but if something happens to them, certainly that's a major problem in a big building. Fire, which may follow an earthquake. If buildings are air conditioned you don't want the smoke to go from a fire floor to other floors. We have very complicated sequences of relays to open and close ducts and turn fans in the opposite direction. There are a lot of things that should be looked at, and theoretically are looked at, but I doubt that they're going to work in a big earthquake.

There is such a thing as flexibility. That Santa Clara County Building really astonished me in the [1984] Morgan Hill earthquake. But the flexibility also means that partitions and doors jam. I saw the case of the Banco Central in Managua, where a lot of the access doors into the fire tower, the stair tower, were jammed—you couldn't open them. These are little side effects that can get overlooked when we divide the building process up into different areas of concern—structural vs. architecture and so forth. Somebody should look at it *all*, rather than just parts of it.

The Most Important Things Are Not in the Code

Degenkolb: Engineering is not a nice mathematical certainty. Engineering in earthquakes is even worse. There's a lot of judgment that goes in it, and I've often said, some of the main things in earthquake-resistant design are not even mentioned in our codes, because we don't know how to put them in the code. Probably the most universal truth or the most fundamental requirement for a building to be earthquake-resistant is to tie the components together so the structure acts as one unit. That's not in the code. We attempted it in ATC 3, and said you have to have at least 5% of the weight beyond any section, tied together. The 5% is a pure grabbing-out-of-the-air guess. We know that it's important, but we don't know how to quantify it in the code.

Scott: You know that the building needs to be tied together, but you don't know the forces?

Degenkolb: The force levels to do it for, or how to do it. Certain things are automatically taken care of: cast-in-place concrete, by the time you've reinforced it properly, is tied together. Structural steel is tied together. Then you get some elements like precast concrete, or maybe like masonry, where the bricks aren't tied together. With modern stuff we do put in reinforcing, but it's that kind of an elemental thing that we really don't know how to do, except we know it works if we do it in a certain way with certain materials. We also know that while you may be able to calculate it for certain stresses on the precast concrete—which we calculate to be as strong as a cast-in-place concrete element (like the various buildings up in Alaska or San Fernando or elsewhere) if it's not tied together, the stuff just comes apart.

It's hard to quantify, so what we do in practice is, when the tilt-up wall buildings fell down in San Fernando, we were supposed to make the anchorage stronger. Or if we're using precast T's or double T's, we found out that they perform fine if we put a topping slab of reinforcing on, as in Mexico City. The most important things really are not in the code, but I guess that's true in almost any profession, medical and everything else. That's why you're supposed to be licensed and know all the principles. That's why we chase earthquakes—to find out what actually happens.

Chapter 10

Developing Codes and Standards

"As an engineer and a professional, you can't write everything into the code. Sometimes the wording is not the best because it's written by engineers, not attorneys – but maybe that's an advantage!"

Scott: Frank McClure recommended that we discuss code-writing and related matters. Here are some questions that will help do that. The San Fernando earthquake occurred in 1971. The Applied Technology Council was organized in 1971 and ATC 3-06 was printed in 1978. The 1985 Uniform Building Code has just been printed. It will be 1987 before all the lessons learned from the San Fernando earthquake are considered for incorporation in the Uniform Building Code. From 1971 to 1987 is sixteen years. Why is the ATC-BSSC code change process so lengthy and drawn out compared with the time it took to review the SEAOC "Blue Book" during the 1960s? Was it because of the federal funding, the large amount of money available for management fees, and the lack of a realistic deadline for completion of the project?

Degenkolb: Those are sort of loaded questions. I think we'll start with the Blue Book. Before that, however, L.A. had come out during World War II with the first of the dynamic formulas. In 1948 San Francisco followed suit in getting a code [the Vensano code] that seemed to be dynamic, but it was a very mixed up code that the engineers objected to very much.

The "Vensano" Code: 1948

Degenkolb: The building code San Francisco adopted in 1948 was an important development. Some of the background on that was that in 1948 Harry Vensano was San Francisco's director of public works. He was a good friend of John Gould. Vensano was head of construction over at Treasure Island [World's Fair, 1939]. And Harry, frankly, probably did more for the structural engineers in San Francisco than any other director of public works before or since. He's one of the best friends engineers have had at City Hall.

His consulting office in 1906 was in the Shreve Building, with the stone or marble steps. The Shreve Building came through the 1906 earthquake, but the stairs were ruined. The story goes that after the earthquake, Harry had to get some records from his office. He had to climb up and down on the handrails, so he wanted a more severe code. The experience had made an impression on him. Actually seeing damage or experiencing it is more convincing than just learning about it out of books. So he wanted a more strict code.

As a result, Vensano wanted higher earthquake coefficients than had been common before this in northern California, and higher than were prescribed for buildings by the Los Angeles code. In this, he was seconded by Harold Engle and Lydik Jacobsen. The vast majority of the northern California engineers thought the proposed coefficients were too high and argued for lower values. This was not settled on a technical basis, but led to a major fight before the San Francisco Board of Supervisors who, of course, were laymen. I was a young guy at the time and I remember the fights, and they were bitter fights. In the end, the board decided to trust their employee—Vensano—and not the profession, and so the 1948 "Vensano" code was adopted.

Separate 66

Degenkolb: So the San Francisco section of ASCE and the Structural Engineers Association of Northern California (SEAONC) appointed a 10-man joint committee to take a new look at earthquake codes. I was on the 10-man joint committee, and we wrote what is now called and generally referred to as "Separate 66." It came out in the American Society of Civil Engineers *Transactions*, "Forces of Earthquake and Wind."[66] I've seen it referred to in Russian and practically every language in which I've ever looked at a book on lateral force design. That formed the basis of a meeting of the same committee with the building department, and we came up with the '55 [San Francisco building] code, with everybody backing it. Then that became the standard until this last fall [1985]. Whatever the engineers wanted and agreed on, on earthquake matters, we got.

66. Anderson, Arthur W., John A. Blume, Henry J. Degenkolb, et al., "Lateral Forces of Earthquake and Wind," *Transactions of the American Society of Civil Engineers*. Vol. 117, ASCE, New York, NY, 1952.

So the structurals in northern California really couldn't kick, or ASCE cannot kick much that the code was weak, because if there were any weaknesses, it was our combined fault.

SEAOC Blue Book Committee

Degenkolb: Meanwhile, the Los Angeles code had changed to a different form, with different coefficients. That made us different from Los Angeles. Here is the biggest state, the only state really subject to heavy earthquakes, and yet the two parts of the state couldn't get together. So when the Separate 66 report came out, a [SEAOC] statewide committee of 17 men was appointed to write a new code based on the concepts of Separate 66. I was appointed to that committee, too, and it met for about three years. The outgrowth of that was the first SEAOC [Structural Engineers' Association of California] earthquake code—the Blue Book. The Blue Book, the commentary Blue Book, came following that. It formed the basis of the Uniform Building Code's earthquake provisions.

When we picked the committees, incidentally, the people selected were the good workers that knew what they were doing. One of the successes of that was avoiding certain people who had to have it their way or nothing else. You have to make compromises—you stick up for what you think is right, but then compromise so that you can get along. There were several people who would have been qualified otherwise, but their personalities were such that they had to have it their way or nothing.

As a matter of fact, four or five years ago the statewide structurals had that problem. The chairman of the seismology committee felt completely different from the rest of his committee, and finally resigned in disgust. As a consequence, for a couple of years, nothing got done. You have to have people who can get along.

Our 17-man statewide [SEAOC] committee was a pretty good group. There were some wild arguments, but we came up with a reasonable code, which is the forerunner of the codes we have used since then and still use today.

The structurals have always been quite close to ICBO [International Conference of Building Officials], and these new earthquake requirements were used as a basis for the Uniform Building Code provisions. In all engineering matters, the writers of the Uniform Building Code gave great weight to the opinions of the structural engineers.

The Blue Book has been revised and brought up to date many times since it first appeared. The last one, '85, is in the works now and should be printed by the end of the year, although again some differences between north and south are to be ironed out. All of that has been done on volunteer labor.

Scott: Is the Blue Book a statewide document?

Implementation of Codes

Degenkolb: The Blue Book is a statewide document and it has no force. But it is almost always used practically verbatim without amendment by the Uniform Building Code.

Scott: So that's how it gets into regulation?

Degenkolb: Into code form. ICBO, the Uniform Building Code and the Office of the State Architect—they will take those [Blue Book] recommendations and add some of their own or make certain changes that they feel are advisable for school buildings.

Scott: And it gets adopted by reference into Title 24.

Degenkolb: Or whatever.

Scott: Then at the local government level?

Degenkolb: It's really enforced at the local government level by the local supervisors or the city council. And that means being adopted there too. Even the Uniform Building Code is only an advisory thing. The local jurisdiction still has to adopt it, and they can adopt different versions and make their own amendments.

Scott: In terms of being an active, formal sort of exercise of police power, a code must be adopted by either the State Architect or associated regulatory bodies at the state level, or by a local governing body?

Degenkolb: For state things, and things that are governed by the state, it has to be adopted by the Building Standards Commission if it pertains to buildings. They have jurisdiction over the State Fire Marshal, the State Architect, and all that. On the non-state things, it goes to the local level.

Liability Concerns: Some Cities Rescinding Building Codes

Degenkolb: Now here's an interesting development—there are several smaller cities that have now "unadopted" any building code. They have rescinded all building code actions, because of liability concerns. They're getting into lawsuits.

There was a case quite a few years ago up in Seattle where the building official knew that a certain hotel didn't meet code—practically any building in town doesn't meet the most modern code, since codes change. Anyway there was a fire and a man died, and they successfully sued the building official for not enforcing the law.

You now have the landslide cases down in southern California. When their landfill grading ordinances were not strict enough, I could build a house that was later damaged, so I could then sue the city or the county because they didn't make me build my house strong enough. And the suits are winning. This is the idea of the "deep pocket" thing, discussed in the legislature recently. The bigger things, of course, involve traffic and that type of liability. Medical and hospitals, ambulance services, but another big one is the possibility of liability on buildings. "You've got inspectors, why didn't you notice that this parapet might fall at the time you looked at the building?"

So some cities are rescinding their building codes. I was surprised to hear of one in the Bay Area here. I forget which city it is, and I know that there are several down in southern California, but the climate on liability is such that they just close off on everything. It's an interesting development.

Scott: A fascinating but pretty disturbing kind of development.

Degenkolb: Yes it is. I'm not sure what happens in a case like that, because certain things are state laws in housing. Local action wouldn't affect schools and hospitals, and regardless of what they did, it wouldn't affect the State Fire Marshal's regulations on public assembly and things of that nature. But then, if you don't have any enforcing agency, I don't know what is happening.

Scott: It will get to be kind of a jungle if many do that. I find it hard to believe that a lot of jurisdictions in a seismic state like this would go that route.

Degenkolb: Well, I would find it hard to believe myself, but I guess that the ABAG [Association of Bay Area Governments] study on public liabilities[67] may have had some influence, but I don't think that scared them. I don't think papers or reports like that really scare somebody. It may make them think, but I have a hunch that some of the landslide cases, possibly big fires, and in some of the places where there was actual liability—they actually did have to pay large sums.

A Big Change in Enforcement: Less Interpretation

Degenkolb: Enforcement. It gets into the enforcement of the code. Now there's a big change in enforcement. Traditionally, the building official interpreted the code and he did it relying a lot on his experience and feelings and knowledge of the past. If you have a good building official it's a pretty good basis, but it can also have its bad effects, because it does lead to favoritism and political chicanery. Anyway, the building official had quite a wide latitude.

Now, however, the building officials are becoming more personally liable, largely as a result of that fire up in Seattle some years ago, and I guess there was also the fire over in Marin County 3-4 years ago. Consequently, they are less willing to change the code or write exceptions to the code, which I think is generally good. We have established the San Francisco Board of Examiners—that's one of the things we did in '55. I feel very strongly that we should not be subject to rules and interpretations of one man, acting alone.

The Board deals with questions of interpretation, any substantial question, and they have an awful lot of power. If the building official has any question about interpretation, we suggested, "Don't assume the liability yourself, take it to the Board of Examiners." At least there are five or six of them and they are supposed to be experts and not have any conflicts, and be free of politics because they're nominated by the professional organizations. Let them take the heat.

I do know in the last few years that Bob Levy [chief building inspector for the City of San Francisco] was much more—maybe you normally grow that way in a position like his—he was much more determined to go by the letter of the law, by the book, not the intent. That bothered me, but I could see as it was developing that if he did not do something, he could be held personally liable and not the city.

67. Perkins, Jeanne et al., *Liability of Private Businesses and Industries for Earthquake Hazards and Losses.* Association of Bay Area Governments, Oakland, CA, 1984.

By the Letter of the Code

Scott: And that bothers you?

Degenkolb: Yes. As an engineer and a professional, you can't write everything into the code. Sometimes the wording is not the best because it's written by engineers, not attorneys—but maybe that's an advantage! But we know what the code means. It goes back to one old engineer who's now long dead. After the '33 earthquake they wrote Appendix A, which is now Title 21. Then he had to submit a school design to be checked up in Sacramento, and some young fellow there called him on something—"You didn't do this and that"—and the guy comes back with, "That isn't what I meant when I wrote it!"

There are a lot of instances in the code, despite all the going over, where you see some interpretation and think, "By god, the words could be interpreted to mean that, but that doesn't make sense—the intent was thus and so, and not this."

Scott: Using engineering judgment you either figure out the intent, or you figure out that a certain interpretation of the code is going to wind up with something that will be inadequate. Is that basically what you're saying?

Degenkolb: Yes. On the Board of Examiners, a portion of our work was to interpret the code, the code is not 100% clear in all cases. On a lot of touchy decisions and issues, I noticed that over the years, Bob, who was one hell of a good engineer, would think less and less like an engineer in some cases, and more and more like an attorney.

Scott: Code administrator, I guess is the role.

Degenkolb: Yes, and I can't blame him. I think it's a normal thing when you're under pressure like that, and you see what happens when you interpret something differently.

With a big building, the chances are you're going to need variances. There are a lot of provisions in the code. You see, the more specific you get in the code, the more you're going to run into trouble with individual situations or individual buildings, because the code wasn't written with that in mind, and you need some safety valve. In the older days, it was perfectly normal for the building official to take that responsibility, but with present liabilities there's a hazard. Maybe the change is well-founded, because individual discretion can lead to political pressures, payoffs, and all that type of stuff.

Scott: You're saying that there are also these kinds of legitimate problem situations in a big building that the code provisions just don't cover or allow for. There is good engineering justification for departures from the code?

Degenkolb: That's right. We have that on almost any large building. In our [H.J. Degenkolb Associates'] case, because I'm a member, we don't like to take it to the Board of Examiners. I'm the only structural engineer member, so we'll try to settle with Bob ahead of time on what the interpretation will be.

Scott: Is it because of your membership that you do that?

Degenkolb: Largely because of my membership. So we would rather comply than to raise a question, although we have taken certain things to the Board of Examiners. I don't think that we've ever fought Bob.

Oh, I remember one case. I think it was on the Civic Center Garage. You cannot have a gasoline tank in the basement if you sell gas. Well, in that case the Fire Department wanted to follow the letter of the law, to put the tank outside. Well, we got an exception, which I think is safer than what the code requires.

On 101 California—we were not the engineers—there is the big sloping roof toward Market Street. The code says all that stuff has to be fireproof. Well they maintain there isn't going to be anything burnable, and you're 7-8 stories up in the higher portion of the lean-to. That's extra cost [to fireproof]. Actually, the argument was on aesthetics more than anything else. It affected the appearance. So they came to the Board of Examiners, and I think that we have a pretty good reputation, our reputation is that we're pretty tough. But in a case like that, we generally try to examine the reasons, so we said, well all the primary members and the columns had to be fireproofed, but the secondary members didn't.

Bob, I think in 90% of the cases, goes along with the Board in his heart but doesn't feel he has the leeway, or he's too vulnerable liability-wise to depart from the code. In a few cases we've overridden it. A couple of times we overrode him when he was wrong. That's part of the democratic process. So, we have an active board.

How Codes Are Drafted

Scott: Would you describe the code drafting process?

Degenkolb: The process in general—I'm going to speak essentially of the Uniform Building Code (UBC), because the three model codes [UBC, SBC (Standard Building Code), and BOCA (Building Officials Code of America)] follow essentially the same procedure. ICBO [International Conference of Building Officials], which publishes the Uniform Building Code (UBC), is a conference of building officials, not engineers as such. Many of them, however, are also engineers. In the old days, going back to the early '20s, most of the United States was on the national code, which was an insurance company code like the national fire code, but it's lost ground over the years.

The western building officials needed more—well, they wanted a better code—and so they formed the Pacific Coast Building Officials Conference, now ICBO. ICBO writes and promulgates the Uniform Building Code. They meet every year, and any members, or even nonmembers, can bring up proposed code changes. Then these are studied by ICBO committees, and either adopted or not. Now the special interests—and I'm not saying that in a derogatory manner—steel, or concrete, or wood, or a real estate interest or a contractor, have an interest in what the code says. And they will argue it out. The final voting [on whether to include a provision in the UBC] is by the building officials.

Scott: Now these committees, are those principally building officials?

Degenkolb: They're all building officials. Except that ICBO has always been fairly engineering-oriented. And so you do have representatives of the various organizations sitting in, and I must say that ever since 1955, for example, on earthquake matters ICBO has taken the recommendations of the Structural Engineers Association of California practically verbatim. Matter of fact, even before that, when they had the old L.A. code, southern California had most of the influence in that. There's a difference in feeling now that ICBO is an international organization. The Uniform Building Code is used all over the world and sets policy for a lot of the users.

Adopted With Changes

Degenkolb: The model code is adopted by the local authorities. The model code itself is just an example—it has no force of law—it's just a recommendation of a code-drafting body. And very often the code is adopted by the local authorities, generally with changes. Some of the changes are certainly legitimate because, for example, the foundation problems in San Francisco are different than they are in the Central Valley, or the size of the fire department may be a factor, because the code largely covers fire hazard also.

I have no worries about San Francisco, with the houses being built one against the other. Considering our problem with our limited area and the quality of the fire department and all that type of thing, we can allow things that I wouldn't want to see allowed in other places. One of the concerns a few years ago was when we saw a 10-12 story hotel going up in Corte Madera, and the fire department had no ladders to reach beyond the third floor, so there are a lot of things that enter into such judgments. But on the other hand there are a lot of changes to the model code that are purely local. They're in there either because of the local professionals' bias, prejudices, opinions, or because of local political pressures. Not all contractors and real estate people and others are wholly altruistic.

You have different viewpoints in different areas, and in the last 6-10 years or so, the structural engineers of Washington and Oregon and the west coast are all offering opinions and requesting changes or opposing changes, based on their knowledge, their feelings, or their experience. The biggest fight really was between northern and southern California. California was the dominant factor in seismic codes until quite recently. We still have the biggest influence, there's no question about that.

Years ago when we re-did UBC Chapter 25, the wood chapter (I had an awful lot to do with the writing of that), and the timber people in those days were much more altruistic—they built very honestly. And I think 98 percent of what we suggested was accepted, even though we were not members. Oh, I'm a professional member, but I have no vote. But you have your class A memberships of city and county officials—and I'm not sure what the others are—and then there are professional members, but its only building officials who vote.

Just as a sideline on that, the building official has to enforce the building code—it's a law, it's an ordinance—and he prefers something that is very definite, with things not left up to the judgment of the engineer, so the code becomes thicker and thicker with more detail—so that it's not gray, but either black or white. You either can do it, or you can't do it.

As an engineer, hopefully a competent engineer, I'd like things left a little looser so I can use my engineering judgment. In some cities there are politics, but if chief building officials like Bob Levy here in San Francisco or Jack Fratt down in L.A. think something's wrong, they are going to fight for what they think is right. I won't say those two are more insulated, but at least they're more independent. You can have all variations of influence, from farming communities, to big cities, with all kinds of pressures pushing every which way.

San Francisco Parapet Ordinance

Degenkolb: For example, the parapet law. I have mixed feelings about the parapet law. When I was chairman of the San Francisco Chamber of Commerce building code committee—some years ago—it was proposed and pushed very hard. We had big code committee meetings with the real estate department, house owners, the hotel owners, building owners and manager associations, showing what the problems were. We got agreement before we went to the supervisors, so they [the supervisors] went along with us. One of the key elements was that it was going to raise the cost of retrofitting existing buildings, and they were opposed to that. One of the questions that came up related to Bakersfield, which had a '52 earthquake. They [a committee of the San Francisco Board of Supervisors] wrote to Bakersfield and asked "What are you doing about parapets?" The answer came back that they have no parapet problem, because they all fell down in '52.

