CONNECTIONS

The EERI Oral History Series

William J. Hall

with an Appendix on
Nathan M. Newmark

Robert D. Hanson and
Robert Reitherman,
Interviewers

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Earthquake Engineering Research Institute

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The EERI Oral History Series

This is the twenty-third volume in the Earthquake Engineering Research Institute's *Connections: The EERI Oral History Series*. EERI began this series to preserve the recollections of some of those who have had pioneering careers in the field of earthquake engineering. Significant, even revolutionary, changes have occurred in earthquake engineering since individuals first began thinking in modern, scientific ways about how to protect construction and society from earthquakes. The *Connections* series helps document this important history.

Connections is a vehicle for transmitting the fascinating accounts of individuals who were present at the beginning of important developments in the field, documenting sometimes little-known facts about this history, and recording their impressions, judgments, and experiences from a personal standpoint. These reminiscences are themselves a vital contribution to our understanding of where our current state of knowledge came from and how the overall goal of reducing earthquake losses has been advanced. The Earthquake Engineering Research Institute, incorporated in 1948 as a nonprofit organization to provide an institutional base for the then-young field of earthquake engineering, is proud to help tell the story of the development of earthquake engineering through the *Connections* series. EERI has grown from a few dozen individuals in a field that lacked any significant research funding to an organization with nearly 3,000 members. It is still devoted to its original goal of investigating the effects of destructive earthquakes and publishing the results through its reconnaissance report series. EERI brings researchers and practitioners together to exchange information at its annual meetings and, via a now-extensive calendar of conferences and workshops, provides a forum through which individuals and organizations of various disciplinary backgrounds can work together for increased seismic safety.

The EERI oral history program was initiated by Stanley Scott (1921-2002). The first nine volumes were published during his lifetime, and manuscripts and interview transcripts he left to EERI are resulting in the publication of other volumes for which he is being posthumously credited. In addition, the Oral History Committee is including further

interviewees within the program's scope, following the Committee's charge to include subjects who: 1) have made an outstanding career-long contribution to earthquake engineering; 2) have valuable first-person accounts to offer concerning the history of earthquake engineering; and 3) whose backgrounds, considering the series as a whole, appropriately span the various disciplines that are included in the field of earthquake engineering. Scott's work, which he began in 1984, summed to hundreds of hours of taped interview sessions and thousands of pages of transcripts. Were it not for him, valuable facts and recollections would already have been lost.

Scott was a research political scientist at the Institute of Governmental Studies at the University of California, Berkeley. He was active in developing seismic safety policy for many years and was a member of the California Seismic Safety Commission from 1975 to 1993. For his contribution to the field, he received the Alfred E. Alquist Award from the Earthquake Safety Foundation in 1990.

Scott received assistance in formulating his oral history plans from Willa Baum, Director of the University of California, Berkeley Regional Oral History Office, a division of the Bancroft Library. An unfunded interview project on earthquake engineering and seismic safety was approved, and Scott was encouraged to proceed. Following his retirement from the university in 1989, Scott continued the oral history project. For a time, some expenses were paid by a small grant from the National Science Foundation, but Scott did most of the work pro bono. This work included not only the obvious effort of preparing for and conducting the interviews themselves, but also the more time-consuming tasks of reviewing transcripts and editing the manuscripts to flow smoothly.

The *Connections* oral history series presents a selection of senior individuals in earthquake engineering who were present at the beginning of the modern era of that field. The term "earthquake engineering" as used here has the same meaning as in the name of EERI—the broadly construed set of disciplines, including geosciences and social sciences as well as engineering itself, that together form a related body of knowledge and collection of individuals that revolve around the subject of earthquakes. The events described in these oral histories span many kinds of activities: research, design projects, public policy and broad social aspects, and education, as well as interesting personal aspects of the subjects' lives.

Published volumes in *Connections: The EERI Oral History Series*

Henry J. Degenkolb 1994
John A. Blume 1994
Michael V. Pregnoff and John E. Rinne 1996
George W. Housner. 1997
William W. Moore 1998
Robert E. Wallace 1999
Nicholas F. Forell 2000
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Loring Wylie, Jr.

Foreword

This oral history originated from a day of interviewing Bill Hall at his home in Urbana, Illinois, in November of 2007. Frequent correspondence via telephone, email, and edits of versions of the manuscript followed to complete this work.

Included in this volume on Bill Hall is an appendix on his teacher and longtime colleague in research, teaching, and consulting, Nathan M. Newmark. Had Newmark lived longer, he would have been an obvious candidate for inclusion in the EERI Oral History series because of his productive work in earthquake engineering. Hall's recollections of his experiences with Newmark are augmented in the appendix, which includes a list of Newmark's publications, a list of articles about him, and photographs of him. Several of the appendix resources are used by permission of the University of Illinois at Urbana-Champaign, for which we are grateful.

EERI Oral History Committee member Loring Wyllie reviewed the manuscript.

Sarah Nathe edited and indexed this book, and George Mattingly was the page layout consultant. Stephen LaBounty, EERI Membership and Communications Manager, coordinated production arrangements.

Robert D. Hanson
Robert Reitherman
EERI Oral History Committee
December 2014

Personal Introduction

I met Bill in 1969 when I applied to the University of Illinois Urbana-Champaign (UIUC) graduate program in civil engineering. My application was submitted at a very late stage for September admission due to my last year at Mississippi State University (MSU) having been interrupted by six months of U.S. Army active duty training. I originally planned to remain at MSU, but "eleventh-hour" thoughts prompted me to apply to a few universities with more comprehensive graduate programs. Illinois was recommended to me by several research engineers at the U.S. Army Corps of Engineers Waterways Experiment Station in my hometown of Vicksburg, Mississippi, where I was then employed as a summer intern. Within a few months of applying, I received an offer to become a research assistant at the University of Texas. While quite pleased to receive this news, I was also anxious to hear from Illinois so I made a blind, cold call to the UIUC civil engineering department. My call was routed to Bill, who at the time was the departmental professor in charge of graduate student admissions. I explained that I was calling to inquire about my application. He located my application, confirmed that my file was complete, and said that I should expect to hear from them within two or three weeks. I then explained that I had received an offer to attend UT via an assistantship and that I needed to respond to them within ten days. Bill, in what I later determined was his typical rapid-fire style, asked, "Well, where do you want to go?" Before I could answer, he said, "I suppose you must want to attend Illinois, otherwise, you would not be calling." He went on to deliberate another few minutes and then said, "We can offer you a research assistantship." Without much further thought, I quickly accepted. Little did I know at the time that Bill's no-nonsense quick decision would be a major turning point in my life.