We've also had several occasions to fight when good engineers in the building department tried to expand the law to include belt courses and certain things that were not covered in the parapet law. But we had an agreement that they [potential opponents] would go along with the parapet law, but not other things. I think they could have killed the proposed law if they wanted to. We [the Chamber of Commerce building code committee] had to see that the engineers in the building department did not expand the law unilaterally. It first has to go through the law review again. So appendages and parapets are taken care of. Generally belt courses are not a problem, though certain ones obviously are.

Scott: What are belt courses?

Degenkolb: Belt courses. You've got parapets and all the junk at the top. And then maybe at the third or fourth floor of a highrise building, you have a projection that goes out, with more ornamentation there. Those are belt courses. They're architectural features, but the law did not cover that, because we'd made agreements with the others that we would go so far and no further. So in a couple of places we had to fight the building department. They wanted to enforce these other things, and the first manuals that they drafted and the questionnaires to the owners covered all these other things. We said, "You can't do that. The law only says thus far, and that's what the agreement was."

Frankly, from my own experience, once the building owners know what the problems are, we can recommend going beyond the law and we have no problem. For example, the Marines Memorial Building. There were problems in the third and fourth floor with ornamentation. While the law did not cover that, we just said to the owners that while you're doing it, take care of the other ornamentation as well. We discussed it with them. We generally found if you present it decently to an owner or manager, they go along. They're not as selfish when they understand the background.

Basic Objectives of Codes

Scott: Would you talk about the basic objectives of the code? What are the basic objectives of codes and code-drafters? What do they try to accomplish, especially with respect to seismic safety?

Degenkolb: Well, as it is stated in the [UBC] code, the objective is to preserve life and property. There are different levels, which are really never ever stated. Traditionally, the code is concerned only with life safety and health, which includes fires, one of the big things in the code. Otherwise the preservation of the property is really up to the owner.

Now under the Field Act, in the early '50s we got quite a change of position from the State Division of Architecture.[68] It was the first time that property value came into it. They [the State of California] took the attitude that a school is a state building, and part of the code's job is to preserve the value. And that is why certain things got into the code for public schools.

Scott: So the code can go beyond life safety and health, which formerly had been the principal concern.

Degenkolb: Yes. That applies to public schools and to hospitals. The Uniform Building Code really does not do that. It's not supposed to protect property, as such. And yet, more and more, there are provisions that come into that.

You remember the fight on the Hospital Act? The office of structural safety of the Office of the State Architect did not want to get involved with mechanical-electrical matters. They wanted life safety, but only for the structure, and they were trying to get the law [the Hospital Act] changed. We [the Building Safety Board Advisory Committee to the Hospital Code] stopped that. Because I think both life safety *and* the operation of a hospital are important, and operation depends as much on the nonstructural elements as it does on the structural. The basic code—you will get all kinds of interpretations from the various building officials and their feelings—but the basic code generally emphasizes life safety.

Now there are the exceptions [in the UBC] such as when you're dealing with residences, and you are supposedly dealing with an *uninformed* owner, and so some of the provisions of the code and interpretations are intended to protect the owner from the cheap builder.

In any event, while the stated purposes of the code are life and safety, there is also a strong element—for the smaller buildings—of trying

68. In 1933 and for some years, this state office was known as the Division of Architecture. Later it became the Office of Architecture and Construction (OAC). It is now the Office of the State Architect (OSA).

to protect the laymen who may build a house once in a lifetime. But when it comes to the big, supposedly intelligent owners, the experienced owners, such as Standard Oil or whatever, who have engineering departments and all that, they're assumed to be smart enough that they should be free to make the economic decisions, as long as life safety is preserved. And that is a big variable as to where the line is drawn. It's interpreted differently in different places.

Basically, a code should be for life and safety, with certain exceptions. But the exceptions are a very gray area and will depend on local interpretations and some other things. Also, items are liable to get in the code not on the basis of life safety, but more on the basis that you're protecting the public. So differentiation gets very, very muddy in some places.

But except for hospitals and schools, seismic safety is almost all life safety. The wood buildings that failed, even collapsed in San Fernando, caused no casualties, or at least very few. Wood construction is light, and while there have been some horrible failures, there have been very few casualties. So you can't argue much about life safety on that basis. But on things like curtain walls—there's a strong emphasis on curtain walls, which are *not* a matter of structural performance, but you don't want them falling in the streets. Again because of the fire aspects, the highrise fire danger, a new building over 75 feet must be sprinklered. And the ventilation system for smoke removal, and the elevator requirements—and, well, that's all emphasizing life safety. But there are more and more elements on performance getting in the codes to minimize loss of value.

And that sort of bothers me. Let's say you have an earthquake once in a 100 years, and you spend a half percent extra on every house, on the chance that a few hundred houses will occasionally be damaged. Economically, you can't say that the half percent is justified. When you get into a high-risk area like southern California is supposed to be now, maybe that changes, but I have problems with the whole argument for preserving property values.

Now, I think for very low cost you can do both—safeguard life and protect property values—with intelligent systems and intelligent engineering. It would be stupid not to do it. But safety can be expensive if you start off with the wrong system, or architectural or engineering design.

Applied Technology Council

Scott: So your early work with codes was in developing new codes, such as Separate 66, which formed the basis of the Blue Book, which, in turn, formed the basis for the UBC, correct?

Degenkolb: Yes. Then from 1955 to let's say about 1979 or '80, I forget the exact year—'78—it was obvious to many of us that we couldn't just keep revising the old code. We needed a new approach. There had been too many new developments. So the Applied Technology Council (ATC)—which is an arm of the structurals—and the structurals and the building officials, under the umbrella of the National Science Foundation and National Bureau of Standards, all got together to write a new code. There were 80 of us I think, from all over the country to write a new [building] code, which was ATC 3-06.[69]

Consensus Standards

Scott: I know it used to be that codes were developed largely by the engineers, but I understand that you now have to reach a broader consensus on standards and codes.

Degenkolb: That's right. About 15 years ago, when I was on the ASCE codes and standards committee, active in ASCE nationally, the federal Office of Management and Budget (OMB) had some proposed rules to the effect that producers, or single groups of people, should not develop standards. Instead you needed to have all elements of society agreeing, and thus get a consensus standard. That would involve not only the producers, but the consumers and anybody else affected by the product. There was this famous case of the boiler valve, where ASTM [American Society for Testing and Materials] was fined $11 million for restraint of trade, because of the way they put out one specific standard.

At that time I spent a lot of time, along with other committees and national organizations, on how you get a consensus standard. A matter may be highly technical and the only people who know anything about it, for example, are the engineers, and yet you had to have the ultimate users, renters, real estate people, everybody involved in it—I'm speaking of an earthquake code.

So when ATC 3-06 came out, it was necessary for it to become a consensus standard. ASCE for example, was listed by the Department of Justice as in restraint of trade [because their published code of ethics prescribed and proscribed certain practices], and they had to change their code of ethics. The American Institute of Architects did also. The materials interests got very cautious about any liabilities that would accrue if they wrote standards, like the steel specifications that we design to. These had been written by experts, often by the producers, but the general public as such had not been consulted, not involved. So now society is represented in its different viewpoints, such as real estate people, contractors, supervisors, occupants of buildings. A code affects everybody. So you can't just consider it technically as an isolated element. Everything you do affects everyone.

69. ATC 3 was a project undertaken by the Applied Technology Council to develop a new generation of recommended seismic design provisions. It was sponsored by the National Science Foundation, took several years to complete, and engaged the efforts of practicing engineers, particularly from California, and earthquake engineering researchers from throughout the country. ATC 3-06, *Tentative Provisions for the Development of Seismic Regulations for Buildings*, published in 1978, was the result of this effort. The Building Seismic Safety Council (BSSC) then managed a national technical review of the ATC 3-06 recommendations in order to obtain broad consensus approval, and included material and other interests that had not participated in the ATC 3 process. The resulting revised document became the so-called NEHRP provisions, since by this time, the National Earthquake Hazards Reduction Program had been created by Congress and provided funding for this effort. Degenkolb served on both the ATC 3 and BSSC committees that completed these efforts.

OMB Guidelines, Justice Department Actions, and Consent Decrees

Scott: Was the new climate due principally to the OMB, Office of Management and Budget, regulation?

Degenkolb: OMB was writing guidelines [on acceptable processes for formulating codes and standards], 30 or 40 pages of them, and I remember going through that and writing letters objecting. ASCE people appeared, as well as all the others—the chemical society, mechanical engineers, all of the technical societies and some not so technical, were represented at hearings on these things, trying to get some reason into it.

One of the questions that kept coming up in my mind at the time was this: here's a bunch of engineers in California writing the Blue Book, which, like it or not, has been copied all over the world. And that process had only practicing engineers participating, and depended on the judgment of those engineers to preserve a balance between extra safety and extra cost.

OK, ATC 3-06 came out at about that time. ASTM [American Society for Testing and Materials] does a lot of stuff on the standards of almost everything—photographic equipment, ASTM steel, concrete, the way you test concrete, the way you test things, not only in the construction industry, but everything. Then there's the American National Standards Institute (ANSI), which also has standards and is the parent organization for a lot of standards. For example, they put out the standards on windows, and certain design functions. Technically, the structural engineers' thing [the Blue Book] was not a standard, but a set of recommendations that people have followed—but if enough people follow it, it becomes a standard whether you want it to or not.

Building Seismic Safety Council

Degenkolb: Well, when ATC 3 came out then, it had to come out with somebody pushing for adopting it. NSF can't, because it's not in their program. They're promoting research, not an ongoing standard. The National Bureau of Standards would have very much liked to have done it, but most of us were quite afraid that they would try to take over. In many of our minds, ATC would have been ideal at that time, but it was a brand-new organization, and for something as important as this [promulgating standards] you don't rely on some untried group.

So Chuck Thiel got the idea, and a bunch of us got together and formed the Building Seismic Safety Council (BSSC), under whose guidance this is done. They took over ATC 3 and the further studies on it as far as the usage of it throughout the country, any bugs, any special discussions for any regions, and that. At about the same time, FEMA was started—the new federal organization, Federal Emergency Management Agency, set up by combining fire, flood control, disaster, civil defense and earthquake. We [ATC 3] sort of came under FEMA's wing. The ATC document was developed partially under contract by paid labor, but it was mostly voluntary. My time and that of some of the others, worked out to less than $1/ hour. It was really a volunteer effort. The Blue Book had been a volunteer effort. Now, suddenly we were handed an organization [BSSC] whose main function is to coordinate about 60 different organizations to get a consensus standard. Times have changed somewhat.

The Consensus Process

Degenkolb: Frank [McClure] was asking about volunteer and paid effort. Compared to the Blue Book, which was written by practicing engineers in one area—and we had our fights, north and south, we now have ATC 3, the national standard [NEHRP], where we have not only our fights north and south, but all over the country. If it took us a couple or three years to develop a Blue Book for just one state, you can imagine the time it takes to develop a consensus throughout the country, especially now that not only practicing engineers are writing it, but everybody is—the elevator association, the Portland Cement Association, the steel people, the masons, the structural engineers, the architects—there are 60 organizations. Many of them are very much competing.

There were some studies made by 10 committees of ATC 3-06, and we had recommended that there be further studies made on the cost impact on some of the things and the practicality of some things [we were recommending]. These committees then wrote a bunch of proposals for change—seemed to me there were 60 or 70 of them, something like that—and it was voted on. For a consensus standard, you have to have two-thirds of the people vote for it. These things were then voted on, and the concrete people pushed very hard for a lot of relaxations. A lot of things passed, but a lot of them passed without the two-thirds majority required for adoption. So this poses a big quandary, causes some real problems. Then next there was a written ballot, which tried to resolve those things through certain committees, and we had another ballot recently. That was supposed to be official, so the thing could then be printed. And the same four or five major items were defeated, for example, on some of the restrictions on concrete. Yet the Mexico City earthquake reinforces what we've known since the 1964 Alaska earthquake.

Scott: About the kinds of things that fail?

Degenkolb: Yes. The concrete people fought the restrictions very much, on the basis that they're not in California, this is a national standard, and you don't have to be so severe on buildings built in Chicago, New York or wherever. California engineering groups voted "no" on the same parts, because they considered the restrictions were not tight enough. They knew that too many compromises had been made.

All of these things, I think about 120–128 of them, were sent back to a committee of 12—an overview committee, of which I am a member. The votes should be coming in again for the second round. Most of these things were sent to committee, or temporarily we'd do this with the understanding that it will be reviewed in three years, but there are still several items, half a dozen or so, that I've already seen some of the ballots and they're going to go down in defeat the same way. They will have a majority, but will not get the two-thirds vote. The only thing I can see is that they're going to have to publish two versions. You can't get a consensus standard on a national matter with the hazard so unbalanced [in different parts of the country].

Part of what Frank was getting at, and something I was wondering myself—while we've made mistakes and had wrong things in the

Blue Book—it's an evolving thing. It was done by volunteer labor and we got it out in three years or so. And there were compromises. But they were compromises made among people who knew the necessity of designing for earthquakes.

Scott: In other words, they understood the significance of the decisions?

Degenkolb: That's right. Now we have two paid organizations [BSSC and ATC], but with the new Blue Book that is coming out, they say there's 20,000 man-hours of volunteer labor in it. I suspect that is right. It's a major rewrite.

Volunteer Labor vs. Paid

Degenkolb: The question comes up again, and there is no answer: is it better to do it with volunteer labor—or on the other hand would you get a better product quicker by having paid labor? Some of this is very touchy, but some of us are concerned that ATC has grown from a service organization for the structurals, set up to take care of certain structural problems and research that we think is needed. It has grown like any organization that is reasonably successful, to where its number one purpose is to promote itself, get more research jobs to keep the staff busy. And I'd say that on the whole they have turned out some pretty good work—although a couple of things have not been very good.

But the promotion is very much on keeping the staff, who are drawing substantial salaries. It's a promotion—you promote yourself to exist. BSSC has turned into almost the same thing. It started out as a small operation, not to get into big projects, not to handle big staff, really just coordinating things. Their big effort now is also in getting more projects, getting more stuff from the federal government in order to exist.

The question is—which gives you the better product, quick? Nationally, compared to statewide, we can easily see the difference between three years and seven or eight years. And even then we still don't have an agreed-upon product under the paid plan—at least with paid staff. ATC 3-06 is not accepted yet [as of this October, 1985, interview]. Now it's called NEHRP (National Earthquake Hazards Reduction Program). That is what bothers Frank [McClure] and it bothers me. I can see pluses and minuses.

Scott: You mean the paid enterprise has taken seven years or more?

Degenkolb: Yes. That's why I wanted to explain the issues. First it's national versus local, and it's consensus as opposed to what a group of engineers do. Then you have the structurals, who are now getting a large organization too, but they've set up these organizations mainly to be service organizations, to do a certain job. And like almost anything else, once they've done the initial job, the next thing is to keep it going—self-preservation, getting funds and projects. I have the same feeling that I think Frank was getting at in his question—that maybe it was better the old way. I'm not sure if it is or not. At least there is a serious question about it.

Scott: Back to the volunteer work on standards, was that principally a California enterprise?

Degenkolb: Yes.

Scott: As to the national effort, has that been principally a paid enterprise, despite a lot of volunteer hours that went into it?

Degenkolb: In the ATC national effort, every one of the guys was paid. I was chairman of the design committee and there were seven of us on that committee. That was all materials and design. I think I got something like $3,000 out of it, and probably put in 5,000-6,000 hours over the several years. And every guy did the same thing.

Scott: You could call that "paid," but only in a manner of speaking.

Degenkolb: And now in the service we're doing on the committees or the overview committee and all that, we get our expenses paid. We will meet in a couple of weeks back in Denver, so I'll get my plane fare and hotel paid, but the time is free. And that's been a pretty good committee, having a broad background—some concrete and steel people and everything else, but we're fortunate in having a pretty good sprinkling of practical engineers. That phase of it, I think, is okay. It has certainly exposed an awful lot of politics, with a lot of pressure applied by competitive materials interests.

Scott: Let me ask you more on the issue of paid versus unpaid. It's one thing to call you paid if you get $3,000 for 5,000 hours, plus your expenses, but with the typical federal formula—I think they pay your way and your per diem but your time is free, and they schedule it so they work the heck out of you. So you work from early in the mornings to late in the afternoons and have evening sessions, and with no compensation for the time.

Degenkolb: It depends, you can be a consultant. I've been on some of the commissions with consultants, but with an effort like this, it's free time. As a matter of fact, some executives back in Washington were out here for the recent SEAOC meeting, and Paul Fratessa, who is chairman of the SEAOC seismology committee, made the estimate that they [the SEAOC seismology committee] got 20,000 hours of volunteer labor. He asked, how do we do this nationally?

Well, it's one thing to do something for your local area without being bothered by outside influence and a lot of nitpicking, so that you feel you're accomplishing something and it's necessary. It is another thing to do some of this national stuff, where an awful lot of time is wasted on things that you know are wrong. Some of it I find out myself in going over a lot of these changes, as to how organizations vote and how we compromise with them. If it were a California thing, I'd just throw it in the wastebasket as not worth discussing, it's so obviously wrong. But you can't do that with this national consensus thing.

Changing Climate on Consensus

Degenkolb: The climate on consensus has changed. If you were a professional in the old days, not the *real* old days, but 10-15 years ago, there was a major concern and we acted accordingly. Every one of the professional societies had been sued by the Department of Justice for restraint of trade, antitrust actions. Maybe I'm just out of the mainstream of that now, so maybe I don't see it as much, but at least that pressure doesn't seem to be on.

Scott: Are they still expecting the consensus, the two-thirds vote?

Degenkolb: Well, they are on BSSC, and I think the rule on the consensus vote is two-thirds. But I think the pressure has let up on getting all facets of society in on it. As a matter of fact, in Sacramento some of the members working on the Blue Book have said that [the consensus requirement] is the whole thing that's wrong with NEHRP [National Earthquake Hazards Reduction Program, ATC 3-06]. We've got too many materials people on committees, we've got too many people who don't know what it's all about, and yet they're entitled to a vote. It should be left in the hands of the people who know what we're voting on.

Some of the organizations, when they vote, will abstain because the topic is something they don't know about. For example, the association that does things about elevators, they're interested because there are earthquake provisions for elevators, but when it comes to how you design steel, masonry or concrete, they will generally put in "I abstain." But there are a lot of other people, who for political reasons, though they don't know anything about the issue, will still vote. I guess it's a comparison of an elitist society versus a democracy. Everybody votes whether they know anything about it or not.

The West Wants Things Stricter

Scott: Let me ask you to comment with respect to this national standard, or the sets of standards, and the California contingent who want things somewhat stricter.

Degenkolb: It's not only California, it's Washington, Oregon—it's the west coast really, the structural engineers, EERI. EERI was really a west coast organization. Then it grew nationally. So it was really the same people that were active and interested in earthquakes who were writing reports and such at first. EERI generally was influenced by the west, so they would look at things like the west coast people do. We have our differences—that isn't to say we vote 100% the same. On the big key issues, however, we find Hawaii, Washington, Oregon, EERI, the California engineers, and even Arizona engineers, will generally vote for more restrictive things. There are some exceptions.

EERI Members Voting Like California Engineers

Scott: Would this be true to some extent of the of the eastern U.S. EERI members? Are they to some extent a self-selected group?

Degenkolb: Bob Whitman appointed a committee with Frank McClure as chairman when this vote [on the NEHRP provisions] came out, to select a committee, a national committee—I don't know most of them—of EERI members from all over. It's interesting, quite a few of them were engineers, we had eight or nine people on the committee. I saw the replies to his questionnaire, and by and large they were saying we were not severe enough in the proposed standards.

Scott: That the national code was not severe enough?

Degenkolb: That's what we were voting on, the NEHRP, the national code. They were voting like California engineers, saying that on certain things it was not severe enough. I know of eastern engineers that I have a very high regard for, because I think their offices are like ours—they're trying to do the right thing. But then you have the materials interests and their organizations and their followers, and they're quite opposite. So it's a funny mixed-up world, is all I can say. Like this voluntary versus paid issue, and whether we're making progress—we're certainly making progress in a lot of important areas. Whether we've lost some ground in others—I tend to think so.

We've Lost Some Ground

Scott: You tend to think we've lost some ground?

Degenkolb: But you've got to take that as coming from an old guy who is used to the old ways.

Scott: Would it be useful for you to say a few words about where you think we've maybe lost some ground, or does it get too complicated to spell that out?

Degenkolb: One of the things is that by expanding—it's a comparison of having a rather small group of dedicated people on the one hand to having a larger group, a mixture of those who are dedicated and those who are not. Compromises weaken things. In order to get an agreement, you compromise here and there. And a larger group always makes more compromises. On the whole consensus thing, basically I consider that the structural engineers—who have been writing the codes and the legislation, and pushed for legislation in the public interest, not for their own jobs—have been quite altruistic. They've been trying to be fair with the real estate people, for example. You don't overprice something, yet you want to provide safety.