The next week I traveled to Champaign-Urbana to seek housing. I made an unannounced visit to the civil engineering department, proceeded to the administrative office, introduced myself, and asked to see Professor Hall. He was not in his office; instead, I was handed off to Professor William Walker. He pulled my file, gave it a quick review as I watched, and replied that the file seemed to be in order and that I should be hearing from them within two to three weeks. Apparently, there was no record of my having spoken with Professor Hall and receiving a verbal offer. Fortunately, Bill arrived at the office before I had a panic attack.

To my relief, he quickly confirmed our previous week's conversation. I'm sure Bill does not remember this first encounter, as he dealt with hundreds of graduate students in various ways over the years. What probably was merely routine for him was unforgettable for me.

After about one year as a research assistant, I realized that I could make more rapid progress if I switched from an assistantship to a fellowship. I organized my thoughts on the matter and approached Bill to inquire about my prospects. He once again pulled my undergraduate file and took another look. After a few minutes he looked up at me with a bit of a grin and said, "You must've really enjoyed your time at Mississippi State." He went on to say that fellowships were few and went to those with the very best academic records. At that point I transitioned quickly to damage control and made a quick exit, counting my lucky stars for having an assistantship. I did not want my record scrutinized any further.

Bill was very popular among the graduate students. He took an interest in all of us, and his door was always open for consultation. He managed his time well, brutally well; if one had a question or request, it needed to be well formulated, concise, and to the point. It was common for him to say as we walked in his door, "Okay, you have one minute, one minute, what do you need, what do you need?" One of my graduate student friends who went on to have a very successful career with Exxon, nicknamed Bill "meter man." We joked that he should have a parking meter at his door for us to deposit coins before entering. I don't think Bill was ever aware of his moniker. No doubt his time management skills allowed him to be readily available to all, faculty and students alike. Even now, I still find Bill always to be in a hurry—never wasting a moment, he has covered a lot of ground in a single, distinguished career.

As I neared completion of my graduate program, I began to look for a career opportunity. Jobs were relatively abundant at the time so it was a matter of sorting them out and making the best choice. I sought the counsel of Bill and Professor Newmark, whom I had also come to know while at UIUC. They mentioned a number of possibilities, and they contacted some companies on my behalf. Their strongest recommendation was for me to consider the

Trans-Alaska Pipeline project, as it would be once-in-a-lifetime opportunity if it were to proceed to construction (it was still in the permitting phase). Both Bill and Professor Newmark were engaged by the pipeline project as seismic consultants, and a position with the project offered me the unique opportunity to work on a major, high-visibility project and to be mentored continuously by Professors Hall and Newmark over a four-year period.

Bill has been a member of the civil engineering faculty at the University of Illinois at Urbana-Champaign (UIUC) for the past 60 years. He was Head of the Civil Engineering Department during the period 1984–1991; he retired to emeritus status in 1993, although "retired" for Bill is only a word. Bill is well-recognized for his work in fracture mechanics, blast load effects on structures, and seismic engineering. Numerous national defense and critical infrastructure projects have engaged Bill as a specialist consultant. His vast experience and insight have benefitted the UIUC civil engineering program in both the classroom and laboratory. He has served in leadership roles for the advancement of civil and structural engineering through his participation on national professional committees charged with advancing the state of knowledge. He has received numerous awards for his professional contributions. To this day, Bill remains an important contributor to the Civil Engineering Department and mentor of younger faculty.

Bill's engineering accomplishments are well-chronicled and need not be repeated here. But there is one contribution to society that has gone unmentioned in this oral history. In 1990 the Governor of Illinois, James R. Thompson, appointed Bill to a legislatively created commission to determine whether a site proposed in eastern Illinois was safe and suitable for low-level radioactive waste disposal. Bill served as the sole engineering member of the three-person commission that conducted hearings for over 70 days in the small town of Martinsville, which was near the proposed site. A fascinating and authoritative account of Bill's participation on the commission was delivered at a 1993 Symposium held at UIUC by former Illinois State Supreme Court Justice Seymour Simon, who also served as one

of the three members[1]. Over 100 witnesses, including 30 expert witnesses, most of them PhDs, were heard on topics of geology, hydrogeology, geochemistry, risk assessment, storage techniques, seismology, and health dangers. According to Justice Simon, "Never had so many PhD's assembled at one time in Clark County, Illinois." Bill expected candor and accuracy from the experts, and he was quick to expose any lack thereof. His examination of expert witnesses, many of whom he had been associated with personally and professionally, displayed great courage. In the end the commission ruled that the site was unsuitable for radioactive waste disposal.

I am honored that Bill has been professor, mentor, colleague and friend to me for the past 45 years. He has been the single most influential person in shaping my career as a professional engineer; for that and much more, I will be forever grateful. Moreover, he and his wife, Elaine, have been truly wonderful family friends for all these years. I know that I am only one of many inspired by Bill. He has our deepest respect and sincere appreciation for all he has done.

Doug Nyman
October 2014

1 *The Art and Science of Structural Engineering, Proceedings of the Symposium Honoring William F. Hall,* Prentice Hall, Upper Saddle River, NJ, 1996.

CONNECTIONS

The EERI Oral History Series

William J. Hall

Chapter 1

Growing Up in California

We had 51 pear trees and also every fruit tree you could think of. We had vegetables, cows, and chickens—we were mostly self-sufficient.

Hall: So you want me to start with my early years?

Hanson: Yes, and in these oral histories it's good to include information on your parents and ancestors that goes back further.

The Ranch in Lafayette

Hall: I was born on April 13, 1926. My father was Eugene Raymond Hall and my mother Mary Harkey Hall. My brother, Hubert H. Hall ("Hub"), was born in July of 1928, and my other brother, Benjamin D. Hall, was born in December of 1932.

Reitherman: For the record, what is your middle name?

Hall: Joel. We were all born in Alta Bates Hospital, in Berkeley, California. We lived in various apartments in the Berkeley area for a number of years. We lived up behind the University of California stadium for about a year at 300 Panoramic Way. For

part of one year, we moved inland a little way over the hills to Orinda, and we ended up in November of 1930, when I was four, in Lafayette, which is also just over the hills east of Berkeley. It was a 12-acre plot right off the main drag in Lafayette, a mini-ranch. What did we have there? We had a well and a house. We had 51 pear trees and also every fruit tree you could think of. We had vegetables, cows, and chickens—we were mostly self-sufficient. Sometimes people see pictures of my brothers and me from back then, and we have big holes in our blue jeans. They say "Gosh you were poor." I say, "We weren't poor, we just didn't have any money." [laughter]

Reitherman: Have you been back there?

Hall: Yes, but they tore the house down. Actually, Joe Penzien once worked on it when it was a Girl Scout building some years ago, but it is gone now.

We were typical boys and played and worked in the orchards. We had a work ethic because lots of things had to be done. The nice thing about being on the ranch is you don't leave a cow to be milked tomorrow, and you don't feed the chickens next week. So we learned self-discipline and how to work as we grew up. We got busier and busier helping the ranchers in the area. My brother Hub had a lot of fun driving a Caterpillar tractor discing hundreds of acres of orchards. Part of the time I was a cowboy on a 2,000-acre cattle ranch over by Clayton, near Mount Diablo. We did everything from castration to dehorning—everything. I helped only a little with the work of breeding Palomino horses, which is a dangerous business. Palominos are kind of cream-colored and have a white mane, being bred for looks. The lines are confused. A lot of the mares were Arabian mares. You would get an incredible genetic product. It is a science of its own. Most people are familiar with them from their appearances in the Rose Parade.

Hanson: Speaking of that, how about the Rose Bowl? Illinois is in it this year (2007).

Hall: Illinois beat Ohio State this year, and that shocked Ohio State out of their socks.

Reitherman: Do you recall experiencing any earthquakes?

Hall: Yes. The most severe earthquake was when I was in the Opera House in San Francisco in the early 1930s, and it sounded like cannons were firing. The building shook, but the orchestra didn't stop what they were playing in that confusion so nobody ran out and trampled people. My grandmother, mother, and my brother Hub were with me.

Hall's Parents

Hall: My father, E. Raymond Hall, had received his PhD in zoology at the University of California, Berkeley in 1928. He was the curator of mammals in the Museum of Vertebrate Zoology there starting in 1927, doing a lot of field collecting of mammal specimens. We boys went on some of the trips. In 1938 he became the curator of the museum. In all fairness to him, not to brag, he published over 350 books and publications.[2] He was a

2 Among the works of E. Raymond Hall (1902–1986) is a two-volume classic, *The Mammals of North America*, co-authored with Keith Kelson (New York, Ronald Press, 1959). The book remains a leading authority on that subject.

leading vertebrate zoologist of the twentieth century. No question about that. Having come from Kansas originally, getting his undergraduate degree from the University of Kansas, he returned there in 1944 with my two younger brothers and my mother and became the Chairman of the Department of Zoology and the Director of what was known then as the Dyche Museum, later named the Museum of Natural History.[3] Have you ever been to Lawrence?

Reitherman: No, but I have heard of the zoology collection in the museum at the University of Kansas, which is now a center for making its collection and other collections around the world electronically available to researchers.

Hall: Right, that's correct. When my dad retired in 1967, by then he had greatly built up the museum—not just collections—but added on to the building and started new programs. He was also a dedicated conservationist.

My mother, Mary Frances Harkey, was a botanist trained at the University of Kansas, where she met my dad while they were undergraduates there. She went on to take some additional education in California and then had her children. When we lived on the ranch in Lafayette, we were so self-sufficient that she canned a lot of food and we basically spent hardly any money—we didn't have it. Later on when they moved to Kansas, she established a Girl Scout camp of 40 acres on the edge of (now the middle of) Lawrence. She, like my dad, was a determined conservationist. Her father, Dr. William C. Harkey, was a doctor who eventually was Head of Pediatrics at the hospital that later became part of the University of Kansas Medical School in Kansas City.

Hanson: Where did the parents of your parents come from?

Hall: Their relatives go back several generations in Kansas. Joel Hall was my great grandfather. He was in the Civil War and he was shot with six slugs, two of which I keep in a safe deposit box. On a trip once with my wife, Elaine, and my son, Jim, and his wife Melody, we were down in Murfreesboro, Tennessee and went over to the site of Stones River battlefield. That is where he was shot. There were roughly 80,000 men involved in that battle. The North had 42,000, the South 38,000, and 23,000 lay dead on the ground when it was over. One of the biggest slaughters of the war. After my great grandfather got shot, he recovered somewhat in Murfreesboro and then went home to Ohio. Later he and his family moved to Kansas. Joel's son, my grandfather, was Wilber Hall, and he worked

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Another is *Mammals of Nevada*, first published in 1946, still relevant and re-printed by the University of Nevada Press in 1995.

3 See "Eugene Raymond Hall–Biography and Bibliography," Stephen D. Durrant, in *Contributions in Mammalogy: A Volume Honoring Professor E. Raymond Hall*, edited by J. Knox Jones, Jr., Museum of Natural History, University of Kansas, 1969. Raymond Hall (1902–1986) was Director of the Museum of Natural History from 1944 to 1967, approximately the same span of years that he was the chair of the Zoology Department. He named and described nine new genera, one new subgenus, 23 new species, and 138 new subspecies.

at the Haskell Institute, now the Haskell Indian Nations University.