Now we have the materials interests, which were sort of on the sidelines—they were not in it before. Now we're having them in it with both feet. The professionals are sort of watching the materials interests fight.

Scott: Fight among themselves?

Degenkolb: Yes. Therefore you've got to compromise, or at least there is heavy pressure to compromise lower down in favor of certain materials.

Scott: You mean reduce standards so that certain materials would be favored?

Degenkolb: That's right. I can look at a failure, and another guy from materials interests can look at it, and we see two different things. I can see there was something wrong in the design process, and that the code should be changed here and there. And the other guy says it's all poor workmanship—that we don't need to change the code.

Dealing With the Western Need for Stricter Standards

Scott: Let me go back for a minute and ask you: where you have the national code or a national set of standards arrived at by consensus, such that some of the standards are less than the western or California contingent would like. How are we presently handling this differential? In other words, in California I presume that we still have the stricter standards in place.

Degenkolb: First of all, these [the NEHRP provisions] are *recommended* provisions for consideration—they are not a code. The U.S. does not write a code. The only place that they would be using it is in the Tri-Service manual, or with their own federal construction.

Scott: Tri-Service?

Degenkolb: Defense has a manual for their construction. That would be for the three services [Army, Navy, Air Force].

Part of the argument was that most of the western places voted "no" on everything on the second ballot because they didn't want it to become a code. So they sent people to the board of directors meetings, and it was reemphasized that this was not a code. These are things to be considered in writing the code. At the very beginning, the National Bureau of Standards would not let us use the word code at all. They are very touchy about that. The people have to write the codes.

This is essentially what is happening—and what we tried to do in San Francisco and lost. It was to take the basic concepts, the basic ideas and the approach and take all that was good, and add to it what we thought was necessary for our thing. For example, in San Francisco, we're not interested in all these other zones. We have only one zone. We're near a fault so we have an effective acceleration of 0.40g—the worst case [effective peak acceleration 40%g], the highest, so there's no use in referencing all the other things. For California, there's no use to reference anything except 30% or 40%, because all of California comes under that. And the Blue Book, in addition to the ACI standards, has always had several pages of extra things that we want for California.

So you take what you have and you adapt it to your needs. If Kansas doesn't want to do this, and they want to vote themselves in another zone, they can say, "Considering all the other economic factors, our risk is not that high, we can lower some of the standards." We've always said in the structural engineers association, these are recommendations to be used in considering with your local seismologists and engineers according to what you feel your risk is.

Scott: The Blue Book recommendations?

Degenkolb: The Blue Book recommendations have always been that way.

Organizations Being Built Up—Self-Preservation

Scott: To recapitulate a bit, whereas formerly work on codes and standards was mostly done through volunteer effort, more recently there has been greater reliance on paid help, and organizations such as ATC and BSSC have been formed. Do you have any comments on these developments?

Degenkolb: Well, I guess it's evolution, but I hate to see any other organization being built up to the point that it has to preserve itself. If there is a need for the organization, it will be preserved anyway. After a while, a lot of the organizations just hang on because of the staff and the money flow, rather than for providing a service.

Scott: Is this part of a problem that you're pointing your finger at—that is, when you get a paid staff you inevitably also get an interest in preserving the organization.

Degenkolb: That's evolution. That's the way things go.

Scott: The staff then has either got to hop to some other place, or beat the bushes for some additional funding. And it's very hard for them not to do that.

Degenkolb: I've seen too many organizations like that. In northern California we [SEAONC] deliberately, when we hired a staff man, got somebody that was not likely to do that, to take over. All policy was to be made by the members of the organization, the directors. Because we have the example of another one in the state where the staff ran the organization.

Scott: Which one was that?

Degenkolb: That was the structurals of the south [SEAOSC]. When we got our staff men, that was something we wanted to avoid, and we succeeded in keeping it in the hands of the association.

Scott: When you say "we," you mean northern California?

Degenkolb: Yes. The Seismological Society [of America (SSA)] has kept small, it's a service, mostly for publishing. EERI did the same thing. We [EERI] were not contaminated with money until a few years ago, though now we are going the same way. There are good things about it and bad. I saw it, and am a little perturbed about some of the projects and results, and the fact that the staff is doing most of the writing, rather than the members. But if you're a big organization you need a staff. That's one of the prices you pay for jumping in membership from 100 to 1,000, or whatever it is now. So you see I pine for the old days, but I'm not sure that's logical.

Scott: You're of two minds about it, aren't you?

Degenkolb: Yes, I can see the advantages and the disadvantages.

Scott: Is EERI keeping a good deal of the sort of volunteer atmosphere, the volunteer activities?

Degenkolb: I think EERI is still basically volunteer, although the staff is doing a lot more than it did, and it's a lot more organized, and there's constant writing of new proposals for doing this, that, and the other thing. And some of it is good, no question.

Scott: Would you be willing to comment on some things you think are maybe not so good?

Degenkolb: I think that there is a certain amount. In some of our seminars, when you go to different places—seminars in Hawaii and so on—there is a certain amount of playing a little politics with who does it, and not getting the best. I've been perturbed a little about editorial work—a lot of work was done that I don't think was necessary, and really weakened the reports when the drafts went to staff from the guys that wrote them. It's more of a concept than anything else.

Scott: Editorial work—did it have the effect of watering down the report?

Degenkolb: No. Well, it may have in some cases, but the text is just different. I think while they work with the editing somewhat, they shouldn't change the flavor and completely rewrite it or something like that. There's another attitude also I see that bothers me in somewhat the same way. There's a tendency among some contributors to write a hell of a lot. And you get a report so thick. But when you analyze it and look at it, it's so much fluff. It doesn't say anything.

Objectives the Codes Cannot Achieve

Scott: Let's get back to codes for a minute. Are there important seismic safety objectives that codes either cannot achieve, by their very nature, or that they are unlikely to achieve (for example, due to compromises)?

Degenkolb: Seismic safety objectives the codes cannot achieve—in the average house you're not going to prevent plaster or sheetrock damage, because it's inherently a loose system. It has a high degree of life safety, and low degree of hazard, yet inherently it's going to move, and you're going to have damage. Maybe the damage repair can be limited to puttying up some cracks and painting it.

Scott: As long as it's limited to that, it doesn't involve much damage.

Degenkolb: No, that's right, but it can sometimes be rather expensive. I had an experience in Park Merced [a large residential complex of multi-story apartments, condominiums, and garages in San Francisco, CA], where there are eleven 13-story buildings, and they each have four wings. So you've got 11 x 13 x 4 units (572), and they came through the '57 earthquake beautifully. They are rigid buildings. In the other development, I forget the name of the other development out there, adjacent to Park Merced, where the windows went out and there was a lot of damage.

Scott: Stonestown?

Degenkolb: Stonestown. The Park Merced buildings came through beautifully. But there were cracks where the plaster walls met the concrete, tiny cracks I'll admit, but they all had to be painted. It cost $50,000. This is '57 money—$50,000 just to repaint the stuff. Of course, that's a small price for a large project like that, but in those days it was a shocking amount of money, and I kept looking at that and said, we made those things way above code, very economical, much cheaper than down in L.A. (Park La Brea), very rigid. I think ours are some of the safest buildings in town, in spite of the time they were built, and yet look at the damage.

We have tried in the last 20–25 years to limit the deflections to prevent glass breaking. I would never guarantee that we won't have glass breaking. When we did the International Building [a Degenkolb-designed highrise on the corner of Kearney and California, San Francisco], there were economic considerations, and I felt at the time, and I still do, that if that building is subjected to a major earthquake, the rest of the town may be leveled but this building will be better than most.

I don't know what will happen politically, about disaster recompense and insurance. We recommended that they carry glass insurance—there's no deductible on that—but not earthquake insurance. On the Bank of California Building they're carrying earthquake insurance because that's a big possible loss for a limited corporation. No matter what we do, glass is variable, the workmanship of setting it is variable, and I don't think that there is a way in the world that you can be very sure. You only hope you'll have a minimum of breakage.

Scott: You're just going to have to live with certain kinds of damage?

Degenkolb: That's right. One of the amazing things in '52 [Bakersfield] was the schools—you saw examples of the pre-Field Act schools with horrible performance. And you had the new schools, which performed excellently, but they had light fixtures that came down on the desks. I mean, you learn from one earthquake to another. But unless it's a school and/or a very conscientious professional, following up—that's one of the things that gets skipped quite a bit. We found that out in recent earthquakes.

Considering the bolting to the foundations and the nailing of sheathing we call for in houses, I think those measures will prevent major damage, but the structures will probably shift a 1/2 inch or an inch and do some splitting and cracking. I wouldn't guarantee no damage. Water heaters are going to be overturned, even some of them that are tied up. So there are certain things where all you can do is do your best, and accept the damage.

Even on life safety, when we examine older buildings that had the best partitions—which used to be the tile partitions—we limit the drift, but they're going to crack. There will not be a big collapse, but we have sort of agreed that you must accept a piece of tile killing or injuring someone, as I think may occur in some buildings like those over on the Berkeley campus. The cost of repairing, or the cost of changing a building is enormous. As long as the building won't come down, and you have only an occasional casualty—not much different from a piece of equipment falling off a shelf, or something of that nature—I think you're going to have to accept that type of thing.

We did studies some years ago on the Sonoma County Hospital (this was way before the Hospital Act). It was very well designed—but happens to be on the fault. So we projected the possible damage and took care of some falling hazards. In some of the poorer buildings they did a lot of reinforcing and evacuated the critical facilities. But if the only "safe" site for the hospital would be, let's say 3-4 miles away, maybe the extra travel time for ambulances would cause more life problems than locating the hospital on a fault in the first place. Especially since we probably have a big earthquake only once in 50 to 100 years. We need to consider these other factors, otherwise we tend to look at things in only a one-dimensional way.

Scott: A single-purpose way.

Degenkolb: That's right. You really should have to consider everything. I'm not sure I have the courage to do that in some cases, but it's still a valid point.

Chapter 11

Licensing and Continuing Education

"Once an engineer gets his license, if the guy doesn't make waves, he can get by without doing very much. There are movements afoot to improve that."

Scott: Frank McClure suggested that you comment on some matters relating to professionals keeping up with the literature. There is only so much time the average practicing structural engineer can devote to keeping up with the technical literature. What can be done to minimize the proliferation of reports and papers in the earthquake engineering field that have little application to engineering practice, and some may consider to represent research for the sake of research? It's a bit of a loaded question, but it's a good question.

Reading and Studying

Degenkolb: You don't have too much of that at Cal, Stanford and Michigan, thank god. Some of the other universities are pretty bad. The basic problem of the engineers is how to keep up-to-date. I don't know of any way, except, like the doctors—you read the reports and study a hell of a lot. I don't believe there is any shortcut. I imagine doctors have a lot of chaff in what they read too. I now recognize certain authors and certain types of papers, and say, "I don't have time for that."

Scott: You know what sort of thing they're writing on.

Degenkolb: Yes, with other authors you read almost everything they do, and I'd imagine it's the same in any profession. I think I know what Frank's getting at. Frank is one of those who reads an awful lot and goes back into the old books. I am one. I think Karl [Steinbrugge] is. And I think quite a few real good engineers keep up-to-date that way.

Continuing Education Seminars

Degenkolb: But the average engineer doesn't devote that much time to it, and so they're not brought up-to-date. So we have seminars. I would say on that score probably EERI and the "Learning from Earthquakes" seminars—the seminars that we have before the [EERI] annual meetings—and the reports and some of the ATC studies where they've tried to condense the whole field in concrete design and recent developments, are probably the most important elements. But none of those are effective if the engineer won't learn. For a lot of engineers it's more interesting to go skiing or whatever, than keep up.

Scott: Well, the kind of reading you're talking about takes some evening time, or some weekend time, or some vacation time, or some of all of those. Of course going to seminars means you've got to take one day or several days off from your office or company.

Degenkolb: But the seminars are very well attended. Some of those over at Cal, when they put on one of the summer seminars—a full week—they'll have 400-500 people, so there are a lot of people who are interested. But still it's only a small percentage of all the practicing engineers.

Scott: Okay, now that's the other side of the coin. There are a lot of them who attend, but it is only a relatively small percentage. Those who aren't attending very much—aren't they nevertheless still designing substantial structures?

Degenkolb: Unfortunately, yes. That's where some of our problems lie. They all read enough to know the code and some of the old basic principles, but as to keeping up with modern developments, only a percentage of them do. I think that's true of any profession, I think it's true even of an auto mechanic. They've got to go back to school and learn. The best way to explain it is it takes two to tango. We can present the stuff, we can make it as easy as possible, we can condense it, but somebody also has to want to receive it.

Incentives—Requirements?

Scott: How about giving them added incentives, or making it some kind of requirement? In some professions the members are required to go back and take refreshers. Maybe it's one day or maybe a week.

Degenkolb: All the courses and seminars that we give now offer continuing education points. One point for this course, three points for that course. I'm not sure where we stand, but there was a big push a few years ago to require that when you renewed your license you had to have so many refresher points.

Scott: But that's not been made a requirement?

Degenkolb: I don't think that's a requirement now. It is in some states [*Ed. note:* Only in Iowa is it a requirement]. When it was proposed, nationally and in California, a lot of consulting engineers argued against it, saying that if the guy's in regular practice, he has to see that his knowledge is current.

Scott: You mean that, in theory, he has to keep up?

Degenkolb: In theory, if he's in practice, he has to keep up. We know that's not 100% true. But in some fields, for example if he's going to be a good waste water facility designer, or do anti-pollution work, he's *got* to keep up.

Scott: Is that because those fields involve new technology, and he doesn't have it at all if he's not up-to-date?

Degenkolb: That's right. But it's the same thing with earthquakes. On vertical load there's a little new, maybe, on some techniques, but not much as compared to earthquakes.

Earthquake Safety: Tested Infrequently

Scott: One problem may be that with earthquakes, it could be 5-to-50 years before you figure out who the guys are who weren't up to snuff.

Degenkolb: That's one of the big problems: if someone is a bad doctor it shows up fairly soon. If you're a bad accountant, the IRS will catch up with you pretty soon. But you can be a bad engineer, and if you've taken care of your vertical loads, the building may outlive its usefulness and be torn down before it's ever tested in a strong earthquake. So meanwhile, we have many different opinions as to what's good and what isn't, and it's hard to say who is wrong or right until you actually see the results of an earthquake, and they don't happen very often. That's a field where I think I can get out of my depth. It's something we've discussed in every organization.

Bay Area: Good Location for Continuing Education

Degenkolb: The Bay Area here is unique—the structurals put on seminars, all the universities put on seminars. We have ASCE available nationally, as well as other programs. We are probably in one of the best locations in the country for continuing education. We have not only Stanford and Cal, but also San Jose, and San Luis Obispo. All of these are putting on courses and seminars. A lot of the young people take them, and some of the older people take them. You can tell when they're giving a good seminar. They'll get a good percentage of the community who belong to the associations, like the structurals. But there are also those who don't even belong to the organizations, that don't do anything. Maybe a continuing education requirement would be a good thing.

Scott: Well it would be a way. At least, if it were put in place and enforced, they jolly well would attend.

Degenkolb: Yes, they'd have to attend, and they'd have to study enough to pass.

Scott: These seminars and continuing education programs you're talking about are good programs—they're not just little flimsy ones?

Degenkolb: No, this is good solid programming.

Establishing a Requirement

Scott: What if a move were made to put in such a requirement? It's not revolutionary—some of the other professions already have such requirements.

Degenkolb: Yes, and some states [only Iowa] have it for engineers.

Scott: What or who would be pushing for it? What will be likely sources of support, or of the effort needed to get something like that in being?

Degenkolb: Legally?

Scott: I'm thinking politically, the structural engineers for example. Would they be for it or against continuing education requirements?

Degenkolb: My hunch is that they would be divided, but that the majority would be for it. ASCE has a strong program. Every time they have an annual meeting, there are always 20-30 courses being offered, for which continuing education credits are given. I think most of your technical societies, while there would be some division, they would be for it. The whole thing—as to whether it's valuable or not—depends on the quality of the programs. Here [in northern California] we have good ones. If I were an engineer in, let's say, Fresno, where you don't have a very large engineering community—although Fresno is getting pretty large too—it could be a hardship. And you could argue that they don't need it as much [in the country] as in the cities, where we have more industrial growth.

Standards of Professional Practice

Scott: There is a good deal of concern about the standards of professional engineering practice in California and about enforcement. Would you talk about the system of regulation in California, under the State Board?

Degenkolb: First of all, the State Board [of Registration for Professional Engineers and Land Surveyors][70] has a majority of public members, which is a mistake. It used to have only a few public members, one-third or something like that.

It used to be that only civil engineers and land surveyors were registered. When others (mechanical, electrical, etc.) were registered, they changed the name of the board to "professional engineers." By changing to a professional engineer, a P.E. can operate in anything, although they should not. Thus, as a civil engineer I should not be practicing electrical or mechanical engineering. An engineer should first of all be either civil, mechanical, electrical or chemical. Everything else is made up of those. They licensed a lot of people in fire protection with no background in the basic things, and also you kept on getting "grandfather" provisions.[71] Mechanical and electrical engi-

70. The full title is the State of California Board of Registration for Professional Engineers and Land Surveyors. Degenkolb generally refers to it simply as the "Board of Registration" or the "Board."
71. Grandfather provisions are those from which currently practicing members are exempt and which apply only to new applicants.

neering are related fields, but a good mechanical engineer will not do electrical work or vice versa. While civil engineering and surveying are related, civil engineers don't do surveying—I'm a civil—we don't do surveying, we don't do drainage, parking lots or things like that. We do structures.

Lack of Enforcement

Scott: How are the State Board standards enforced?

Degenkolb: It's up to the guys to police themselves. It's just wrong. Right now the license is not protecting anybody, because there is no enforcement. We have this one guy up in Reno who went broke in L.A., got seven lawsuits against him that we know about, yet nobody said anything about his practicing. He's a California structural engineer, yet I wouldn't be surprised if he loses his license in Washington before he loses it in California.

When failures occur—Kansas [licensing board] made a mistake on the Kansas City thing [the failure of the interior bridge at the Kansas City Hyatt Hotel], and I think they are nailing one guy who should be nailed, and also maybe nailing some poor innocent engineer, but at least they are doing something. We have failures all over the place and we're not doing anything. The board is just sitting there.

Scott: My impression is, first that the actual examination and the granting of the license is in question. The people who are well qualified get licensed, but so do people who are of questionable capabilities. Then the second thing is following up afterwards in terms of enforcement.

The Importance of Judgment and Experience

Degenkolb: You get into real legal, technical problems. When California was a small state and the engineers knew all the young fellows, we relied a lot on references, as well as on the examinations. We have now become a big state, with literally hundreds taking the exams. I've turned down guys who worked in our own office when they asked me for references [to take the structural engineer's examination], yet they are licensed. I said "No, this man is not qualified." In mathematical knowledge he is, and he is a college graduate, but he does not have the judgment or experience. This is very painful.

I don't know what the answer is. A lot of people have the requisite numbers of years of experience, but not the ability. They have mathematical ability, but they don't have the engineering ability. But maybe I'm just getting old.

Scott: When it comes down to evaluating engineering judgment, that's a hard point.

Degenkolb: That's right. Yeah, I think it's wrong now, but I don't have anything to offer that is better.

Licensing Tests

Degenkolb: When I was young I was on the [SEAOC] legislative committee, and was one of the guys who helped put through—in error I think—the engineering fundamentals test that is taken either in the senior year or when they first graduate. This is a national test that judges only their background. Then for political reasons—we [in California] use the national civil engineer's test—the same civil engineer test that's used around the nation. I think it's a mistake technically. We have a special problem of earthquakes, and the national exam doesn't test for earthquake knowledge.

What happens, actually, is this—you take the engineering fundamentals test as soon as you get through graduate school. Then after a certain number of years of experience—two or three years—in addition to school, you can take the civil exam, or the mechanical, or electrical, or whatever.

Then eventually with more years of experience we take another test, as structurals. I think structurals are the only ones that do that, have to take an additional test. In the days when I took it, it was a 16-hour test. It was a 16-hour test of the civil, 16-hour of the structural. And they're open book. You had to know your stuff.

Scott: A pretty demanding test.

Degenkolb: Those are demanding tests. But then because of other states.... A lot of engineers here would like to practice in Maryland or Pennsylvania or some other state on an occasional job. But they can't because California doesn't recognize their [those states'] civil tests.

Scott: No reciprocity.

Degenkolb: And so the civil engineering test is done on a national basis. I can understand the reason for this, but from an earthquake point of view, since the civil can do a highrise building or an auditorium—can do anything except a school or hospital—I can argue for public safety, or I can argue for reciprocity.

Scott: The single national test does not include earthquake-related matters?