Hall's Brothers

Hall: Let me tell you a little about my two brothers, since of course they have been part of my life and both have had interesting careers.

My brother Hubert went to the University of Kansas to get his undergraduate degree, then he went to the University of Wisconsin and studied with a very famous geologist, Professor Lowell Laudon, and then he worked with Carter Oil Company, which later became part of ESSO, which became Exxon. My brother said recently, "I found oil for Exxon on seven continents of the world." He had many interesting adventures, one escaping out of Iran. We visited him in 1986. At that time he was located in London, and he was the manager of exploration for Exxon in the North Sea and Ireland. He's dead now; he died in September, 2010. In 2013, his wife Kathy established the Hubert H. and Kathleen M. Hall Professorship in Geology at the University of Kansas.

He was all over the world. You'd like this story, Bob (Hanson), having to do with a fellow University of Michigan faculty member of yours. Bill Richart,[4] who studied under Newmark, was in Singapore and was going to a golf club. Turns out my brother Hub's wife Kathy was president of this golf club. [laughter]

My other brother, Ben Hall, was so much younger that I didn't have as much to do with him as with Hubert. He is a biochemist who graduated from the University of Kansas. He went on to Harvard, but in the middle of his studies ended up in Munich on a Rotary Scholarship. He is fluent in German and he felt sorry for students who came from America to study there who weren't. He said you walk into class the first day and the professor says in German, "You're going to do this, this, this, and this. See you later." [laughter] He came back to the states and got his PhD at Harvard. He came to the University of Illinois for a few years in the 1960s, then elected to take a post at the University of Washington. His appointment letter there in 1994 said his title would be "The Washington Research Foundation Endowed Chair in Basic Biological Science. Your appointment as Professor of Botany and Genetics will also continue." He was Chair of the Genetics Department for about 20 years.

Some years back, Ben cornered the patents on the vaccine for Hepatitis B as well as others based on his research on yeast. That was a big financial windfall for the university. Just recently, October 17, 2007, they named a University of Washington building after him, the Benjamin Hall Interdisciplinary Research Building. Ben was elected to the National

4 Frank E. "Bill" Richart, Jr. (1918–1994), after getting his PhD under Nathan Newmark at the University of Illinois in structural engineering, was hired as an assistant professor at Harvard in 1948, where he met Karl Terzaghi and became interested in soils and foundations. Moving to the University of Florida, he authored a report on research there, *Foundation Vibrations,* in 1960. After moving to the University of Michigan, he authored a textbook, *Vibrations of Soils and Foundations*, with Richard D. Woods and John Russell Hall, Jr. (Prentice Hall, 1970).

Academy of Sciences in 2014. He is married to Margaret Hall, and they have two children: Charles and his wife Stephanie live on the east coast, and Anne lives in France.

Chapter 2

In the Merchant Marine during World War II

We were attacked by Japanese bombers. All I'm going to tell you is that I survived and some people located close to me didn't.

Starting College at Berkeley

Hall: As I was raised in Berkeley, I watched the Golden Gate Bridge and the Bay Bridge go up, never realizing the connection that I was going to have later with them. I did know who Glenn Woodruff[5] was. He was a professor in the College of Engineering. I knew him as a man. I knew he was a great engineer. My dad took me to a lecture about that time by Ernest Lawrence, the radiation expert at Berkeley. He gave a fascinating lecture, and I just soaked that up from A to Z. Of course, for security reasons, he wasn't

5 Glenn Barton Woodruff (1890–1973) worked on a number of bridge engineering and construction projects. His work on the San Francisco-Oakland Bay Bridge as Engineer of Design began in 1931. Along with Theodore Von Kármán and O. H. Ammann, he was a member of the federal panel investigating the 1940 collapse of the Tacoma Narrows Bridge.

telling the bottom line about what was going on. [laughter]

I also knew who Charles Derleth was, the Dean of Engineering at Berkeley.

I went to the University of California, Berkeley, for one year, and majored in mechanical engineering.

Reitherman: When you entered Berkeley as a freshman, you already knew you wanted to be an engineer?

Hall: I was as interested in agriculture as I was in engineering, and I still am today. I applied to Berkeley, because I was pretty sure I could get in. I also applied to the agriculture schools of Iowa State and the University of California, Davis. I was accepted at all of them. I decided that I would major in mechanical engineering. But of course, when you're majoring in mechanical in your first undergraduate years, it's not all that different from civil engineering.

Reitherman: Anything else about living in the 1940s? Movies, sports, world events?

Hall: My dad took me to a football game, the first one I ever attended, in the Cal stadium, and the Berkeley team was playing Michigan. Berkeley kicked off, and who was the big Michigan star at that time?

Reitherman: Harmon?

Hall: Yes, Harmon[6]. He took it and ran for a touchdown. That was my introduction to football. [laughter]

Hanson: He was a great athlete, and I say that not just because I was on the faculty at Michigan. He was a true national hero.

Hall: Cars went 35 miles per hour, gasoline was 5 cents a gallon, and you pumped it with a pump.

Joining the Merchant Marine

Hall: World War II came along, and I knew I would be drafted, so I got interested in where I was going to go. I took a physical, and they didn't like the sound of my heart.

Hanson: A murmur?

Hall: Yes. It was a murmur never found since. I immediately took an exhaustive physical for naval officer candidates and passed all the requirements. Naval quotas were full, so I went to the U.S. Merchant Marine to become a cadet. There is a fine but important distinction here. That branch was run and is run today by the Maritime Service. It has Kings Point, Long Island, as an academy. Kings Point is a federal academy that you don't usually hear about. In addition to West Point, the Annapolis Naval Academy, and the Air Force Academy, you have Kings Point.

Reitherman: What about Kings Point? What was it like?

Hall: It's in Great Neck, Long Island. It's a beautiful academy. I've been to all of the

6 As an indication of his overwhelming prowess as a college football player, Tom Harmon (1919–1990), in his final game against Ohio State University, which Michigan won 40–0, scored five touchdowns, three rushing and two passing; punted three times, averaging 50 yards; and kicked four extra points.

academies and it's one of the prettiest, actually. It is a first-class college. The Kings Point academy was mostly providing training for the merchant marine, but at that time during World War II, they were also taking some of us to be officer candidates in the Navy. So I was in the U.S. Merchant Marine Cadet Corps and also a cadet midshipman in the Naval Reserve, but not on active duty; thus after the war I wasn't a veteran, per se, though through some legislation in 2009, Merchant Marine men serving in the war zones became such.

Little did I know what I was getting into. I took my basic training for 12 weeks at Coyote Point in San Mateo County, California. Do you know where that is?

Reitherman: Today it's a marina, golf course, and natural history museum. Planes flying into the San Francisco airport usually do their final approach over it.

Hall: Right. I consider my basic training the best education I ever had. Unknown to us they were preparing us to go to sea immediately upon graduating instead of going to Kings Point, as would normally be the case. Then I went out to sea, in the Pacific, and later came back to Kings Point, but most of my time was in the Pacific.

Only later, after the war, was it public knowledge that a large number of our cargo ships were being sunk by German submarines in the Atlantic and Japanese ones in the Pacific. No wonder we were so soon assigned to a ship instead of getting more training at King's Point. We were running out of sailors.

I was assigned to a Victory-class cargo ship, the Haiti Victory.

Reitherman: Can you describe the ship a little bit?

Hall: You've seen the Liberty Ship? You know what they look like?

Reitherman: Yes, there's a restored one docked in San Francisco Bay, the *Jeremiah O'Brien.*

Hall: This was the advanced version of the Liberty Ship. It was faster and sleeker—it had a nice shape. It was slightly longer than a Liberty Ship. About 500 of these Victory-class cargo ships were produced, as compared to about 2,000 of the Liberty Ships. The Victory model had a speed of 17 to 19 miles per hour. That was considered fast enough to outrun a submarine. At any rate, that was the theory, and we sailed by ourselves, not in a convoy. If you sank, there was no one to help you. We were attacked by Japanese bombers. All I'm going to tell you is that I survived and some people located close to me didn't. In addition to the bombers and the submarines, when we neared our Pacific island destinations, there were still Japanese snipers around taking aim at ships.

We made two round trips in the Pacific, both of them going to Saipan and Tinian. The first trip we had on board beer. We always carried beer because troops like beer, and I later found out that's especially popular among the troops going into battle or contemplating same. Of course, we were also transporting war materiel.

So that was my wartime experience. After shipboard service in the Pacific, I went to Kings Point, and I was there through the end of the war. I've only seen one of my Merchant Marine classmates, a man who hailed me at

O'Hare Airport 20 years ago. A lot of our classmates were lost at sea.

The captain of a ship has total control over your life. The two captains that I served under, you couldn't have asked for better leaders. They were really responsible for me because I was trained under them. One time a captain took me with him up to the military shipping order office in San Francisco, which is where captains received their sealed orders. We left San Francisco Bay, and after we went past the Farallon Islands, which are often shrouded in fog, we dropped off our pilot to his boat. (A large ship needs a local pilot to navigate into or out of San Francisco Bay.) The captain then opened the orders, which told him where he was going and which he had to keep locked up in a safe. He, the first mate, and the chief engineer were the only three people that knew where the ship was headed. I don't even think that the radio operator knew.

There's not much traffic out on the Pacific to run into, but suddenly one day the radio operator comes up from his post below and says, "Get the captain, we just got a message that repeatedly says XXX." It meant we had to start zig-zagging. Obviously we were in submarine waters. That happened a number of times.

Chapter 3

Completing an Undergraduate Degree and First Job

It was my first applied experience in dynamics—solving the problem of the pumps vibrating the lady's house four miles away.

Hall: After the war I moved to Kansas to finish up my undergraduate education, getting a degree in civil engineering at the University of Kansas (KU) in 1948. From my work at Berkeley and Kings Point I was about two years' worth of credits shy of graduating when I got to Kansas. I took the standard courses in civil engineering. I took a course in welding that was taught in civil engineering, and later on ended up doing laboratory and consulting work on that topic.

Reitherman: Could you comment on the welding? Many engineering schools don't teach that subject anymore, as if it's too vocational.

Hall: At Illinois we still do to some extent, as part of the Material Science course. I was a little older than most undergraduates because of my time in the war and probably soaked up more learning because of that. I took a lot of math. For example, the thermodynamics I learned later paid off in my work with nuclear power plants.

When I got back from the war, I met Elaine Thalman at KU; she was from Kansas City. She was a year ahead of me, having majored in music. Elaine and I got married in December of 1948. How lucky I was! This year (2014) we're celebrating 66 years of a wonderful marriage. She had graduated in 1947 from the university and was employed in Kansas City by an oil company that became part of Mobil.

When I finished up my degree, I already had some working experience with a professor at the university, William McNown, who had dealt with the Kansas River dike systems. Going out in the summer and working that way gave me a real education in surveying, a subject I taught in my senior year at the University of Kansas.

One summer as an undergraduate I worked in the Phillips Petroleum Refinery in Kansas City, Kansas. Upon graduation, I was looking at other places as future possibilities for employment, including Sverdrup and Parcel in St. Louis. Sverdrup was a famous general in World War II. Parcel was from Kansas, and I met him several times. I also looked at the SOHIO Pipeline Company, part of Standard Oil of Ohio.