Degenkolb: I don't know what the present practice is. They used to get around that by giving a so-called oral test to a civil from another state. This may be a written one-hour test on just earthquake, or it may be an oral test. I remember [Nathan] Newmark was a consultant on the Gate Bridge—a very famous earthquake engineer—I was one of his references. They gave him an hour oral on the earthquake exam when he came from Illinois. You can recognize the problem but we don't have the solution as far as I'm concerned.

Reciprocity Issues

Degenkolb: I do think we need some sense of reciprocity. In my case, I have it for several states because I took their examinations. While they don't want to recognize California, as long as I got my Oregon license back at the beginning of the war, they'll recognize the Oregon license. And Nevada recognizes California. And a couple of other states recognize Oregon's license. Maybe not now, but they did in those days. Anyway, reciprocity is important, but it is on the opposite side from earthquake public safety in California.

Scott: Is there any way to have reasonable reciprocity through some modification of the one-hour kind of test you were talking about? It seems pretty minimal. But if the guy just doesn't have it—I guess you could screen out the real incompetents in a one-hour test.

Degenkolb: I don't know.

Scott: Or would you make him take a day-long or week-long test, or short course in how you do it (and don't do it) in earthquake country?

Degenkolb: Then you would not be giving reciprocity. You would really be hurting a lot of people.

Scott: Well, it would give the guy an option.

Degenkolb: That's the way you and I would argue, but politically I don't think it's very sound. I'll use an example. We did a school up in Seward, Alaska. Gordon Dean [of H.J. Degenkolb Associates] is licensed there, so that wasn't a consideration, but the architect had to have an architectural license up in Seward. Well, to get his license in Alaska he had to write a paper on permafrost foundations. Well, now, who helps him write the paper? We do, naturally. So I mean it's a token thing. It really is the same as your one-hour, or fundamental, or oral test. It's a token thing. It really doesn't mean much. Yet in a big state you can't handle it the way we used to handle it in the 1940s.

This licensing thing and the competency of engineers—that is one reason that I think independent review is so important. It's more than just to catch mistakes. It also means that certain matters of doubtful competency—whether people from out of state or local—have a chance of being caught.

I just ran into this project in Oakland, we looked up two of the names of the engineers involved, and they don't even belong to the structurals, which leaves them in about the lowest level. It isn't the lowest organization, but it's the most direct organization, and almost every brick contractor, you name it, belongs, just for the contacts if nothing else. Yet we have a lot of structural engineers who don't even belong to the organizations, and others only come to meetings once a year, or only a few times a year.

Scott: That is not a very high level of professionalism.

Degenkolb: That's exactly right. But the structurals recognize the problem and they will be doing something about it. Because actually, if something fails to perform, all disciplines of engineers and architects are affected, even if only one was at fault. When the fault is the structure, that generally involves safety and everyone has been getting much more concerned about this. Any improvement has to be done through the State Board of Registration and I don't know just how.

Board of Registration: Inadequate Enforcement

Degenkolb: Right now they're [the Board of Registration for Professional Engineers] in the throes of a lot of trouble. They are changing their practices from grading the examinations on a curve—so that a certain percentage of each group tested will pass, based on the bell curve. They have just changed over, or are in the process of changing, saying, "The heck with the curve—everyone tested will have to meet certain minimum requirements to qualify." And I think with the first test that was done that way, the number passing dropped from 30+% to 10%.

The Board has not been effective in weeding out incompetent engineers. Once an engineer gets his license, if the guy doesn't make waves, he can get by without doing very much. There are movements afoot to improve that. There are certain engineers that have had a lot of troubles, and they should have their licenses lifted. But the Board has not done that.

Scott: Is the Board aware?

Degenkolb: They've had some upheavals about it.

Scott: Is it a matter of Board policy to be very lenient?

Degenkolb: I'd say the policy is that they felt they couldn't do anything about it. Maybe that policy has changed.

In the old days they used to tell me when they'd catch a fellow designing something—practicing engineering without a license—it would be prosecuted in local courts by the local district attorney. But it was very difficult to take away a guy's living.

Scott: Even when he didn't have a license at all?

Degenkolb: That's right.

Scott: But isn't that flat-out illegal?

Degenkolb: Yes, but you still have to convince the local people. I think they've now gone past that step, but the next step is to weed out those engineers *with* a license who have consistently had failures, and have not been chastised.

Scott: You mean their poor performance is common knowledge?

Degenkolb: Yes. There are several right now that everybody knows—certain individuals who have so much trouble. As long as they are allowed to practice, the license law doesn't mean much.

For example, a firm had designed a building down in San Jose, right near the City Hall. Some allegations were made that it was incompetent design. So the State Board of Registration asked us if we [H.J. Degenkolb Associates] would review the drawings and give an opinion as to whether it was competently designed. That building was bad, and so they charged the firm with incompetence, and then the fur flew for several years. That case dragged on for years and years because they [the firm that designed the building] had good attorneys. It seemed to me that every six months the Assistant Attorney General in charge of the case would leave for private practice, and then you'd get a new one. The case kept getting delayed, and delayed and delayed. They would set a trial date and then it'd be postponed. They'd set another trial date and there would be depositions and it'd be postponed.

Finally, it ended up that they got a slap on the wrist, and the company involved turned out the publicity as if they'd won. I was in the middle of that, and was castigated all over the place, and I couldn't say anything. And I have a hunch that experience may have caused the Board [of Registration for Professional Engineers] to go pretty slow.

Scott: Was it the Board that charged the firm with incompetence?

Degenkolb: It was the State Board of Registration. They, in effect, lost.

Scott: In court?

Degenkolb: There was a settlement before it went to trial. I think, in court, the Board would have won. But it kept getting delayed. They finally settled out of court. It wasn't tried at all. It had been going on for so long.

Scott: Why did the Board take so long?

Degenkolb: My understanding is that once such matters go the Attorney General, it's out of the Board's hands.

Scott: That's probably true. This was probably a decision by the Attorney General's office to drop the whole thing, or to make a settlement.

New Policies of the Board

Degenkolb: Right. There's been a turnover in the Board, and a new executive secretary. I do know that they were trying to move against that guy in Reno with a California license, who went broke once down in L.A. One of the concerns was that the Board wanted to hire an attorney and not turn it over to the Attorney General, because they would lose control over it, and their experience had not been so good. Then this got mixed up with some changes in Board membership. The executive director was fired and another guy came in, and I don't know where things stand now. It gets very mixed up in policy.

But the status today [November, 1985] of the engineering license in California? It is supposed to be the toughest license by far in the nation, but the status is really not very good.

Scott: It's supposed to be the toughest in the nation—in terms of the exam or by what measure?

Degenkolb: Well, as I said, on civil engineering they [the State of California Board of Registration for Professional Engineers and Land Surveyors] use the national exam. There was a big hullabaloo about that quite a few years ago, because a civil engineer is also authorized to do earthquake engineering. Nevertheless, they used the national exam, but from what I've heard, the national exam has been beefed up, and I think that they can add some local questions if they want.

The structural engineers [SEAOC] recommend questions and people for writing the state [civil engineering] examination, although the state [Board of Registration] officially does it. Gordon Dean for years was on the SEAOC Structural Examination committee. That committee would have engineers write the examinations and with each question they would have a couple of the fellows answer it, and then go over the questions and answers in committee to make sure there were no goofs, that they were good questions, etc. That committee also graded the structural portion of the exam. I always avoided that. Since I was teaching, I thought that would be a conflict of interest—at least it was a good alibi.

The change in policy, as expressed in the last Board newsletter, is that an applicant must have a certain amount of experience, in addition to the examination, to determine whether he can practice or not. Since there is so much judgment in being a specialist, such as a structural engineer, they've now appointed technical advisory committees [to recommend technical qualification requirements] for different specialty fields. The first one established was for electrical or mechanical or something. Going into past records of applications and test scores, this advisory committee made up of several top engineers in the state found that except for a very few cases, when they said, "This guy isn't qualified to take the exam," the test results proved it. So now they're trying to be much more careful about who they admit to take the exam—asking if they really do have the experience they say they have. Ensuring that applicants have the necessary experience and background before they are permitted to take the exam.

Scott: In other words, they check back on the references?

Degenkolb: Yes. And it's supposed to be much better, at least potentially much better. That goes along with the idea that if you're getting this type of person more, you're probably getting a higher proportion of people who are really interested in keeping up in the field. But only time will tell.

Continuing Education Requirement

Scott: If a continuing education credit requirement were put in place, so that every three years or whatever a professional would have to have obtained those credits in order to renew his license, would that automatically create a substantial market so you'd have a lot more engineers coming in to flood the existing programs? In other words, could the existing programs handle the load?

Degenkolb: Oh, they could handle it all right. Our programs for the structurals are held in the PG&E auditorium. They've been very cooperative. Over at Cal, we've got Dwinelle Hall, which can hold 600-700, and if that's too small, there's always Wheeler Auditorium. Details of handling larger numbers—some details would of course have to be worked out. More than just evidence of having attended lectures, you would also have to have some proof that you'd learned something. The way it would be set up, or at least the way it is set up now, you don't have to require everybody to take certain specified courses. You'd require them to take so many credits in the field. The work could be given at San Jose State, or Santa Clara, or Cal. We've got a lot of universities around here. There are a lot of sources.

Ensuring Quality of Courses

Scott: Would all these programs you mention be presumed to be pretty good?

Degenkolb: That's the other thing. I would assume there'd have to be some accreditation setup. If the subject is earthquake safety, maybe by some Board representing several disciplines or experts in the field.

Scott: To review the curriculum, the exams?

Degenkolb: To give approval, yes. There must be some setup now that does this nationally. I've often wondered about this. When I see the descriptions of the courses like those of ASCE: this course gives 1-1/2 credits and this other one gives 2 credits. You wonder why should there be that difference? Obviously there are some criteria I'm not familiar with used to determine that.

There are courses given at ACI [American Concrete Institute] about earthquake design that probably do more harm than good. I've seen some of their courses, and the teachers I know who are in it don't know what they're doing. So there would have to be some system of accrediting. It's not an impossible task.

Actually, if it is done for earthquake engineering, I think they should also do it to a certain extent with practically all the fields. Right now, some of the worst fields are asbestos management and waste management. No insurance company will insure—our policy has a rider so that we are not insured for anything having to do with asbestos, the Clean Air Act, anything of that nature. There have been too may lawsuits. You can't get insured. I should think that things like fire prevention engineering might be involved—they would want to make sure that if you're qualifying for that specialty you'd be up-to-date on atriums and a lot of other new things that are coming into buildings, and that pose special fire problems. While I see it from an earthquake point of view, when you look over the whole field, you see there would be room for an awful lot of these other things.

Scott: When you talk about the basic structural engineer, and the firms that design buildings and structures, what kinds of things are covered in refresher work, is it mainly good design for vertical loads?

Degenkolb: Oh yes. But there are seminars on all kinds of things—on plain old civil engineering, without earthquakes. We've had seminars on welding—a big thing, and not as simple as many people might think. There are seminars on the use of the concrete code. The concept behind the ultimate strength design. There's the American Society for Testing and Materials—ASTM. To keep up-to-date on what's going on, there would be work in all the fields.

Possible Requirements

Degenkolb: I should think you'd have different requirements, that if you specialized in civil engineering, and in certain fields, you could get so many continuing education units in this field or in that field. A structural engineer is supposed to be a civil engineer with a specialty in structures. So there would be maybe two-thirds or three-fourths of the work on earthquake design, and the rest on newer systems—such as curtain walls, and foundation things that have been learned. We're interested in earthquakes, but I think every field in civil engineering has essentially the same problems—though maybe not to the same extent.

Strategy for Enacting Requirements

Scott: How would you go about working out a curriculum or a set of requirements? Would you set up a committee under the umbrella of the structurals?

Degenkolb: I would either go under the umbrella of the structurals, or the technical advisory committees of the Board of Registration. We renew our licenses every three or four years. I'd ask what they think would be needed in order to keep up-to-date, what fields and how many courses should be taken? I would guess that engineers should average taking maybe one course a year, or maybe a couple of courses, depending on their length, and the credits given. The work should be in specified general fields. Maybe with one or two required fields, and the others as electives.

There was some talk at one time about giving credits for attending the structural engineers' monthly meetings. I'm not sure if that's good or bad, but our structural monthly meetings are on technical matters. That is, they talk about the failure of this structure, or the research in Japan on some topic, or about everyday problems that we have. Maybe credits could be given for reviewing work like that of the committee that wrote ATC 10,[72] or something like that.

Scott: How would you go about getting continuing education requirements enacted?

Degenkolb: First of all I would try to ascertain the attitudes of the Board of Registration and its committees. Then, at least for the civils and structurals, I would go to the civil engineers and the structurals and explain it at a meeting, first of all a meeting with the officers. Then try to set up an association meeting, or maybe use one of their monthly meetings, to describe what is proposed and why. If the response is halfway favorable, you go ahead, either writing a Board regulation, or if necessary getting some legislator to introduce it as a law. If there were a well-worked-out plan, and the program would obviously not be too onerous, and would be something meaningful, I don't think you would have too hard a time to get it through. Maybe I'm fooling myself, but a lot of the engineers I know are trying to keep up-to-date and they attend these seminars. And they're eventually the influential ones who determine the outcome. If they go along with it, then the guys that don't come to the meetings will be dragged along without their knowing.

Scott: And the ones that are attending are not going to be afraid, because they've been going to the seminars anyway and know what is offered and they presumably like it.

Degenkolb: That's right. But certainly after getting some early discussion with the Board or their committees, I'd make sure it's discussed with all the organizations, like civil engineers and land surveyors, the structurals, the consulting engineers, the ASCE, so that you'd have all of the basic groups informed and on our side—or at least not fighting it.

That has to be done first. You don't just all of a sudden drop on them the idea that you want to do this. It would fail. You'd scare people and antagonize them.

Working Out A Plan

Scott: You said, if a well-worked-out plan were submitted, you thought it wouldn't have too much trouble getting support. How would you work out such a plan, and would you do it before you talked to the Board and the advisory committees?

Degenkolb: I'd first talk to the Board staff in generalities, and then I would go to the technical advisory committee and make sure they are involved, and that you have their blessing. They are representatives from the structural organizations in the state, and they are generally the ones that are pretty well thought of and acquainted with certain problems.

72. *ATC 10: An Investigation of the Correlation Between Earthquake Ground Motion and Building Performance*. Applied Technology Council, Redwood City, CA, 1982.

I would try to work it out with them, or have them recommend, or have them get some help. Anyway the plan would sort of come from them, rather than from somebody outside. If it comes from them (advisory committees to the Board) I think it has a lot more chance of being sold. Not knowing what the other fields are, I think I would try to limit it [the continuing education requirement] to the earthquake question, which we know about and know we have a problem with. And suggest that the other Boards look similarly at their own areas. I'd work mostly with the earthquake matter, and get that in place if possible. I think if it's carefully done, it wouldn't be too darn hard to do.

Other Vehicles: EERI? SSC?

Scott: What would be some other vehicles? Do you see EERI, for example, as possibly playing a role, or the Seismic Safety Commission? What are the pros and cons there, or would it be better to work with others?

Degenkolb: EERI I would not see. It's sort of in a state of flux. I've always had in mind that the original intent was that EERI was mostly to deal with the scientific and engineering end, chasing earthquakes, basic knowledge, coordinating everything about earthquakes. The code stuff was done through the structural engineers or ATC, or whatever. There was a division there. The Seismic Safety Commission could well be involved, but at the present time I would not take it on as a big highly-publicized crusade.

Scott: That could blow the proposal right out of the water.

Degenkolb: Yes. I can see quietly discussing it with the State Board of Registration and seeing how they react, and with a little encouragement from the Seismic Safety Commission, talking about it to the advisory Boards to see if it can be sold in a nice way, then going to the organizations. I'd try to clear all the paths first. Whether it would come from the SSC, or the Board, or the profession itself. It would be sort of nice to have it seem to come from the structurals.

That might not be too hard to do, actually. I would clear it first with the Board, or at least the staff of the Board and then through their advisory committees, because they represent structural engineers from all over the state. If you get their blessing and have them take it up and sort of start to agitate that the structurals should do this, it would have a better chance.

The First Move

Scott: Who might make the first move? Would there be some way of getting an ad hoc self-starter committee of one-to-three people?

Degenkolb: If you want, in the next few days I can talk to Ted Canon of our office, who happens to be chairman of the [State Board of Registration of Professional Engineers and Land Surveyors] advisory committee of the structurals. It's a statewide committee and I have nothing to do with it, but he has been meeting with the Board and is very active in this whole changeover examination. I'm not sure, but think its about 10-12 guys from all over the state. Al Blaylock, who's on the Seismic Safety Commission is also on this advisory committee. There are some good people on it.

I'd broach it to Ted and see what he thinks about it. Let him broach it informally to the advisory committee at their next meeting, and see what their reaction is.

Scott: And maybe talk to Al Blaylock. Of course, we'd have to be careful because it's probably not good for it to look like it's a push coming from the SSC.

Degenkolb: It can be a gentle nudge, but not a push. There are so many things that are involved. For example, I will be talking down at Cal Poly—they're interested, so next April I'm giving a talk down there on earthquakes. Also in the spring, I've agreed to go to Hawaii. When I was giving a lecture up in Seattle, they had about 250 attend. The average engineer is interested in this stuff.

Scott: Seattle, was that the workshop given recently for architects?

Degenkolb: No, for engineers. It was a year and a half ago. The majority of the engineers are interested in doing things right. There's not much that's written on the subject, unfortunately. Most of the textbooks are too erudite in a way, too hard to read. This incidentally is why EERI's seven-volume monograph series[73] went over so big. That was a huge success because it put things down that were easily explained and understood. Top people in the field contributed. That grew out of the seminars—these were joint SEAOC, ASCE, and EERI seminars on earthquake design, held in San Francisco and then elsewhere. As a result of the seminars, seven small books were published—highly successful in all aspects.

Getting Research Results Into Practice

Scott: Much of the intent of continuing education is to encourage use of existing knowledge and new research findings in actual practice. Would you comment a bit more on that—the practical application of research findings in engineering practice?

Degenkolb: The big concern of NSF, and a concern of a lot of us, is that while we are doing a lot of research—and while a lot of it is chaff, I'll grant—it's also very difficult to get significant research results put into practice. So ATC published a resume about 1/2" thick [ATC 11][74] on all of the recent and current research on concrete joints and columns and beams for moment frames. The varied shears, the loadings, all of them with large and indeterminate loadings like earthquakes, into the nonlinear range and up to failure. So instead of a guy having to read 15 or 20 reports, each of which is 1/2" thick, he can read one 1/2" report and get the basic information as to what was learned.

As a matter of fact, I just wrote one of my real nasty letters to the US-Japan Joint Technical Committee [of the U.S.-Japan Research Program Utilizing Large-Scale Facilities] on the 7-story test over at Tsukuba, and on that project we had concurrently a dozen or so minor tests—that is subassembly tests, model

73. *EERI Monograph Series,* various authors. Earthquake Engineering Research Institute, Oakland, CA, 1979-1983.

74. *ATC 11: Seismic Resistance of Reinforced Concrete Shear Walls and Frame Joints: Implications of Recent Research for Design Engineers.* Applied Technology Council, Redwood City, CA, 1978.

tests at Cal, Michigan, Texas, and Stanford. My concerns were with some very uncertain points of this full-size test. It was thoroughly agreed that a rather short, fairly easy-to-read summary would be written for the practicing engineer, so he wouldn't have to dig through all the detailed stuff.

Well, a draft came while I was in Mexico City, and the summary report is worthless. They had a draft about a year ago that was excellent. I think there was too much opposition from certain parties because of the stating of limitations and such things. So I just wrote a hot letter to the committee about the thing being worthless and misleading the way they've written it. What we'd all agreed we should do was take all the reports and boil them down to maybe 20-40 pages on what a practicing engineer could learn from the investigations. I think it is very important. In this case it came out mush—well it's not mush entirely, and it will change.

Scott: They'll respond to you and maybe to some others?

Degenkolb: There will be others who will agree with me. They'll change the draft. All is not lost. With some of these things you have to hit them to get their attention.

Chapter 12

Ruminations

- *Earthquake Casualty and Damage Projections*
- *John Blume*
- *Seismicity of the Eastern United States*
- *The Liquefied Natural Gas Terminal Seismic Review*
- *School for the Deaf and Blind: Relocation to Fremont, California*
- *The California Hospital Act*

Earthquake Casualty and Damage Projections

Scott: What did you think of the EERI Annual Meeting? I attended both the seminar and the annual meeting.[75]

Degenkolb: I went to both, but missed the seminar in the afternoon, so I missed the papers by Karl [Steinbrugge] and Robert [Whitman] and Chris [Poland]. I read Karl's though.

Karl took over from Harold Engle and Jack Shields. They were the old insurance people and he was picked by Harold to follow up on that. Because of that he's had data that nobody

75. This Degenkolb-Scott interview took place following the 1986 EERI Annual Meeting.

else can get. He's gone to see the earthquakes. He's a structural engineer—he worked for the Offices of the State Architect and he's worked in engineering offices, so he knows what it is. So he has the background and everything else and a very unique way of putting things together. I was glad to see that he was on the EERI program. He knows a lot more about risk than the vast majority.