I decided to go with SOHIO. That was when I had my first experience with applied dynamics. SOHIO had a pipeline for crude oil that had reciprocating piston pumps. We had to have a battery of 12 or 15 pumps going at a site in Ohio, which makes a lot of vibration, and they like to keep them in sync to get coordinated pulses. There was a lady living in the area, four miles away, who came to the management and said, "I can't sleep, I just bounce all over the place." My supervisor told me to see if I could help her. I went out and got my hands on some geological maps, saw where the pumps were sitting, and quickly found that her house was sitting on the same strata of rock, which acted like a vibration conduit. So I came back and explained this to the bosses. I said the choices are to isolate our pumps, which is pretty expensive, or we could make the pumps operate out of sync. Just changing the operation of the pumps a small bit brought the vibration down to a level where she was happy. That was real. It was my first applied experience in dynamics—solving the problem of the pumps vibrating the lady's house four miles away.

SOHIO was training me, as I later found out, to go on up the line. They wanted me to go Harvard Business School on their money and then come back into the management of SOHIO. I said, "I don't think that's what I want to do."

I worked for SOHIO for about 14 months. Never did I guess that some of these SOHIO employees would appear again in my life some 20 years later when I was involved with the Alyeska, or Trans-Alaska, Pipeline.

Chapter 4

Graduate School at the University of Illinois at Urbana-Champaign

Before I arrived, I was re-assigned a different advisor, by the name of Nathan Newmark. That was one of the luckiest things that ever happened to me in my whole life.

Hall: I decided to go back to school and get a Master of Science or PhD in civil engineering. I applied to Illinois, Michigan, and Cornell and got accepted to all of them. Some of the faculty at Kansas had been at Illinois, and one thing led to another. I ended up going to Illinois and got my MSc in civil engineering in 1951 and my PhD in 1954. During those years, I was a research assistant and then a research associate. When I went to Illinois initially, it was on the assumption that I would be under Professor Shedd,[7] but before

7 Thomas Shedd (1890–1959) was on the Illinois civil engineering faculty from the 1920s to 1950s. He authored *Theory of Simple Structures* and *Structural Design in Steel.*

I arrived, I was re-assigned a different advisor, by the name of Nathan Newmark. That was one of the luckiest things that ever happened to me in my whole life.

Reitherman: Before talking about Newmark, tell us about the process of applying to doctoral civil engineering programs in 1949. Readers today may not realize that there were only a few universities offering graduate degrees in engineering back then. In his oral history, Egor Popov notes that the first PhD in structural engineering wasn't awarded by Berkeley until 1950, for example.[8]

Hall: The first PhD in civil engineering at the University of Illinois was in 1926, conferred on Linton Grinter. There's an educational award named after him today.[9] There weren't a lot of choices for graduate education in civil engineering, as you say. I was cautious about schools like Caltech and MIT, because my father said that I should be careful about private schools. Because they weren't state supported, they lived on soft money, research money. Of course, as a practical matter, Illinois isn't really state-supported today; it's only minimally so, the way budgets have evolved.

The only money I was offered was from Illinois, but that wasn't the compelling reason to go there. I went from my oil company wages of $320 a month to $75 a month. I went to see the Dean at Kansas, Professor Brown, and I asked him what I should do about my graduate school choices. He said, "If you want to make money, go down and join Shorty in the junkyard. If you want a good education in graduate school, these are all fine programs. I think Illinois is among the best. You can't miss." The department chair at Kansas, George Bradshaw, had been at Illinois, and Professor William McNown, the man I worked for on the dikes in the summer at Kansas, knew about the Illinois program.

Hanson: That's interesting, because when I was trying to decide which graduate school to go to, having lived in North Dakota, one of the primary things was to get out of the cold, right? So I applied to Brown, Florida, Stanford, and Caltech.

Hall: When I got assigned to Nathan Newmark, I didn't know about him. "Newmark" was just a name. I got there and realized my program of study was to be quite different from what it would have been if I had worked under Shedd. Shedd was a famous professor in bridge engineering. Newmark was a young man who was brilliant, interested in a number of different engineering topics. At one time, Newmark's uncle or somebody wanted him to be a farmer, among other things, but Newmark came to the University of Illinois. We can talk more about Newmark later.

I had an interesting experience meeting Newmark. He wasn't there when I checked in, and in the next room there were about six Chinese students who had Marchant

8 *Egor Popov*, Stanley Scott interviewer, Earthquake Engineering Research Institute, Oakland, CA, 2001, p. 48.

9 The Linton E. Grinter Distinguished Service Award is the highest award given by the Accreditation Board for Engineering and Technology (ABET).

calculators[10]. They were calculating the living daylights out of analyses. Newmark was also interested in numerical analysis. For some reason, the graduate students in the room were talking about artichokes in California. So I drew a picture on the blackboard showing how you take an artichoke apart and eat it. Newmark walked in the room, right by me, and demanded, "Who drew that?" [laughter] That was my introduction to Newmark. Nate and I talked about that in later years. And who was my office mate? Tung Au.

Hanson: Is that right?

Hall: Tung Au was later at Carnegie Mellon. I walked in and said something about being at Berkeley. As it turned out he had worked as a research assistant in Canton for a Berkeley professor I knew: small world. We became friends for life. He lived in Walnut Creek, near you Bob, as you know?

Hanson: Yes. Now (2014) we've moved back to the Midwest.

Hall: Tung is now retired and lives in Modesto, California.

When I arrived at Illinois I was assigned to work with Wilbur Wilson[11] on machine design for fatigue testing. They had a big walking beam machine. Wilson had done the materials engineering work for the steel on the Golden Gate Bridge for Bethlehem Steel some years before. So later in life I got ahold of the Bethlehem Steel film on the Golden Gate Bridge. It never mentioned Wilson. He did all of the testing on all of the joints and rivets and the members, the various steel materials, in Talbot Laboratory at the University of Illinois. In my first semester, I designed and had built a small walking beam machine for fatigue testing, which could vary its force as it was running.

I basically had two jobs during my graduate work. One was working on my thesis, especially on weekends and evenings. I wasn't doing any teaching. The other was the research. I was working on military-related topics in the laboratories in those years.

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10 The line of Marchant calculators extended from 1911 to the coming of the electronic hand-held calculator. As of the era Hall is discussing, these calculators were mechanical devices resembling a typewriter.

11 A biographical summary of Wilbur Wilson (1881–1958) is provided in William J. Hall, "Teacher, Analyst, Researcher, Experimentalist, Structural Engineer," University of Illinois at Urbana-Champaign, Department of Civil and Environmental Engineering, 2011, http://cee.illinois.edu/about/history/wilson, and in R. A. Kingery, R. D. Berg, and E. H. Schillinger, *Men and Ideas in Engineering: Twelve Histories from Illinois*, University of Illinois Press, Urbana, IL, 1967. Wilson originated the walking beam testing machine, in which an apparatus resembling the drive mechanism for a locomotive wheel works in reverse, the rotating wheel driving a rod back and forth (oriented up and down). That rod makes the end of a lever, or pinned beam, move up and down like a pump handle, and along the underside of that beam is another vertical strut to impart rapid up-and-down loads to a specimen at the desired rate. Wilson was also instrumental in the testing to verify that high-strength bolts rather than rivets could be used for structural connections.

Some involved fieldwork. For example, in the summer of 1953 I worked at the Nevada Test Site on experiments on nuclear blast effects on buried and above-ground structures. Throughout my entire career at Illinois, I was in some capacity working on, or connected with, Department of Defense studies on blast, shock, and other issues. Almost half a century after my initial involvement in that research, I became involved with John Haltiwanger in an archival effort to preserve the history in that field.

Some of the military work was of a consulting nature, especially with Newmark, but a lot of it was also done in the University Illinois laboratories as regular research. That continued over the years, with big projects like military facility elements and the Trans-Alaska Pipeline. I got a call from a friend, long since passed away, who said I'm coming to Illinois on behalf of Alyeska, the company running the big Alaska pipeline project, and I'm going to give you $50,000. By the time he arrived it had turned into $100,000, and eventually $1 million dollars for research came to the university, primarily to study the support members of the pipeline and permafrost issues. In the early years it was not necessarily earthquake-related, because there was so little funding for that. But we were lucky. We didn't have to write lengthy proposals to get those jobs.

Hanson: You didn't waste a lot of time writing proposals. What a difference from today! [laughter]

Hall: For my thesis, I was working under Newmark on the shear deflection of steel beams, and I carefully collected data that extended into the inelastic region. It was very thorough work, carefully done, but also in a way quite simple. Newmark is really best known for the simple concepts he carried out. Years later, in the mid 1990s, Bill White of Bechtel International pops into my office and says, "I want a copy of your thesis." And I said, "What?" He says, "You're part of my Bible and somebody stole that piece of my Bible." I said, "Sure, but what's this all about?" He says, "We've been using it for 40 years and you didn't even know that?" [laughter] I asked why, and he said "Because it is the only data we trusted." My thesis[12] was used in the fields of nuclear power plants and offshore structures, especially for the effects of heavy loads dropped on steel structures.

Hanson: The author is always the last to know.

Hall: In 1950, when I hadn't been at Illinois even a year, Elaine and I and two other Illinois engineers, Jim Stallmeyer and John Brooks, took a car and went down to the Norfolk Naval Base in Virginia to work with German scientists on nuclear weapons effects on submarines. Later we ended up doing structural tests on scale models of submarine hulls on campus in Talbot Lab, experimentation that later spilled over to the university's airport facility. This was all part of a large research effort run by the National Research Council. We met Alfred Keil there at Norfolk, who later was the dean of engineering

12 *Shear Deflection of Wide Flange Steel Beams in the Plastic Range*, University of Illinois, 1954; see also the same title in *ASCE Transactions*, Vol. 122, pp. 666–687, 1957.

at MIT. He was one of those German scientists that they brought from Germany after the war. Another German scientist became head of mechanical engineering at the University of Illinois, Dr. Helmet Korst.

As I was finishing my doctorate in 1954, the question arose, what was I was going to do next? I couldn't see any openings at Illinois at that time, so I started up correspondence with R. R. Martel. Because you later got your PhD at Caltech, Bob [Hanson], you'll like this story. Martel and I didn't get very far in that correspondence, just two letters back and forth, I think. Newmark walks in one day and says that two of the engineering faculty working on steel fracture were about to leave to go into the aircraft industry, and he needed somebody to continue our fracture work. He said that we're going to be doing an extensive testing program for national agencies on ship structures. Would I take it on? He said, "I can make you a Research Assistant Professor." A nice sounding title, but you know it means you're on soft money, dependent on the research funding. He said it wasn't on the tenure track, it was a gamble, but he said he thought it could all get straightened out and I'd become a professor. In due course, we were talking about big research money, big equipment, and fast production work. So I said, "OK, Elaine and I will discuss it." And we decided to take that job. Hence, I had only a passing connection with Caltech at that time.

Chapter 5

Faculty Member in the University of Illinois Department of Civil Engineering

Newmark ran the department from 1956 to 1973. He knew how to delegate. He gave you a job to do and expected it to be done.

Hanson: Tell us a little about your typical teaching load and the sorts of work you did in the Civil Engineering Department.

Hall: Throughout my career on the faculty, from 1954 to 1991, I taught one or more courses each semester while also doing research and administration, with the exception of three semesters when I was on special assignment. My usual courses were basic and advanced courses in structural analysis, steel design, and concrete design. Many of those years were when computer programming came into vogue, and in those days that was challenging. In my later years, I shared a graduate course with John Haltiwanger

on blast and shock design. And perhaps it's unusual enough to note: I never had a teaching assistant to help me, not one. I also never took a sabbatical.

My summers were free, which I spent with my family, and that's when I got most of my consulting work done.

Hanson: What about advising graduate students?

Hall: Usually I had two or three masters' and two or three doctoral students. All together over the years, I had about 30 PhDs.

University-wide Management Roles

Hall: Newmark ran the department from 1956 to 1973. He knew how to delegate authority. He gave you a job to do and he expected it to be done. John Haltiwanger, who ran the undergraduate division, and I, who was in charge of the graduate program and research, never remembered any criticism from Newmark. Later, I was the Department Head from 1984 to 1991.