Scott: I think he felt like he was revealing some trade secrets for the first time.

Degenkolb: I think so. You see, several of us have been pretty close to him and worked with him. And he had data from his position in the insurance industry that couldn't be made public. So we were able to work with those data, but he would never publish on that type of thing.

Discrepancies in Damage Ratios

Degenkolb: But since Karl has left the insurance industry, he has been consultant to California insurance, and nationally the climate has sort of changed. A lot of his information is now being disseminated. I know I had some arguments with some others—why did they have wrong projections of damage? Why didn't they use the best? Well Karl's [data] does not appear in published sources. They can't refer to him. This is the common argument, because the insurance data is privileged. Actually, a lot has been published, but not as a single, coherent source.

They can't refer to him. I can't understand it, but among the researchers, if they can't quote an authority, they use what they can, even if they know it's wrong. As an engineer, even if I have to guess to get the right answer, I'd rather do that and have the right answer than be wrong about it. But that isn't the way a lot of the research people work.

Scott: You mean they feel they've got to find a published source?

Degenkolb: Yes. If they can't quote a source because it is unpublished, they will take another source, one which I can prove is wrong. But because I can't point to a published source, they'll take the wrong answer. That's the problem with ATC 13. In some cases Karl's figures and their [researchers'] figures are the same. In some other cases there are some big, big differences.

Scott: Are these with respect to damage?

Degenkolb: Damage ratios, probable damage from certain extended shaking. One of the results of the NOAA studies we did for the Bay Area[76] and Los Angeles[77]—the first two—was that there were some other studies done by USGS and Blume's office that had much different damage ratios. For certain reasons it became important to know which damage ratios were more likely. This gets into defense and economic studies and everything else.

76. *A Study of Earthquake Losses in the San Francisco Bay Area: Data and Analysis: 1972.* A Report Prepared for the Office of Emergency Preparedness, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Research Laboratories. U.S. Government Printing Office, Washington D.C., 1972.

77. *A Study of Earthquake Losses in the Los Angeles, California Area.* A Report Prepared for the Federal Disaster Assistance Administration, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Research Laboratories. U.S. Government Printing Office, Washington D.C., 1973.

They ended up going with our figures. Karl has the best dope in the world, literally.

Scott: You mean the damage data he's collected?

Degenkolb: Yes. He's made more studies.

Scott: Going back to '52 [Bakersfield] I guess.

Degenkolb: His is to '52, but Harold Engle before him did work in '33 [Long Beach] and some in '25 [Santa Barbara]. They worked for the insurance industry and they made studies on all that stuff. The water tanks in those days were a big deal because they were for fire, and if the water tanks went, then the sprinklers wouldn't work.

Scott: This was back in those days when you saw those tall water tanks way up a 100 feet or so on spindly legs.

Degenkolb: They still have them in some cases. I was glad to see that Karl is getting some of that stuff out, because it is a difficult field. The data tends to change because our building process changes, so you have to find some common denominators, which are not the codes—they're based on observations and the types of structures. And the types of structures have been changing over the years. But at least—like on the Mexico earthquake now—some of the effort is on statistical study of the damage ratios, which may not be too pertinent to the U.S., because the building practices are somewhat different, but they should at least give indications that would be relevant to some parts of the country. You look for any data points you can get on something like that.

Critique of Methodology

Scott: Well, as I understood it, Karl's talk basically critiqued the methodology for using and interpreting data, even though some of the data and methodologies were his own, as well as other people's. He was criticizing the inadequacies of using these to project probable future damage and costs.

Degenkolb: He was going into things that the others don't even appreciate—the definition of cost, the definition of replacement value, and all these kinds of things. Everybody knows what cost is, what replacement value is, but when you really get down to it as to whether you're going to use one figure or another, some of these get very, very fuzzy. A lot of people use the figures without really knowing the implications, and the implications can change several hundred percent.

And Karl has gone into certain phases. He took several typical highrise buildings and had Gosliner-McLean [estimators] estimate the relative and actual costs of the various components—beams, columns, floor slab, walls, elevators, electrical systems, plumbing, air ducts, etc., literally everything that goes into a finished building. Then, from his records and experience, he estimated the damage and repair costs of all of these factors so that he could estimate what replacement costs would be. For example, if the elevators were damaged, he knew what the percentage of total building replacement costs it would be.

He had 50 or 80 items—a long list. Karl went into a lot of detail for the insurance industry. He doesn't have to bring out all that detail, but the background that he has on that—he has done it so much more thoroughly than anybody else.

Worst-Case Assumptions

Scott: There's another aspect that's long bothered me about the estimates, the projections of probable damage and casualties. There may be an equivalent of double counting going on—in other words where they make worst-case assumptions, but then apply them to the whole damn region. In a real earthquake, it may be unlikely that worst-case conditions are actually going to be experienced totally region-wide. Am I overstating that?

Degenkolb: No, that's a real problem. I think maybe one of the best illustrations is San Fernando. Right at San Fernando and at Sylmar, there were high casualties and a lot of damage. But for future projections, then how much of an area do you spread that over? A mile radius, a 10-mile radius? When you have a poorly-designed structure 20 miles away that has had structural damage—not collapse or anything like that—yet for 10 miles intervening with decent construction you've got no damage. You can easily determine a cost estimate on whatever basis you want, but what is the cost referring to on a percentage? How much do you use?

When we looked at the deaths, unfortunately that's all we have in this type of thing. I think of Alaska. Fortunately, Anchorage in one sense is a rather restricted area and there, community-wide, you can pretty well say that there were 20,000 people at the time of the earthquake. Otherwise you get out in the sticks. It's compact enough that the shaking is more or less the same, so you can say that the 16 deaths or whatever it was in that area, related to a given population. However the mix-up there comes in—as you also have the landslide. Well fortunately you didn't have casualties, appreciable at least, in the landslides. But you don't get that situation very often. Long Beach and Compton and all that—the question is how far out do you count the people that are not affected, or are affected only a little bit, to get your percentage? We've gone round and round and round on that. We've taken all the figuring you can to make different assumptions, and like I said I hope we're within a 100%. If we're within 100% on some of these figures, we're doing real good.

The Data Should be Made Available

Scott: Should we encourage or prod Karl to do a little more? He's done that talk. That's really the first time I've heard him talk that way, other than privately. Should we encourage him to open up on some of these critiques and to do a little more writing?

Degenkolb: I'd like to see him. Well, he does quite a bit of writing I guess, and he's awfully busy, but for the good of the profession, and keeping other people straight, and since his data is better than anyone else's, I'd like to see him write it up and put it out. Right now there are several dozen "experts," and I happen to know that they're all wrong. Frank McClure and Karl and I (and Harold Engle in the old days), Henry Lagorio and Lloyd Cluff—were sort of a group that's worked with that. Karl and I know some of the figures and where they come from. And it just bothers me to see these other guys who know practically nothing about it, except what they read, going off and lying to you, and they're going to be quoted as authorities.

Vulnerability of the Coast

Scott: And those damage estimates are not merely intellectual exercises. The projections are actually used for some important decisions.

Degenkolb: That's right. It is a very important subject. If we're hit hard [by an earthquake], the economic consequences are going to be like nothing that has happened before. I know that sometime on the ATC 13[78] study, one of the driving forces behind it was—this is classified—the vulnerability of the coast in case of a major earthquake could affect our defense status.

Scott: You mean some of this information is considered classified because of that?

Degenkolb: Our parts of it are not classified. But it's being used as data for some classified studies.

Scott: You mean by that the military?

Degenkolb: Yes. I'll give you an illustration. It's common knowledge that at the time of the Tangshan earthquake [1976], the Chinese refused to let any information out, and the reason, very obviously, is that they're afraid of Russia. Tangshan was a center of manufacturing, coal mines, transportation. When it was knocked out, that meant the whole northeastern part of the country was highly vulnerable. They were defenseless.

78. *ATC-13: Earthquake Damage Evaluation Data for California*. Applied Technology Council, Redwood City, CA, 1985.

When we were in Harbin, they were building a subway, though the streets mostly weren't even paved. It was obvious that everybody knew that the subway was for air raid shelters, but nobody would quite talk about it. In those days they were very touch-and-go with the Russians.

Scott: Well, there had been border incidents so there was real concern.

Degenkolb: Oh yes. The two countries had different gauge railroads—for the last few miles of the railway (they tell me, I've never been there) they have axles fitting the other side's wheels, so that you can run the cars to a certain point, then change wheels and keep on going. The difference in gauges was an accident of choice way back when. Now, however, if the USSR wants to invade China and use their railroad stock for material and troop transport, they must change axles at the border, and vice versa for China.

Anyway, if you felt like that about another country and here is one of your main industrial centers, your transportation center in that area, manufacturing center, coal, is knocked out for a couple of years—you're not going to tell your enemies that. We were told, in essence, that it was in part done for this reason.

What bothers me about the damage projections is that they're using the wrong information in many cases, and Karl has the right information. I'd encourage Karl—he has such a wealth of information, of data, that it should be made more available.

John Blume

Scott: Would you talk a little bit about John Blume? He goes back to the pioneers, having worked with Lydik Jacobsen as a student at Stanford in the early '30s. Also, his name figures prominently, along with yours, in the development of earthquake engineering.

Degenkolb: We've been friends. Matter of fact, when we went down to New Zealand, John couldn't go. His wife sort of hung onto me and Anna. He was always sort of a driver. He's a little older than me. He's a little more uptight about his name or something like that.

One time I remember he told somebody, in an interview or something, that he wanted to be the biggest office. And I remember a letter between him and—I don't know who—there were strained relationships. He worked together with Newmark on various studies. They were always competing and yet they worked together, so I don't quite know what was going on.

Scott: You mean he and Nathan Newmark? They worked together at least part of the time, but there was tension?

Degenkolb: Yes, there was tension there, too. When Nate published something, and I did get a copy of a letter, which I shouldn't have had but somebody gave it to me, where John was complaining that he [Newmark] didn't name him enough in the bibliography.

Scott: Didn't mention John Blume's work enough?

Degenkolb: Yes. Ever since I saw that letter I keep looking at bibliographies, which I never would pay much attention to before, just to see who's in, what the policy is. It's sort of funny.

Scott: The politics of compiling a bibliography.

Degenkolb: Until that time I never even dreamt of anything like that, and then all of a sudden I started looking.

Scott: I understand that sometime along the way, in your respective studies of earthquake performance and ductility and the like, you and he were involved in some difference of opinion about concrete design.

Degenkolb: John has done a lot for the profession. I think, myself, he's a little bit too much on theory. That sounds like I'm downgrading theory, but I'm not. He's not as practical as I am, I think, and his office does not seem to be quite as practical. We hit it off wrong on one of the questions on steel and concrete. I wrote the analysis of their concrete book[79] for the steel industry, and that really pained him. He really objected to that.

Scott: Why did he object?

Degenkolb: Well, I told him they were wrong in several places. What happened was this. In the past I've probably been more thought of as a steel man than anybody. But I'm a wood man, or basically I was. Anyway, the steel people approached me about the time the Blume-Newmark-Corning book came out.

79. Blume, John A., Nathan Newmark, and Leo H. Corning, *Design of Multistory Reinforced Concrete Buildings for Earthquake Motions.* Portland Cement Association, 1961.

First of all, the reason for the book was the way we wrote the SEAOC Joint Committee code for earthquake [the Blue Book]. We recognized flexibility and we recognized ductility in a very crazy way by using "K" factors. "K" was sort of a judgment factor under which you designed a shear wall building for twice the load of the moment frame building. "K" was a judgment factor affecting the size of earthquake load bases in the type of framing. Theoretically, a flexible system had a low factor (K = 0.67) and a shear wall (stiff and brittle) had a K = 1.33, so it had to be designed for twice the force.

In earthquake country, we always had some highrise limitation or conditions. In San Francisco there was no limitation on height, but when buildings went over a certain height—about 84 feet back in 1906, then after 1955 it went to 160 feet—they had to have a steel frame. They had to take the earthquake load, the lateral load, in the steel frame. That's the first thing in the evolution. It was only steel that could be used, because of experience in 1906 and 1923.

On highrise construction, we did not have the experience of concrete. The concrete people—the Portland Cement people—up till the early postwar years, had really been the leaders in earthquake-resistant design. Like some of the other leaders, they got very commercial. They rebelled very much against the fact that only steel could be used in highrise buildings. They spent a lot of money then—we had debates about it throughout the state, I've been called evil and everything else.

Scott: When was this?

Degenkolb: Late forties, early fifties. So the concrete people, evidently (I'm told), spent about three-quarters of a million dollars, which in those days was a lot of money, on concrete testing and publishing the Blume-Newmark-Corning book to prove that concrete frame structures could be made earthquake-resistant. By that we're talking about the frame structure, we're not talking about shear walls. We're talking basically that steel had to be in the frame when it's above a certain height limit. The shear walls only work effectively to a certain point.

So the steel people approached me about writing an analysis of that book for their information. I got Roy Johnston, so the two of us—one from northern, one from southern California—we wrote this analysis, which was never published.[80] The steel people got 75 copies. Of course, it made the rounds, especially in California and New Zealand and Japan.

Scott: You mean your critique?

Degenkolb: Yes, our critique of their book. Ever since then, I am considered to be a steel man. I am seen as "absolutely against concrete." I grew horns.

Scott: You mean these are all allegations that people level at you?

Degenkolb: You're not kidding! John Blume, of course, was considered the champion

80. Degenkolb, Henry J. and Roy G. Johnston, *Critique of the Portland Cement Association's "Design of Multistory Reinforced Concrete Buildings for Earthquake Motions."* American Iron and Steel Institute, 1963. Unpublished manuscript on file in the Earthquake Engineering Research Center library, Richmond, CA.

of concrete. Actually, I think John has done fewer concrete buildings than we [H.J. Degenkolb Associates] have, and done more steel buildings than we have. We've done our share of both.

Scott: Could you say a word or two—or is it too complicated to sum up—on the essence of your critique.

Degenkolb: There are two keys:

1. One is that due to lack of knowledge, the code has always said we must have the most ductility we can possibly get. The best material, the most ductile, is steel. The concrete people went through these analyses and said that concrete may not be as ductile as steel, but it is ductile enough. It's sufficient, instead of the best. Well, we said "the best," *not* just sufficient. We took great exception to sufficiency, and that fight is still going on.

2. The other point is on certain of the tests. They tested members, and tested them in such a way that the joints weren't tested. I brought out that the joints were not tested and that they possibly were not strong enough. There had been one or two very minor tests, but there had been very few tests on joints. Something was going on in the joints, which they were not testing. It could prove to be a weakness.

I remember when the Engineers' Club was across the street from the present one, I spent three hours with John at the Engineers' Club bar one day. He was telling me how they were going to spend all kinds of money to prove me wrong, to prove him right. Ever since then, there have been very restrictive requirements on joints. The first concrete requirements for what we call "ductile concrete" in earthquake country were stated in 1969 in the San Francisco Building code, and after San Fernando, in the 1973 UBC.

Concrete Imitates Steel: The First Failures

Degenkolb: Concrete had an excellent reputation because it was always combined with masonry or concrete walls. Then the fashion grew to use moment frames and steel resistance—steel frame and its moment frame connections provided this. But then concrete tried to imitate steel and that was when we saw the first failures, which we didn't recognize—a couple up in Alaska in 1964 and a bunch of them in Caracas in 1967. From then on, once that happened, they started writing restrictions on concrete, on the way it's reinforced.

There was a large contribution from the Blume-Newmark-Corning book—how we provide ductility, and how they could calculate it to get the ductility, but they overlooked the joints. This had never been important in the previous types of buildings because of the walls. The tests showed that the joints were weak, and that has been changed. That change finally got into the '73 edition of the Uniform Code. Although we saw the failures in '64 and '67 [Alaska and Caracas earthquakes], it took until the southern California engineers saw the failures in San Fernando in '71 before they really believed it.

Like Frank [McClure] says—you have to see the earthquakes. You don't really understand or believe it in your mind or in your heart until you actually see a collapse, till you've seen bodies. It makes a whole difference from reading even the best reports. When they saw it in '71, then the codes were changed.

The Labels Were Wrong

Degenkolb: But getting back to Blume, it was sort of push, push, push, and that was the background of me being considered a steel guy and him a concrete man. He gets a little uptight about things, and I guess I get uptight about some different things, and relaxed about some things that bother him. I think that's mainly it.

Scott: You've referred to yourself as being called a steel person.

Degenkolb: I'm thought of as that.

Scott: Yet back in the '40s you were instrumental in getting more use of concrete for certain kinds of structures.

Degenkolb: That's right. We did the first highrise, with no frame, flat plate in Park Merced.

Scott: So on that project, you weren't a steel man.

Degenkolb: I'm just saying the labels were wrong. Regardless of all the stuff we did—which most people don't know about—regardless of progress and the changes we've made or anything else, I get the label. Because I wrote this one report, I'm a steel man, I'm considered anti-concrete. As a matter of fact, it even came up in dealing with one of these experts in this lawsuit about a year ago up in Seattle on the Sea-Tac Building [Airport Office Building]. That is Loring Wyllie, from our office, who is now a director of ACI [American Concrete Institute]. He's been up through the chairs, is very active in the committees. One of the attorneys was asking Neil Hawkins, and he thought "Well, Henry is a good steel man but Loring is a better concrete man." I took umbrage at that. This is based on research of the publications. If they go back far enough, they'll find that I did a hell a lot of concrete stuff myself. But it's the label, the appearance.

Scott: A gross oversimplification of your position?

Degenkolb: That's right, and of John's. We've checked some of his jobs, he's checked ours. There's no animosity between us. We're not enemies, but I'll have to grant that since '55 or something like that there's always been a little tension. We're just different people.

I remember at the time of the New Zealand world earthquake conference in '65, Nate Newmark was also rather unhappy with me. He said if only I'd put the thing in a publication, they could answer and put me in my place. I never even thought about publication. I figured there was no sense of criticizing the book publicly. My function was to point out what was in there, the weak points, the strong points. The steel industry was paying me for an analysis. I was not taking sides in that. That isn't the way it was perceived, though. Later on, for ATC 3,[81] when Nate was elected as the overall chairman by the group of us, he got me out in the hall and said "Would you take over the design committee, because if you don't do it immediately and I announce it, I'm going to have to ask John Blume."

81. *ATC 3-06: Tentative Provision for the Development of Seismic Regulations for Buildings.* Applied Technology Council, Redwood City, CA, 1978.

Scott: You said your analysis of their book was not published. When we compile your papers, as Frank [McClure] recommends, can we include that?

Degenkolb: Yes, we can do that. It's had enough publicity. I've been putting together some of my papers. I know I wrote on different things in the past and I've been trying to figure out where they are. However, I'm not one of these guys who because I wrote something 20 years ago, I still believe it. That's what bothers me.

Scott: You reserve the right to change your mind.

Degenkolb: Yes.

Seismicity of the Eastern United States

Use of Acceleration Data/Criteria

Degenkolb: The morning session of the EERI seminar[82] was fine up to a certain point. They were only talking about the geological aspects and getting certain accelerations—that's fine as far as they go, but that isn't where the big gap is. There's a big gap between accelerations recorded and damage observed. The geologists tend to use acceleration, and I notice that they use pga [peak ground acceleration], which is meaningless but can be measured. With ATC 3 we used *effective* peak ground acceleration, and that is where judgment comes in.

Just to illustrate—Pacoima Dam [in the 1971 San Fernando earthquake] had something approaching 1g, San Fernando had $1^1/_4$g. Yet all the damage in Mexico City is at 20%g. Coalinga was up in the 50 or 60 percent levels. They've had some up to 160%. Bill Cloud estimated that the peak ground acceleration in Anchorage was 15%g, so you had all this heavy damage at 15 and 20%, but then we have small earthquakes with a 100%g. So it doesn't mean anything, and yet that's the figure they were using. With our mathematical models and strength of buildings and ductility, there's no really easy way to close that gap.

To repeat, one of the measures most commonly used to estimate the severity of ground motion is the *peak* ground acceleration, but in many cases this is meaningless. It is thought that because the peak occurs at a very high frequency, it [the acceleration] occurs so fast that the building does not "see" it. If I hit a wall hard with my hand, an instrument would register several hundred percent "g"s, yet there is no damage. It has been predicted, and I believe that with better instruments, in more locations, we will eventually register 300%g in peak acceleration.

However, on ATC 3 we took 40%g as a measure of the *effective* peak acceleration. This is a guess, based on observation. Probably a better measure would be velocity, but this is not measured directly and is more difficult to use than acceleration (or at least different).

Scott: You say peak acceleration per se doesn't really mean anything, at least in terms

82. This Degenkolb-Scott interview took place just after the EERI Annual Meeting in February 1986.

of telling you what levels of damage to expect. Is this because it may occur as only a sudden spike on a curve, and not be extended over time?

Degenkolb: If it is a smaller peak, but the motion goes on for 5 or 10 seconds, then you've got a different thing. Maybe velocity is a better measure. In Mexico City you had 20 or 30 cycles of motion at 20%g, so that just builds up and builds up and builds up.

Using the swing analogy, you could say that the peak ground acceleration would give the swing a single tremendous punch and that's it. You could get a far greater effect with just easy cyclic pushes that keep on doing it at the right times.

Scott: Each time when the swing starts up again, you give it another little shove.

Eastern U.S. Earthquakes

Degenkolb: As far as they went, the EERI discussions of the mechanisms in the eastern U.S. and that kind of stuff—it was interesting. As far as mathematically meaning anything for design, all I can say is it may be good background material.

Scott: The message I got out of it on the eastern U. S. seismicity is that it really is a big mystery, or a whole series of mysteries. We don't have anything like a handle on it. We've got some little glimmers here and glimmers there, but it's a big mystery—enough of one that you really can't say much about expectations. Except that there isn't a lot of area east of the Mississippi where we can say we're pretty sure earthquakes are *not* going to happen.

Degenkolb: That's right. Just from the activity that seems to be going on—it's probably going to happen there. And attenuation—like with this recent Cleveland earthquake that was felt up in Ottawa and down in New Orleans—attenuation is completely different there than here [in California].

The big problem I see is that there are low recurrences, and there may be several hundred years or a thousand years between events. But you can't really say that designing for 10%g instead of 50%g changes the risk very much. The earthquake is either going to happen or not happen. If it happens, that 10% figure will not be good enough—10%g, let's say—half of our code or something like that. The whole problem is a tough one.

Eastern-Midwestern Design Criteria and Practice

Degenkolb: Warner Howe of Memphis has been brought up in a certain way, and he believes that we're all wet about all this stuff. He thinks we should just do decent engineering, and that tying a structure all together is all you need. On the other hand, I've been brought up always to design for earthquakes, and I couldn't design his way. What I'm really getting at is that we're both prejudiced. We've each been brought up and live in a certain way with certain attitudes, and it's hard to see the other side of the story.

Scott: That's interesting. Let me ask you more about him. Are you saying that under his philosophy: 1) you basically wouldn't build unreinforced masonry buildings, and 2) the buildings that you did design, you'd just see to it that they were tied together reasonably well, so that presumably the structure, in terms of life safety, would be relatively unlikely to flat-out collapse? Is that it?

Degenkolb: No, that isn't quite it. That's what we were trying to do with ATC 3, but you also have to design for some lateral load.

Scott: And you think he wouldn't have enough resistance?

Degenkolb: No, he wouldn't have enough resistance built in. He'd design for maybe a quarter of our code. Maybe a quarter of our code is enough for some types of buildings, even in a strong earthquake. But for a lot of others, at least a lot of the construction commonly done back there [in Tennessee], maybe even our full code isn't enough, to say nothing of a quarter of our code. He just hasn't seen an earthquake happen. He just doesn't believe it's going to happen there.

Although, I have a hunch, from what I've seen, that he tends to do better buildings than the average engineer there. At least he does tie them together. He does give some thought to it. If you've ever been in Memphis or Charleston—I think their percentage of dangerous buildings is much, much higher than ours by a factor of 10 or 20 times. What they think is good construction is very often pretty poor.

Attitude and Tradition—Not Cost

Scott: In selecting a resistance level or percentage of code, is cost a significant consideration?

Degenkolb: No, it isn't cost. It's attitude and tradition more than anything else.

Scott: And yet a guy like him [Warner Howe] is probably ahead of the rest.

Degenkolb: He's probably the best engineer in that part of the country, and he is aware of the problem for other places. He thinks some of the requirements that we suggested are unnecessary. What I was basically getting at is I don't think that anybody, any engineer, is free from prejudice. My prejudice goes one way because this is the way I grew up, the way I was taught. You should design for earthquakes, period! I would have to design for earthquakes even if I was designing up in Minnesota or someplace where you're not supposed to have any. I would still do a certain amount to provide stability. I couldn't do it differently. Others who have never had an earthquake, never seen an earthquake, their practices are just piling one brick on top of another—they just can't see it. They are prejudiced in their own way.

Scott: They build only for gravity force, a force pointing straight down, and probably for wind?

Degenkolb: That's it. But that also permits certain types of construction that we know are death traps in case of earthquakes.

Designing for Half an Earthquake

Degenkolb: I criticize what we're doing here with tilt-up walls, but in the east they do even less, much less. They have less anchorage, less tying together—that would be common there. Or you'd erect a light column and a bunch of light truss joists—I think if you leaned against a column you could bring it down. But they stand up and they're cheap. It isn't the cost, however, it's the systems used and the experience.

If they do have an earthquake and it's a big one, then designing for half an earthquake isn't going to do it. So you could say that designing for half-an-earthquake is a waste of money. You should either design for the earthquake or not. And for 400 years out of 500, you might be wasting money to design for earthquakes.

Scott: In other words, you either do it right or not at all.

Degenkolb: Right. That's a hard way of looking at it.

The Liquefied Natural Gas Terminal Seismic Review

Scott: Let's discuss the southern LNG (liquefied natural gas) Seismic Review Panel[83] and the process of establishing a need for the Panel, and the way the members were selected. Frank McClure has asked if the report, which supposedly cost several hundred thousand for the Panel's activities, was justified?

Degenkolb: If they ever go ahead with the LNG terminal, I think it was justified.

Scott: At the time, in the late '70s, it was actually quite seriously believed that we would be going into LNG here in California, importing the stuff. That wasn't just an imaginary thing. For a time everybody assumed that was the way it was going to go.

Limitations of the Quasi-Judicial Procedure

Degenkolb: We were in an energy crisis. In the first phase of it [the evaluation of sites and other design and construction criteria for the potential LNG terminal] we were engaged [by the California Coastal Commission (CCC)], along with Woodward-Clyde, in picking the pros and cons of some 20 sites or so. I think that came out reasonably well. However, the results were presented before a [PUC] hearing officer with all kinds of legal stuff, and to treat technical matters that way is incredible.

Scott: You mean they used a quasi-judicial or courtroom-type procedure in dealing with highly technical subject matter?

83. Beginning in 1977, the California Coastal Commission (CCC) and the California Public Utilities Commission (PUC) studied possible LNG terminal sites along the California coast. The CCC hired H.J. Degenkolb Associates to study the structural aspects of facilities design and Woodward-Clyde to study the geotechnical aspects of site location. CCC hearings were held on the reports of both consultants. As a result, the CCC recommended establishing an LNG Seismic Review Panel under the auspices of the PUC. Although the PUC originally rejected this recommendation, continued disagreement over seismic risk and design criteria disrupted their proceedings. Degenkolb was asked to participate in an informal meeting to discuss the formation of a panel, and who should serve on it. The PUC then decided to form the LNG Seismic Review Panel, with Lloyd Cluff as chairman, Degenkolb as a member. The Panel subsequently held a series of hearings in the presence of an Administrative Law Judge to determine the suitability of the Pt. Conception (Little Cojo Bay) site for an LNG terminal and the engineering criteria for the facilities. The report of the Panel was eventually adopted by the PUC: *Seismic Safety Review of the Proposed LNG Facility, Little Cojo Bay, Santa Barbara County, CA.* California Public Utilities Commission, November 1981.

Degenkolb: Yes, it's just crazy. At one time—this was in an earlier stage of it [the site review process] when it was still with the Coastal Commission—when Western LNG and I were on opposite sides and their attorney was asking the damn fool questions—actually, he was a damn smart attorney, but the legal system of questions and answers on very technical matters does not bring out the truth. We were arguing on certain technical aspects [before a PUC Administrative Law Judge], which the lawyers could not understand. Finally, a young engineer who was helping the attorney on questioning whispered to him "Why don't you ask him to tell in his own words what you want." Instead of going through the legal question and answer process.

Scott: In other words the young engineer was saying, dispense with the courtroom procedure for a while and get to the point?

A Different Procedure: Experts Asking Questions

Degenkolb: Exactly. Then later when we had the Panel, which was picked by the California State Public Utilities Commission, it was suggested that the Panel ask the questions. We had representation from both north and south, and we had geologists, seismologists, a professor, two practicing engineers, and Lloyd Cluff. Lloyd ran the thing, he was the chairman. He ran the meetings by giving one guy his head to speak, and keeping the attorneys out of it. Then, by asking the other side—and we had a group of five from USGS in the middle—"What do you think of this and why do you think that?" These were experts asking questions. We did the same thing with structures and things of that nature. The process was supposed to set a precedent. It was watched by the nuclear people.

Scott: You mean they watched the way you did things?

Degenkolb: The way the whole review system worked. And we came out with a report and the reasons for it and recommendations, down to the whole design process. Designating which were critical buildings and which were not. The critical tanks. We could make positive recommendations. For example, one of the questions that came up—which nobody other than an engineer would have said anything about—was how much it would have cost to "underground" these things? And then also on the steels, I asked, "Why aren't you using a certain type of stainless steel, which performs better at very low temperatures?" "Well, it costs more." "How much more?" So we made some qualifications—it costs $1 million more per tank, but that's only peanuts compared to the other things, and to the degree of safety achieved. There's no comparison.

Scott: You mean it's a lot safer?

Degenkolb: A *lot* safer. So we [technical experts] could put on restrictions that would have been very difficult for the PUC or someone else to do.

Less Adversarial and a Better Result

Degenkolb: I think the review process worked out very well. It made an awful lot more sense to have five or six interdisciplinary, competent people looking at the whole problem, not being restricted to what the lawyers wanted to do, being able to run the process and make recommendations. It was a lot more efficient, and I think they came out with a much, much better result, and a less adversarial process. Even so, it was adversarial, all right.

Scott: They got a better result than if they hadn't had a Board at all, or than if it had been an adversarial courtroom type procedure?

Degenkolb: Than if it had been an adversarial courtroom type of procedure.

Scott: How did you get away from the courtroom procedure? You commented right at the beginning that it was kind of crazy.

Degenkolb: Well, we were dealing with the engineers and the geologists, not with the attorneys.

Scott: How did you get away from dealing with the attorneys?

Degenkolb: We told the attorneys to sit in the back of the room and shut up.

Scott: And this was the Panel's decision—and Lloyd Cluff was chairman—and they didn't squawk?

Degenkolb: No. As a matter of fact, they were very interested in the process. I heard various comments on that. They could see that we were getting results much quicker, and getting things out in the open because we were letting the adversaries talk to each other, and finding out why they believe this, why they believe that. When they had the trenching [at Little Cojo Bay], they gave their interpretations and they had to present them and defend them simultaneously—in a discussion group rather than in a court type of setup.

I thought it was damn interesting myself. I learned a lot. We still have all kinds of papers that presented a lot of information. One of the agreements that Lloyd got—ordinarily USGS wouldn't touch a thing like that with a 10-foot pole—was to have participation by USGS guys who had been doing the mapping and knew where the faults were. He asked USGS, "You get your guys here," and they did. Practically everybody knew each other. These are people who deal with each other in organizations and stuff.

Scott: They respected the Panel, and Lloyd, and trusted them.

Degenkolb: And they respected each other as engineers or architects or seismologists. I think—we got involved in some of the safety stuff—the vapor cloud, how far can it go if it ignites, and all kinds of things like that. So we were not really restricted. The aim was to set the technical content, and to make the facility as safe as possible.

School for the Deaf and Blind: Relocation to Fremont, California

Scott: Let's talk about the School for the Deaf and Blind,[84] and the relocation from Berkeley to Fremont. Frank McClure has referred to an alleged "double standard" used by the Office of the State Architect, and the Division of Mines and Geology when reviewing their own work related to the Fremont site selection and design criteria. What do you think?

Degenkolb: That was a horrible set of circumstances. They thought that the Hayward fault went through the School for the Deaf and Blind in Berkeley. It's essentially a rock site, which is not bad. Without investigation, or with only the most preliminary investigation, they moved to the new site in Fremont. It [the Fremont facility] was designed by the State Architect himself.

CDMG [California Division of Mines and Geology] wanted them to trench at Fremont, because there was a report of a fault going through the site. Actually there wasn't a fault there [in Fremont]. There is a problem of liquefaction, however, because the Fremont site is only about 2,000 feet from the main branch of the Hayward fault. I am told that one of the reasons for moving was not earthquake safety, but a change in policy of teaching the deaf and blind. Later the parents sued.

84. The School for the Deaf and Blind was operated as a single school when it was located in Berkeley. Since moving to Fremont, it now operated as two separate schools adjacent to each other on the new campus.

Woodward-Clyde and Caltrans did the foundation exploration, and both again warned them about liquefaction. CDMG wanted to trench, but they were overruled by the Office of the State Architect—some place in the hierarchy of that.

Scott: The trenching would be to find a fault trace?

The "Double Standard"

Degenkolb: Yes, and also for more exploration regarding the liquefaction problem, which was discounted. So the parents of the children in the School for the Blind sued in federal court. The "double standard" is this: if the Fremont facility had been a project of a local school district, the Office of the State Architect would have required trenching and all kinds of tests. But for themselves and their own facility, they didn't do it.

Scott: That really is literally true. If a local school district had been proposing the same kind of building, the same structure, on the same site, etc., OSA would have come down hard on them.

Degenkolb: And how! And yet the same policy didn't apply to their own building. Then, in the actual construction of the buildings—there was a lot of hassle about it, but we [H.J. Degenkolb Associates] reviewed the drawings and the field supervision, and I think that once the site decision was made, they got a pretty good school, a pretty good setup—except that the swimming pool is tipping, and except for the problem of liquefaction. In this case, the liquefaction is not the kind where the buildings might disappear, but I do expect the ground to break up pretty much in earthquake shaking. I expect the buildings the kids are in are going to be tilted—nothing serious, but doors and windows will jam. For an average person, including the deaf, that would be not be too bad—not a real hazard. But for blind kids of preschool and school age, and for those who are handicapped otherwise, to be in the dark where gas lines can be broken and they're caught in the room with the doors jammed, I just think it is awful. Just walking on the sidewalk outside—if you've seen what happens in liquefaction—would be difficult. The sidewalk would be very uneven with breaks and troughs. For the deaf kids, or for the average kids—no problem, but for blind kids it was wrong [to move the site].

Berkeley A Better Site

Degenkolb: And it turns out, finally, that the Berkeley site at Dwight-Derby—that the university eventually got—is a better site than the one in Fremont. They'd have found that out if they had done their exploration.

And now the university, I just read in the paper the other day, has some 700 or 800 students there [on the Berkeley site]. They are fixing it up, and it didn't take very much fixing up. They were pretty good buildings to start with.

They got a final report, so thick, from some southern California geotechnical firm, where they answered specific questions [about the Fremont site]. It is a client's report in which they say "Yeah, there is a liquefaction potential but if it does happen the ground will go down 1/100 of an inch," or some god-awful figure. They were not addressing the truth, really. They were not telling any lies, but they restricted their answers to what they were asked. The judge then asked us what was our opinion, which I expressed in a letter. I said the sickening thing is that now I don't see any point in prolonging it. The Dwight-Derby site is gone, the children who the parents fought for in the beginning, they've outgrown it, there are new children in. You're not going to spend another $50 million or whatever and change the site.

Scott: So you've got to accept what has happened.

Questionable Actions

Degenkolb: And all the people who were involved in the decision have left the state service, and you can't call their actions criminal—they may have been acting in good faith.

Scott: You could call them questionable but not criminal?

Degenkolb: That's right. It leaves a very bad taste.

Scott: Yet, I guess what you're suggesting is that the thing is done, and unless the Fremont facility proves to be really an imminent life hazard, you almost have to recognize the fait accompli. Isn't that in effect what the judge did?

Degenkolb: Well, I'm not sure what his decision is yet. I think he wanted us to say—I haven't talked to the attorney since I wrote the letter. Since I wrote my letter I got a copy of what the geotechnical guy [Ben Lennert] wrote—not the same as the southern California geotechnical firm I mentioned earlier, but the expert on "our" side. He said the same thing I did, and I haven't heard the reply. But I think we probably put the judge on the spot too, because, in essence, we said we didn't like the report but the thing is a fait accompli. What are you going to do about it? I didn't see any reason to prolong the fight. The people that made the decisions are no longer with the state—that was years ago. They spent the money at the Fremont site.

Scott: At one point, according to conventional wisdom that I've heard by word of mouth, the Berkeley site was considered very dangerous.

Degenkolb: Oh yes. Dorothy Radbruch's[85] map shows a dotted line going back there, based on a statement that [Joseph] Le Conte saw a break in his backyard. Actually, we [H.J. Degenkolb Associates] trenched before the university acquired the site. We did a thorough trenching job to locate where the fault was. The break seems to migrate east, I think it is. It did go through a couple of buildings up on the hill, but the rest of it is beautiful. We also did the review/check of all the repairs and strengthening of the buildings. They had other engineers do it, and we reviewed it for the university. They've got good buildings and they got it pretty cheaply.

Scott: They got a bargain, didn't they?

Degenkolb: And it was thoroughly trenched so it should be safe. But the whole thing is sort of sickening. Of course the double standard aspect has no bearing in court. That just relates to our feelings about it, but that was not at issue. The issue in court was—are the Fremont site and its buildings safe for blind and deaf kids?

Scott: I can understand how the double standard would not have been an issue in court in this case. But it *is* an issue in terms of general policy, and it *is* an issue in terms of what constitutes genuine independent peer review, and few things like that. It's very central.

Degenkolb: That's right. It's very central to that.

85. Radbruch, Dorothy, *Approximate location of fault traces and historic surface ruptures within the Hayward fault zone between San Pablo and Warm Springs, California*. U.S. Geological Survey, Menlo Park, CA, 1967.

The California Hospital Act

Scott: Let's talk about the State of California hospital earthquake safety program under the Hospital Act.[86] Frank McClure suggested talking about the changes over time. Was the initial legislation, or the first regulations, a little too restrictive?

Followed Too Literally

Degenkolb: When you're writing a new code like the one on hospital safety, I really don't know how you tackle it correctly the first time. I think at first we tried to follow the law too literally—trying to make facilities safe for occupation after a major earthquake—and we forgot the little words in there, "insofar as practical." We brought up all kinds of things, like hospital access from the freeways, utilities available outside the hospital (maybe they should have a cesspool that's good for three-days usage), things like that.[87]

Scott: Were these all things that were put into the relatively new code for hospitals?

Degenkolb: They weren't put in the code, but it was being interpreted [that way].

86. The Hospital Act, passed in 1972, was a direct response to earthquake damage to both old and new hospitals in the 1971 San Fernando earthquake. The Hospital Act covers the design and construction of all hospitals and was modeled closely on the Field Act. The Act's intent was that all new hospitals built in California should resist earthquakes sufficiently well so as to continue functioning immediately after an earthquake.

87. *Report on the Hospital Act of 1972*, Prepared by the Task Committee on the Hospital Act of 1972; Henry J. Degenkolb, Task Committee Chairman. Seismic Safety Commission, Sacramento, CA, 1977.

Scott: The code was being interpreted in such a way that you actually did have to have these other things?

Degenkolb: Yes. Things that are not directly related to the hospital as such. There was a lot of going back and forth at that stage. I think, finally, one comes to the realization that the one element of seismic safety can't be interpreted to protect everything. You have to have several safety elements, and they each stand alone. If the hospital, for example, is good, and can operate, and has emergency power, and you've got emergency water and all that, but the streets are all littered with debris from other buildings falling down, you still can't use the hospital.

The underlying point is that there are many aspects of seismic safety, and they all have to work together. You can't do one by itself, even if you try.

For example, our experience on Moffitt Hospital [now Long Hospital] at UCSF [University of California at San Francisco]. That was the first of the highrises that was required to have a dynamic analysis, and it was located on a hill.

Scott: Was that analysis required because of the new Hospital Act?

Moffitt Hospital

Degenkolb: Yes. Before that they [hospitals] had been six stories or less, and while some had been done with the dynamic analysis, none had been *required* to have the dynamic analysis. We had quite a few meetings with CDMG [California Division of Mines and Geology] and OSA [Office of the State Architect] at the very beginning, so that we wouldn't waste our time with design and find out that there were some basic disagreements. In trying to do a decent job, I think we put ourselves somewhat in a straitjacket. We agreed to certain response spectra, certain designs that were very hard to fulfill. The new building is probably four to five times as strong as the addition to which it is connected—the original one that Huber [Walter Huber of Huber and Knapik, consulting engineers on the original hospital] designed and built in 1955.

In an earthquake, it is not strength alone that counts—it is strength *and* ductility, and he did a good job with 5%g. We were designing with coefficients of 20%g, and I think, in the final analysis, his building may perform as well as ours, despite all the very rigid requirements we worked under.

Excessive Foundation Anchoring

Degenkolb: One of the requirements—one that I was pretty bitter about at the time, and I still think is a mistake, but I don't know quite how to correct it—goes back to the '60s when we got afraid of the performances of buildings that came down in Caracas [mid-rise reinforced nonductile concrete]. While we see objects overturn, we do not see well-designed buildings overturn. (Actually, we have now, in Mexico City, but that was because they had compression failures on the compression side, and that caused piles to pull out of the ground. But that is an example of *foundation* failure.)

Anyway, with Moffitt, we've got one shear wall the length of the building, and three cross walls that are the full width of the building, and we had to anchor those to the rock for something like 2,000 tons uplift in several places. It would have been good enough if we had just placed it on the rock, without the anchoring. As a matter of fact, by following the results of the analysis to the bitter end, and thoroughly ignoring our own experience and judgment, I've said that we wasted a million dollars in foundation work that will not do any good—it will probably do more harm than good.

Scott: Was it the dynamic analysis that, in effect, told you that you needed that extra foundation anchoring?

Overturning Effect and the "J" Factor Reduction

Degenkolb: No. It was the forces that resulted from the dynamic analysis. It would have been the same thing if we'd used the static analysis. We had gotten our forces so high, that we have this mathematical theory that says the building is going to overturn. If the earthquake force doesn't last that long, there's the rotary moment of inertia of a building as a whole—it may sway, but before it sways very far in one direction, the forces start going the other way. It takes many seconds [of earthquake motion] for a big building to overturn.

It's a rather technical thing, but nobody has been able to figure a way out of it, except what we did on the original Blue Book. We had a so-called "J" factor,[88] which reduced the moments, which would have taken care of the overturning effect. Actually now after just read-

88. The J factor is a reduction factor applied to the axial forces in columns resulting from overturning moments.

ing in Vic Bertero's paper (on moment-shear ratio), it's also caused by making it too strong and overturning. When a crack appears, we want it to come from moment (overturning), which can be ductile—but *not* from shear, which is brittle.

Our mathematics looks very complicated in any earthquake design. You've got a lot of assumptions, and if you follow it too rigidly, you lose sight of the assumptions at times. This can lead you into very expensive things. Also, if you're not using your head, it can lead you into some very dangerous things. This is one of the reasons we chase earthquakes. It takes some common sense, in addition to providing practical experience, and observations of what actually happens so that can be compared to how we analyze probable performance.

Caracas was some time ago, and I've talked to Frank [McClure] about it several times—if we'd kept the J-factor that we had before the Caracas earthquake, we would have reduced the overturning force requirement, and saved a lot of money, and I think had safer buildings. Many column failures were observed in Caracas—and it was before the days when we knew about reinforcing concrete to provide ductility.

One way to get bigger forces into the columns—design forces—was to eliminate the J-factor. So we eliminated something that was good, in trying to correct another problem, and we've been paying for it ever since. But the code is a democratic thing.

The "J" Factor and Design Changes

Scott: Would you say a word or two more about the J-factor?

Degenkolb: The process of calculating a building—whether by dynamic analysis or static—is, first to decide on a base shear coefficient. You design for how much load is coming into the building. That has to do with exposure, the type of building, the period of the building, the location with regard to faults, and everything else that's in the code.

Then, because buildings vary greatly, that load has to be brought into the building by inertial forces on the different floors in a certain pattern. This pattern is not an actual one that you would measure in an earthquake, but it's an envelope of all possible actions. Well, if the moment diagram is like this or like that, we design for an envelope because there are some reversals in the actual building.

If you take that envelope as a static force, however, you generate large overturning moments. You neglect the fact that the forces may be going south in one floor, while three floors down the force may be going north at the same instant. They're canceling each other, which means you may have very high shears. That's what the envelope is for, but because you're not accounting for the canceling effect, it means you are making the overturning forces—really overall moment forces—ridiculously high.

In Caracas, we had these 5-, 10- and 12-story pancakes and column failures. (I've got pictures of columns from 1906 on, I think, failures all over the place.) One way of looking at it is that we were not making the columns big enough, which is true. One way to correct that is *not* to use the J-factor, that is not to reduce the overturning moments. That way you have to handle more force in the columns, and so the columns are designed bigger and, presumably, will not fail as badly. Well, that didn't work. You still got failures because the big element is the bending in the column, and the consequent shear and the confinement. I used the example of Olive View [Hospital in San Fernando, CA]. In the same building, you have the tied columns where the binding bars are only 18-inch centers, and the columns were just gravel inside, as the concrete pulverized. Where you had spirals as confinement, the columns survived a 2-foot offset, and they're nicely curved.

We saw a lot of the gravel columns in Caracas, and in trying to fix those up they got rid of the J-factor, the relief factor for overturning. The engineers tried to treat one problem by changing something else. Now I've just read the results of the Japanese full-scale test, and finished this thing from Egor [Popov]. The requirements of the code are making us design so strong—this does not pertain to Moffitt—in moment where we want it to fail, that we may be forcing the failures into shear, where we don't want it—because shear is a brittle failure, whereas a bending failure is a ductile failure.

That has to be corrected in some way, and it has not been corrected. It's been improved a little bit. I think the only way eventually they're going to correct it is to go back to the J-factor. It's a problem that practically all the researchers are now aware of, but it's not something that we can get in the code. It sounds wrong to suggest we're improving a building by making certain parts of it weaker, but nevertheless, it's still the case.

Foundation Work

Scott: Let me go back specifically to Moffitt Hospital and that foundation work. There again it was a matter of this theoretical overturning problem. Because of that, you had to attach the building to the rock to resist theoretical uplift forces?

Degenkolb: In some places we bored 50 feet into the rock, put down huge steel sections with lugs, and then fastened tension columns all the way down—the tension was worse than the compression.

Scott: And you feel, just in terms of your own judgment and common sense, that it really wasn't necessary?

Degenkolb: That's right. I believe that the majority of engineers who deal with tall buildings agree with me. But you don't know quite how to counter it, and that was the law—we should do it that way, it was in the regulations. You just don't throw them away lightly. That's the biggest thing. We have [calculated] shears that are so big that the shear walls would have been about four feet thick. We couldn't afford the space, so we have steel shear walls—the first in the state. We had steel plates between columns, to act as shear walls, with concrete for fireproofing and transfer of loads. We put concrete on both sides of the steel. That is a very heavy thing.

The state didn't have anyone on the staff to check the job, so they hired four consulting engineers [four firms] from San Francisco to act as the state's consultant—Mike Pregnoff; Graham and Hayes; McClure and Messinger; and CIGNA. We got into some arguments, too.

Scott: Between H.J. Degenkolb Associates and the checkers?

Misleading Computer Results

Degenkolb: Well, actually one of the four consultants didn't agree with the other three consultants, but it worked out. With some of these very technical matters—it isn't a matter of being right or wrong. You make certain assumptions, and then when the computer results come out, all of a sudden something is overstressed. For example, some of the walls, about the third-floor level, had to be discontinuous because of operations. So you bring this wall down here—in essence a two-foot wall with a steel plate in the middle—and we're picking the wall up over here, and all of a sudden we've got fantastic loads on this wall. We carry part of this wall now, and we carried the loads in both directions. When you looked at it, the walls were only connected with about an 8" concrete slab. There was no way we could get those loads into the other wall. But the assumption the computer program used was that the floors were rigid diaphragms and all the columns moved together. So to get a right answer, we had to go beyond the ordinary programs. If you just read it out of the computer, you may get something that is completely wrong.

There was one little element of a wall, I forget even what it was for, and there was no way that we could protect it. We just finally said it's in an unimportant place, nothing is going to collapse, so we're just going to let that wall crack. We don't do that mathematically. But everybody finally agreed that's what we should do. You needed the wall for fire and other reasons.

Problems with the Mechanical Systems

Scott: Let's go back to the Hospital Act generally and regulations or interpretations under that.

Degenkolb: Well, there was a lot of trouble, for example, with the mechanical systems. The first ones that came out—I think we did the first bracing [of nonstructural and mechanical equipment] at Stanford Hospital.

Scott: This is post-San Fernando?

Degenkolb: Yes, with the Hospital Act. There are the usual things done in order to make them calculate, in order to make them figure for code things. We had to do some rather strange things. For example, things that had been 4" steam pipes. You needed some flexibility because of heat, and yet you couldn't let the thing slop around in vibration. I remember that there was a $^3/_4$" water line in the basement of Stanford Hospital to take care of a hose bib for the garden on one side of the building. By the time we'd braced that, it must have cost $20,000 or some god-awful figure just to get a piece of line for a rather unimportant part of a building over there.

After a few examples like that, OSA [Office of the State Architect] realized that this couldn't go on. We can't design individual ducts for every building, so the Sheetmetal Manufacturing Association, sheetmetal contractors, developed a set of standard details for heating ducts. If they were used, they would provide the earthquake bracing required by OSA. So it turned from a rather major make-work problem into a problem with a more sensible solution.

Scott: By having this general-purpose solution?

Degenkolb: That's right. We still have to anchor x-ray machines, and still have to anchor all kinds of stuff, and those are specials—but at least for all the ducts and all the pipes, we now have standard details that seem to work adequately.

Scott: And are not too expensive?

A Shakedown Period

Degenkolb: Not too expensive. But I think you have problems with anything you do the first time. The Hospital Act was a new adventure, it was different from schools because the reason for it is different. You have to have a shaking-out period.

Scott: The key thing was to try to make the hospital safe enough so it could continue to function as a hospital, *after* surviving a major damaging earthquake.

Degenkolb: That's right, that's the main thing. And I think, on the whole, the way things are done, if it does not operate it will not be because of the hospital itself, but will be because the sewer system is broken or the overpass in front of the hospital is down, or something like that.

Scott: In other words you're saying the hospitals designed and built under this law really will do what we have said we want them to do?

Degenkolb: I think so. There are going to be some mistakes, but by and large I think they're inspected better, they're checked, and they're also more expensive. There are going to be some goofs—there's no question about it. But, by and large, I think that the hospitals are going to perform damn well.

Scott: Well, that side of the equation is certainly good.

Degenkolb: That's what we're aiming for.

Scott: Now on the question of the shakedown period. It's now 14-15 years since the Hospital Act was passed. In your observation, do you think it was part of a shaking-out period when we got these exorbitantly expensive requirements, and that they are now being interpreted a little bit differently?

Some Problems Are Universal

Degenkolb: There are still some problems, but that's not limited to hospitals. That's universal. Structural engineers are writing the new edition of the Blue Book. It's been submitted to UBC, we still have to make changes, but it's being prepared so that the '88 edition of the Uniform Building Code will have a new code, a new generation. And there are still some things in it that are not very good. But that's really because of ignorance as to how to handle the matter.

The overturning is still a major problem. If I had it to do over again I might argue much more for reduction of the overturning moments. There are a lot of people who would back me up—I'm talking about the research people who are really working on these problems. But it would have to be on an ad hoc basis, and that also means that the civil service people involved would be sticking their necks out. OSA did better than most, as far as that is concerned. They generally try to cooperate.

Scott: You mean they try to give things a commonsense interpretation when the theoretical requirements begin getting out of hand?

Degenkolb: Yes.

A Big Problem: Modeling a Structure

Scott: Let me ask about the significance of the fact that code provisions, computer analyses, and literal interpretation of the results sometimes combine to give clearly outlandish results. To me, that means there are some weaknesses in our theoretical understanding, or computer modeling, of what goes on in a building under seismic stress. If our theories were better and our models on target, the findings would also be on target. Something seems to be wrong. What do you think?

Degenkolb: One of the biggest problems is to model the structure correctly. Generally, only the structure itself is modeled, but the partitions and other things aren't. And there are some wild assumptions, even for example in that building across the street there [gesturing at the building across Sansome Street from the Degenkolb offices]. The length of the beams and the height of the columns makes a big difference in the results, or whether you take the clear span or the center-to-center span. And there are approximations.

What we do is take the results of the computer model—the computer analysis—and see if, in our judgment, it makes sense. Do the forces balance, is it logical, can we understand how the forces flow? If we can't, then we'd better look at the assumptions and find out what is wrong. One of the complaints today is that with less careful engineers, or some younger engineers, the computer is "god." Regardless of what they put in, they take the results out and follow them blindly. I've known engineers to do this, a lot of them, but I think there is now enough reaction against this that it is calming down.

This also ties in with the educational system, where we're training the engineers. There's a big emphasis on computers, as there should be. But some of us think that there is maybe not enough emphasis on the materials' properties, and on problems that go into the modeling. There are big gaps in knowledge, as to how a building reacts to the foundation—for example, soil-structure interaction. The results of the computer models—there are whole books on it, we've got one that came out recently—do not seem to jibe with what we see in the field, at least not in my opinion.

That should be one of the thrusts of the investigation of the Mexico City earthquake. A building affects the ground motion, the same as the ground motion affects the building. There's an interaction, and yet, as a rule, we pretend that there isn't. It gets very difficult. So we still have to keep chasing earthquakes to see whether the results of our modeling look reasonable.

Some of Our Theory is Primitive

Scott: Well, we're still learning, still working on theory. It just tells me that our theory is a little bit on the primitive side, or at least that parts of it are a little on the primitive side.

Degenkolb: It is a lot more than "a little bit!" There are parts of it that are on the very primitive side. There are other parts where we are pretty sophisticated and pretty well off.

Scott: Well, that's the scientific method—when your results tend to be wide of the mark, you keep revising your theory and doing new experiments. And of course, with earthquakes, the best experiment is still with the earth itself as a shaking table.

Degenkolb: And you may have to wait a long time between earthquakes.

Would You Change the Hospital Act?

Scott: Let me ask a general question on the hospital issue. You say there were some real problems with the law's application up-front, and that a breaking-in process has gone on.

Degenkolb: I'd say that was in the first five years.

Scott: Do you feel at this point that the Hospital Act and its administration are pretty well shaped up? Would you change it?

Degenkolb: Oh, I wouldn't change it. It has to be in general conformance with what our codes are. It can be more conservative in places, with more inspection, and more design review and so forth, but it can't go out completely alone, without respect to the other codes, because we just don't know that much more yet. So I think that, as far as the vast majority of things are concerned, the Hospital Act and its application are about as good as we can do now. I don't see any early changes coming up after '88, when we change the Uniform Building Code. As we learn more, however, our codes change. The *regulation* of the Hospital Act will also change to keep up to date. I hope there would be change, so that the codes are sort of in step.

Scott: You mean the other codes?

Degenkolb: Yes. The other codes and the Hospital Act and the Field Act. The Field Act is different because it deals with small buildings—schools. Where you're dealing with small hospitals that are only two or three stories, so that you're doing something similar to schools, that isn't bad. It's the great big hospitals that still cause trouble. And parts of them—such as the computer floors—are a problem, but that is the same as in office buildings. It's less of a problem in a hospital on the office floor, however, because they observe the requirements and inspect pretty thoroughly.

Anyway, I think the complaints we had 10 years ago have largely been eliminated. The hospital association people may not agree. One thing we did there—we did set up an appeals board. I'm not sure what kinds of cases are coming before it, but the representation is on the Board, and I would expect that is performing all right. Some other questions are posed—should every hospital be a trauma center or a burn center, or something like that. You've got to spread your resources, and I assume these types of questions are being handled with the appeals board process and the administration. I'm not that familiar with it.

Scott: Also, questions like that are not explicitly earthquake-connected.

Degenkolb: No, they are not explicitly earthquake. You had a third question down there, and I forget what it was.

$5 Million of "Unnecessary" Work

Scott: Frank had a question that started out with UC's Moffitt Hospital, and then asked about the role of the Office of the State Architect and the Division of Mines and Geology. Were there interpretations of the seismic provisions you had to follow that accounted for the $5 million of "unnecessary" work you were required to incorporate in the construction? He puts a few assumptions in the wording of the question.

Degenkolb: He's heard me talk about that. We looked at that site at the very beginning—you do your technical survey and everything else—and then it turned out that about three-fourths of the site is shelved into rock, and one-fourth of it, while the foundations go down to rock, has a layer of dirt in between, and the response is quite different. There was a 1,200-seat brick auditorium there at the time of the 1906 earthquake that did not receive damage. You look at the zoning of the damage at that time, and in 1906 that site was not shaken that much. But we did have a lot of questions and discussion about the matter. Here's this hospital, and this is on rock, and that is on dirt—is this going to put a lot of torsion in the building because the earth shakes differently than the rock? You can argue some theoretical points, like our modeling. You can argue those for years and never get any answers until the earthquake happens.

So we had a lot of discussion, but since everything is pretty well tied together, I don't think that is too much of a concern. My biggest concern is that we spent that much more money to anchor it to the foundation, and the building will probably not perform much, if any, better—and maybe worse—than the 1955 building it was added to, which was a pretty good design. That would be a very embarrassing blow to the Hospital Act and to me.

Scott: And yet you say that could well happen.

Fastening to the Ground: More Harm Than Good?

Degenkolb: That could happen. There's a big discussion going on about base isolation, putting a weak layer of some kind—rubber or something—between the ground and the structure to sort of cushion the structure. In a sense if you just put the building on the soil, without attaching it too strongly, you have a kind of base isolation, allowing some play there, and maybe the ground motion doesn't all come into the building. By fastening the building tightly to the ground, most of that ground motion has to go into the building.

To me that's a major concern, in that our codes may be causing us more harm than good on that item. I've seen evidence that we discuss at code meetings. After every earthquake, there are generally cracks around the buildings between the basement wall and the dirt. Generally, if there is a footing underneath a slab, very often you can see its outline in the cracks of the basement slab, you can see the outline of the footing, showing that there was a little play, a little movement. We've seen it in bridge piers, and I know that there is some slack there, some give, and we may be doing more harm than good if we take away that give. That's my biggest concern, and it is a very possible thing.

Scott: Your concern about this is that in tying the building to the ground so firmly we maybe have gone too far?

Degenkolb: Yes. That we are going too far in our present code requirements. Not only in the Hospital Act, but also in the other codes. That's the state of the knowledge now.

Scott: When did that get introduced?

Degenkolb: When we had smaller forces—this is another thing—in the older days we designed, let's say for 10%g, but we designed everything to working stresses, which had a factor of safety to yield, or a factor of safety of let's say, to make it simple, 2. So we're designing, in effect, for 20%g, but the forces actually only show at 10%g. With smaller forces, some things did not appear to be important—and that may be good. With higher forces, the structure is stronger—but so must be the coupling to the ground, and that may be bad in some cases.

Now, however, we've maybe doubled our strength to 20%, and are designing right to the elastic limit, with a factor of safety of 1 instead of 2, so we're designing to the same strength. But the uplifts in the columns are now based on 20% g instead of 10% g—they've doubled. So when we changed from one method of design to another that is theoretically and scientifically more correct, it brought along some other problems. The overturning is one of the problems. We changed the scientific system, the way we calculate things, and we didn't look at all of the complications that come along with that.

More Checking: Beneficial, But Has Costs

Scott: You're saying that an important part of the additional cost—that's what Frank's question is in effect complaining about—was due to a requirement that's not explicitly or solely related to the Hospital Act? It's related to codes in general and to checking and peer review. Whereas the tenor of Frank's question would suggest that the Hospital Act itself, and it's interpretation, was the culprit.

Degenkolb: Under the Hospital Act there are more people looking over your shoulder, more questions being raised by CDMG, and some of the problems become more pronounced, but *any* job that is reviewed by somebody else will bring up the same questions. It is only worse with the Hospital Act, in that you have more people involved and therefore more opinions in the pie, and more people to satisfy, and generally these are also the more conservative ones. But we're also saying, on the other hand, that because we have the Hospital Act, it is a beneficial thing in that more people are reviewing, more people are checking, so it's a beneficial process, except it has its costs at times.

I'm in favor of the extra checking. I don't like it if we expand it [the review process] to include too many buildings, although I'm in favor of checking. The process does cost more. I would venture to say on the schools, overall, it [the Field Act process] must cost 10% more in delays and everything else. The Hospital Act has more checks and balances that you pay for, you have more delays that cost money, and more frustrations on the part of the hospital people, even if they are in favor of it—you have more red tape. It [the Hospital Act review process] costs more than the schools' [review process] because it's more complicated. But that is a known cost to get a certain effect. So some of the deficiencies of the other codes are magnified with the Hospital Act. On the whole, I think it's doing as well as you can do, though it's frustrating at times.

The Cost of Seismic Protection

Scott: My impression is that, for the most part, and unless you are building on a difficult site, it is not particularly expensive to make a well-designed building seismically safe. But in some quarters, there are complaints about the cost under the Field Act and the Hospital Act.

Degenkolb: I guess the best explanation, the best illustration is the schools. Because of the 1933 [Long Beach] experience, we have a very demanding school code (the Field Act), and now we have a hospital code. Construction costs are generally affected only by very few percentage points—1 or 2 or 3 percent or something like that. And the checking process that the state does, probably costs 1 or $1^1/_2$ percent; it is on a sliding scale, but its cost is really not much. The other costs are due from delays to the school board, the red tape, the bureaucratic inefficiencies. My guess is that overall, schools cost 10 percent more [to build] than they would without the Field Act. California society has made the decision that in the case of public schools, the safety is worth the extra cost.

I also happen to think it is worth it. Some may consider it a bad way of doing things but it's probably the best way we have. Certainly in hospitals we fought hard to get that protection in. And certainly the hospital operators are concerned about the costs of a hospital. I would say that overall costs—not the technical costs so much but the overall hospital building costs—have got to be increased 10 or maybe 15 percent by the seismic safety requirements [of the Hospital Act]. That's a guess.

The actual cost of 4-6 months delay in building something, the red tape of following it through the construction process, even if it's only a checking fee of 1-1/2 percent or so that the state gets, becomes a major cost to society and certainly contributes to the medical bill.

Scott: Of course, we're somewhat more demanding of hospitals than we are of schools. Hospitals are expected to keep on functioning, despite an earthquake.

Degenkolb: Right. That's what I'm saying. I happen to believe that the extra cost is a legitimate expense for a hospital. But I'm not sure that I would say the same of the average office building or the average house. And yet, when I see what is going on, and I'm afraid of what might happen in a major earthquake, maybe it would be better to require some kind of higher protection. Certainly I think the present way that we're doing things is not providing the protection the public thinks it is getting. Whether they're expecting too much or whether they would be willing to pay for the safety they think they are getting—these are all questions whose answers I don't know. But if you use almost any other system, like we're doing with hospitals and schools, it's going to cost more, depending on how much of a safety review process you put into it. And as far as society is concerned we've got to balance that against the cost of food, or housing, or medicine, or education, and those are tough questions.

The Hospital Act: A Good Thing

Scott: In hindsight, since you and others had quite a bit to do with it, do you think it was a good thing that we put the Hospital Act on the books?

Degenkolb: Oh and how! You should see some of the problems down at the UCLA Medical Center and some of the buildings built before [the Hospital Act was enacted in 1972]. Loring [Wyllie] spends a day a week down there. Some are related to lawsuits, to repairing things, unsafe buildings. The UCLA report[89] came out the same day as the Mexico City earthquake happened, and they've got some bad buildings. For one thing, Frank [McClure] got involved with a parking garage that's with the Medical Center. Well, that parking garage is actually a collapse hazard.

Scott: There was a design error on that, wasn't there?

Degenkolb: Yes, there's a lawsuit on it, and it was designed in southern California. I'm not sure of the present status. But the water mains for the hospital go through that garage!

Scott: A weak link there.

Degenkolb: There are so many things down there that they did differently that weren't taken care of.

Scott: So you're a strong supporter of the Hospital Act, even though it costs more?

Degenkolb: Yes.

89. Campus at Risk: Report of the UCLA Ad Hoc Joint Senate-Administration Earthquake Safety Committee, September 1985.

Concluding Remarks

The last interview in this series was conducted on May 21, 1986. At the time, Henry and I intended to record one more interview after we had had an opportunity to review transcripts of all the previous sessions. This would have allowed Henry to wrap up any loose ends and make concluding observations and comments. In addition, I would have asked more questions about his early life and family, subjects only sketchily treated here. As thing worked out, however, the final interview was never held.

Even so, the fourteen interviews on which this volume is based are roughly twice the number typically recorded to cover an individual's life and professional career. Henry simply had a lot to say about earthquake engineering and its history. Henry's career began shortly after the science and practice of earthquake engineering began to develop in California. He worked with and for many engineers who pioneered some o the advancements, and himself contributed significantly. During these interviews, he looked back at this history with the unique perspective reflected in these pages.

Stanley Scott
Interviewer

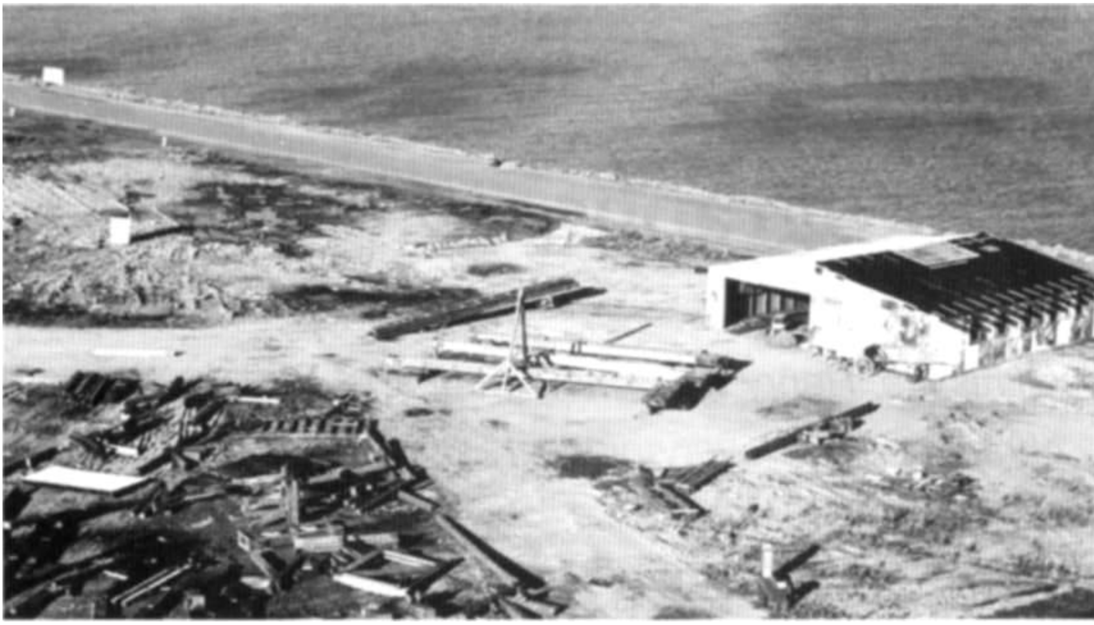
Photographs

All his life, Henry took photographs...
photographs of everything.

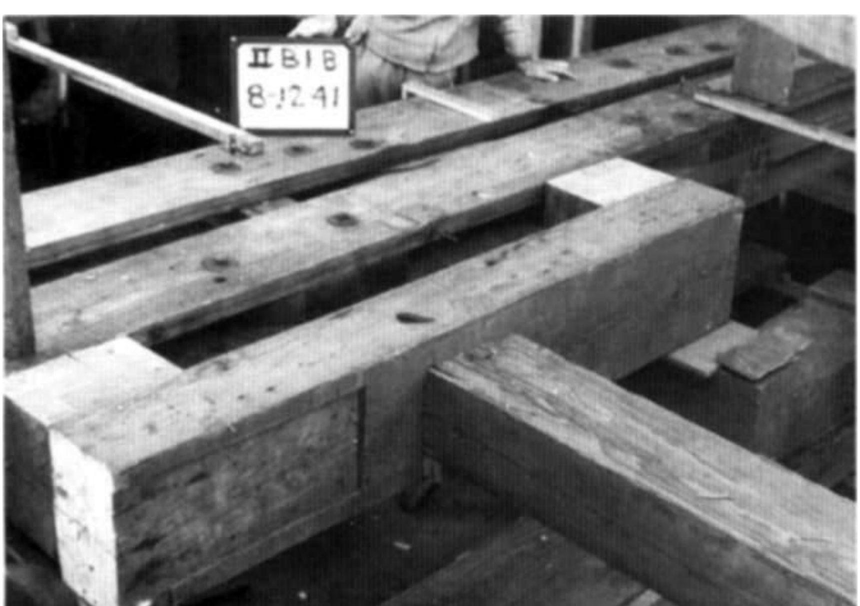
All his life, Henry Degenkolb took photographs. Photographs of construction, photos of earthquake damage, photos of family vacations, photos of everything, He often had two or more types of cameras draped around his neck as he inspected earthquake sites, field construction, materials assembly, or as he shepherded the family on its yearly camping and fishing vacations.

Degenkolb and his cameras documented most of the major earthquakes between 1936 and 1986. His photographic archives are extensive, numbering over 30,000 slides, prints, and negatives. He had an exacting system of cross referencing negatives, contact sheet and photo number, and the print or slide. Journal notes of his travels are punctuated with frame numbers for the photos he shot of that subject. Henry maintained these files all his professional life, and frequently referred back to them.

Though the photo files of Henry Degenkolb are extensive, photos of Henry Degenkolb himself are not easily found. The photos in this section were contributed by the Degenkolb firm, colleagues, friends, and Degenkolb's children.



The testing shed on Treasure Island; taken from the top of the Fine Arts building. Henry worked on the timber testing program from 1940-41 following the World's Fair. Said Henry, "We tested about 23 trusses, some 100-odd joints, and plywood, which was fairly new then as a structural material.... We tested everything to see how strong it actually was.... It was the most comprehensive testing of timber construction up to that time." (photo: Henry Degenkolb)



View of the loading apparatus used during testing of the Brazil Building, 1941. (photo: Henry Degenkolb)

Henry gave daughter Patty her first camera for her birthday in 1960 and she snapped a picture of dad. Henry brought the camera back from Japan, where he had recently attended the Second World Conference on Earthquake Engineering. The camera was a complicated affair, with a viewfinder you looked down into, a lens you focused yourself, and a tiny light meter—perhaps a little too complicated for a young girl, but Henry just loved it. (photo: Patty Degenkolb; unearthed from family archives by Paul Degenkolb)

With John Gould in the late 1950s. The photo behind them is of the Franklin Street telephone building in Oakland; the photo above Henry's right shoulder is of the Park Merced condominium/apartment complex in San Francisco—both Gould and Degenkolb, Engineers projects. (photo: *Engineering News Record*)

At the site of the Alaska Sales and Service Building, Anchorage, Alaska earthquake of 1964. (photo: Karl V. Steinbrugge)

In front of the Westward Hotel, Anchorage, Alaska, 1964. Left to right: Henry, John J. Driskell, Karl Steinbrugge, John H. Manning. (photo: James D. Simpkins; from the Karl V. Steinbrugge collection)

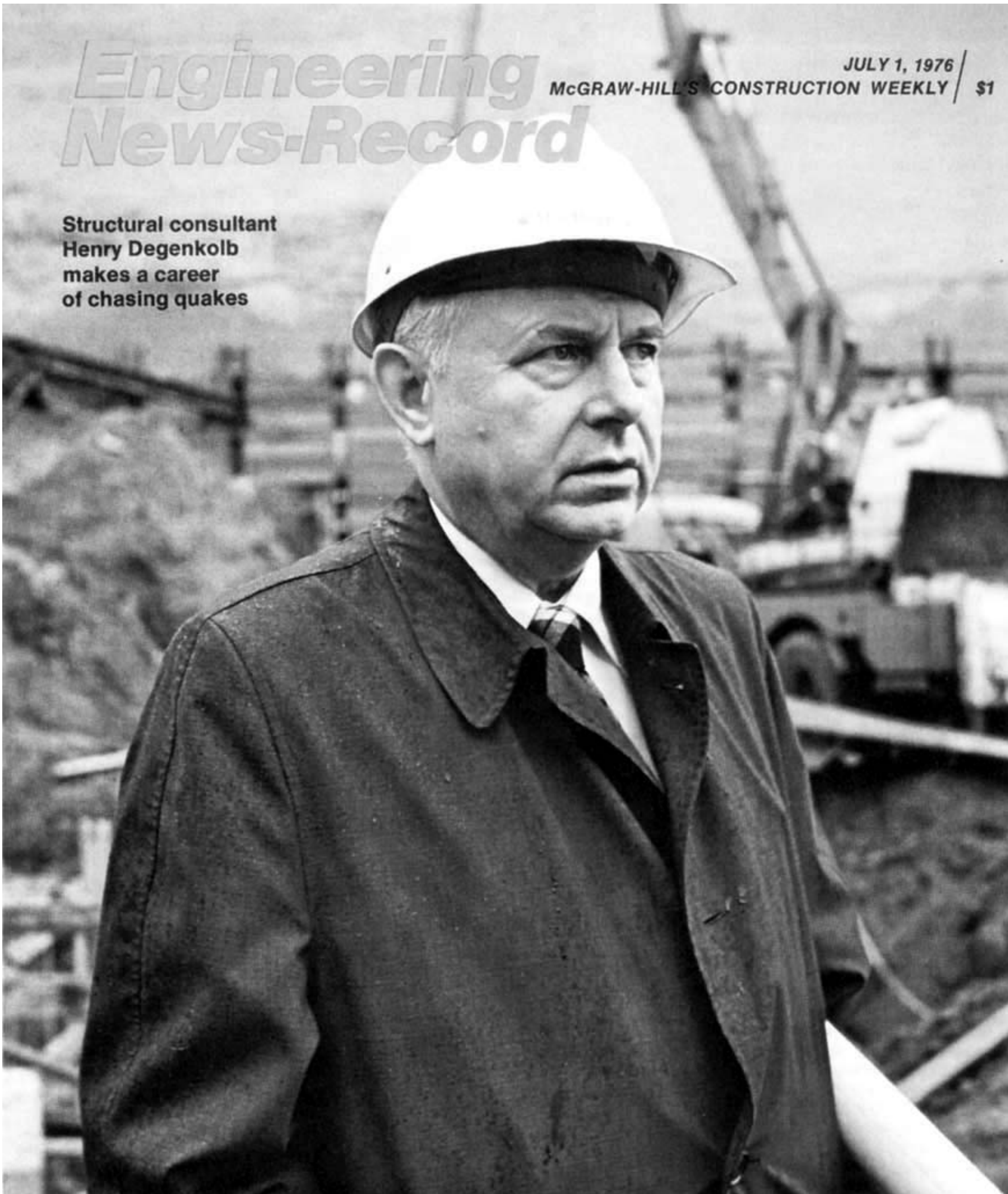
At the SEAOC annual meeting, held in Yosemite in fall of 1964. Henry and Karl Steinbrugge gave a presentation on the effects of the 1964 Alaska earthquake and what implications it held for engineers and engineering design practices. (photo: *Engineering News Record)*

Anna Degenkolb presents an award to her husband. Anna was president of the Femineers in 1962. (photo supplied by Patty Degenkolb Blanton)

Guest speaker at a dinner meeting of the American Society for Testing and Materials in April 1971.

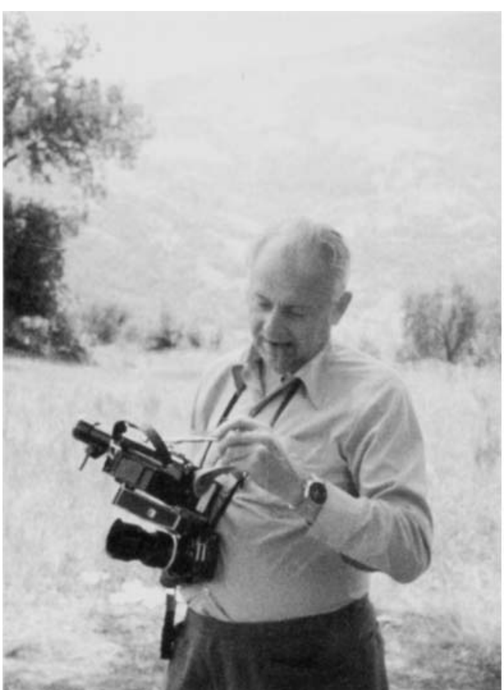
Frank McClure and Henry at Nina Scott's retirement party in 1974. (photo supplied by Frank McClure).

Outside a church in the Sunset district in San Francisco. The Degenkolb family had just attended a wedding, and Henry was snapped outside with camera bag and cigar. (photo supplied by Virginia Degenkolb Craik)



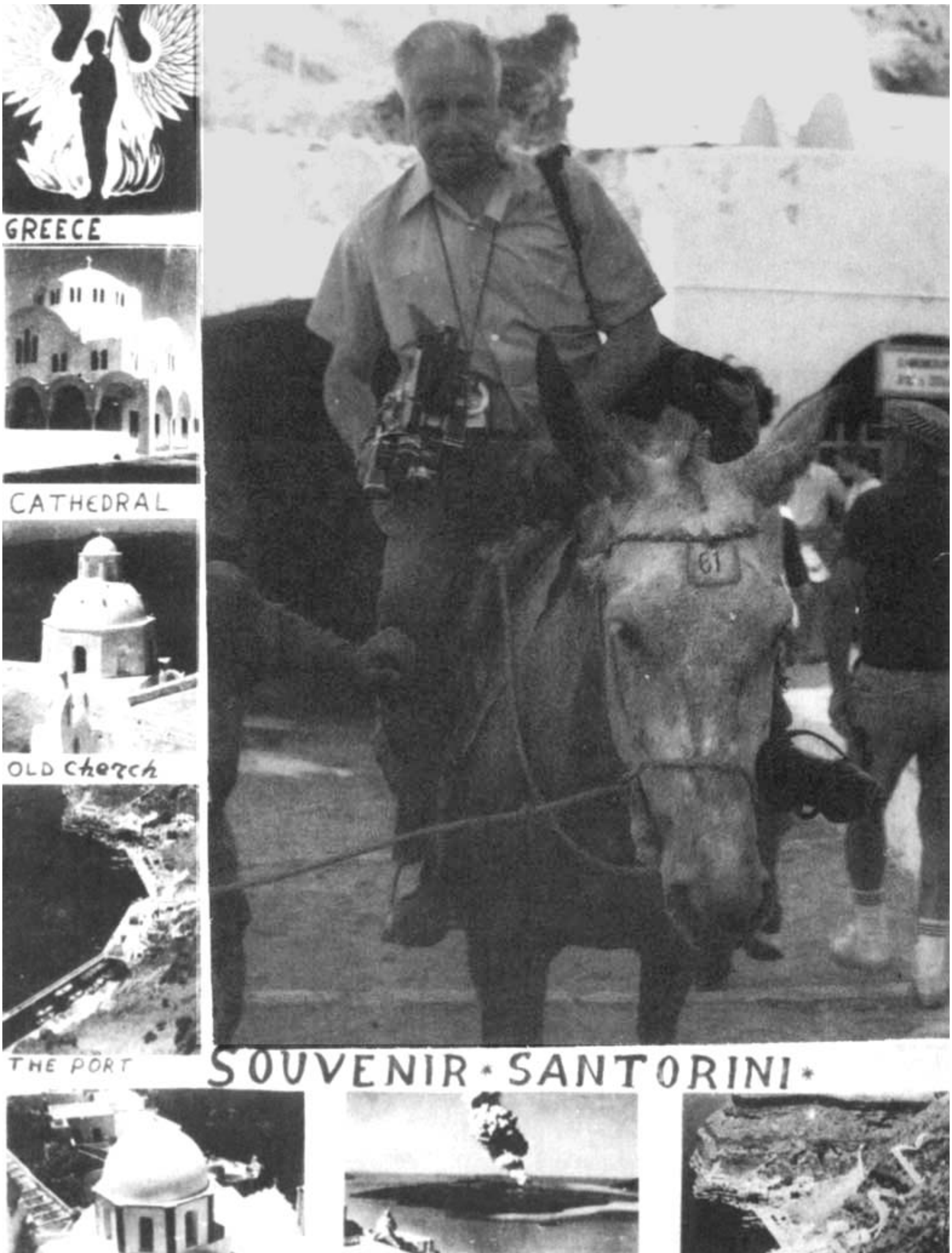
Featured on the cover of the Engineering News Record, *July 1, 1976. One of the figure captions on the accompanying feature article read: "[He] may not be universally loved, but he's universally respected."* (photo: Fred Kaplan)

On a fishing boat off the coast of Oregon during a family vacation in August 1977. Henry loved to sail and fish. According to his son, Paul, "the point of most vacations was to get somewhere where he could go out on a boat." (photo supplied by Patty Degenkolb Blanton)



On family vacation in the Sierra foothills, with a Nikon around his neck, and a Bolex movie camera in hand (late 1970s). (photo supplied by Patty Degenkolb Blanton)

With James Stratta and the three marlins they caught off the coast of Punta Pescadero, Mexico, in May 1980. (photo supplied by James Stratta)



On horseback with cameras—a souvenir photo from Greece, where Henry and his wife, Anna, vacationed after attending the Seventh World Conference on Earthquake Engineering in Istanbul, Turkey, 1980. (photo supplied by Paul Degenkolb)

The conference room at H.J. Degenkolb Associates. Left to right: George Greenwood, Chris Poland, Henry Degenkolb, Tom Wosser, Ted Canon, Georges Bassett, Loring Wyllie, Gordon Dean, 1978.

Photographing earthquake damage in Mexico City in 1985. (photo: Frank McClure)

At his desk, 1973. (photo: Moulin Studios)

Numerics

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