Reitherman: What about university-wide contributions? Newmark headed up the Digital Computer Laboratory, for example.

Hall: He agreed to head up that effort, which was not just software development or working on various aspects of computers—the university actually made computers, some of the world's most advanced. You get called in to do all sorts of things for the good of the overall university. The number of people who handled the administrative work at the College of Engineering and university-wide levels, was about one-seventh of what it is today. A lot of the work was handled by faculty committees. It was an efficient system, and it was an era when the university flourished, with both enrollment and research activity increasing.

In 1998, after I had retired, I was asked to straighten out the campus Patents and Copyrights Office. One thing I noticed was that everybody there had to be an assistant associate vice chancellor. I asked why was that so. I was told, "Other people won't listen to us if we don't have a title like that." I said, "I don't have a title like that, and now I'm in charge of the office." [laughter] They kept those titles until the unit was completely revamped a year later.

Research Board

Hall: Both in my case and in Newmark's, we thought that the time we spent on the campus Research Board was some of the most productive time we gave the university. Its function was to distribute funds from indirect costs, largely produced from engineering. We took proposals from faculty for small grants. I think he served the longest of anyone on the committee and I the second longest. We tended to give the highest priority to the proposals from people who were not engineers and scientists because those faculty had little research funding available to them.

There are also personnel committees and research policy committees that need your time. I was also involved with the Liaison Committee between the university and CERL, the Army Corps of Engineers Construction Engineering Research Laboratory there in Urbana-Champaign.

While we're talking about the university here, I should note that the consulting work Newmark and I did quite often brought in large sums to the university, so there was a nice positive relationship there.

Reitherman: You still have a connection with advising your undergraduate alma mater, the University of Kansas, don't you?

Hall: Yes, I am on the School of Engineering Advisory Committee there. I like comparing the two schools, Illinois and Kansas, which are quite different. I like the program at Kansas, but it is changing rapidly to accommodating research. Illinois is a research-focused school, which can make it hard to start here as a freshman and make it through your undergraduate degree program. And today, we often encourage our engineering graduates to get a Master's in Civil Engineering, or some get a graduate degree in another field, like business, and then return to civil engineering.

And then there's the professional licensing that goes along with that career path. If someone is here illegally, or practicing engineering in Illinois without a license, the company that hired that person becomes liable when something goes wrong. I think California is the leader in enforcing its engineering licensing requirements, New York is second, and Illinois is third. I've become a stronger supporter of licensing as I see some of the shenanigans going on trying to get around the laws.

Raising Money for a University

Hall: One of the big donors I recall was Arnold Beckman—there's a Beckman Institute on the campus here, and there's one at Caltech. I knew Arnold when I was on the Research Board. He went to both schools, so he gave a lot of money to both. There was a ground breaking for the Beckman Institute here at the University of Illinois, and Governor James R. Thompson gave a 30-minute speech. Then another dignitary gave a 20-minute speech. And then it came time for Arnold. He stood up, looked the audience over, and said, "We've heard a lot about how we need to be the best there is at this, and the best at that. Let's just try to do better," and he sat down. One of the best and shortest speeches I've ever heard.

Hanson: I'd like to pursue a little bit the topic of the gift to the university you and your wife gave in 2005: the William J. and Elaine F. Hall Endowed Professorship in Civil and Environmental Engineering.

Hall: Well, we give to all of our schools, we give to Kansas too, as have our relatives in many cases. Here at the University of Illinois at Urbana-Champaign, Elaine and I started an endowment fund about 30 years ago for the Civil Engineering Department. In 2006, Elaine and I decided we would use those funds, occasionally kindly augmented by gifts of former students, fill it out with our other savings, and establish the William and Elaine Hall Professorship. The professor who receives the award gets access to most of the income from the fund. The Department Head has to approve those expenditures, but you don't have to go through the usual route of writing proposals. The funds can be used for travel, hiring students to do research, for equipment, all approved by the Department Head, but none

is used for salary. I wish something like that had come my way when I was on the faculty!

Donating to our alma maters is common in our family. My brother, the geologist, has donated to the University of Kansas, the other brother to the University of Washington, an uncle to the Colorado School of Mines, and his wife, my mother's sister, to Kansas.

Hanson: It must be the bloodstock. [laughter] As Chair of the Civil Engineering Department at Michigan I always had to have arguments with the fellowship office on some of the details. One of the fellowships was tied to surveying. After a while we no longer had a surveying program, so the campus wanted to give it to the Law School or some place else. [laughter]

Hall: We shouldn't laugh! My aunt, a sociologist, gave a really large sum to the University of Kansas and it ended up in the Law School! My brother Hub went to the Endowment Office and said, "My aunt hated lawyers. Change it." And they did.

Hanson: Do you go back to campus a lot, now that you're retired?

Hall: I used to go every day until a few months ago, when I slowed down. I still help the department with awards, raising money, writing vignettes of faculty, vignettes of relevant history. One of those vignettes is on Charles Ellis,[13] who was a professor at Illinois from 1915 to 1921, when he quit to work for the Chicago Bridge Company, which was the company run by Joseph Strauss. The vacancy at Illinois was filled by Hardy Cross.[14] Strauss was the big advocate and force behind funding and approving the Golden Gate Bridge, but he did not design the Golden Gate Bridge; in fact, his design for a combination cantilever/suspension bridge was soundly rejected. Ellis did the calculations and much of the design work. Strauss told Ellis to go on vacation, then fired him while he was gone and expunged his name from the records, including drawings. I've looked at a set of the original drawings dated August 1930 that have the name Charles Ellis on them. The error was not corrected for many decades, until John van der Zee wrote a book about the bridge.[15] Even after that, it was

13 "Golden Gate Bridge Revisited: Seventy Years Later a Former U of I Professor Is Given Credit for His Design," *CEE*, the magazine of the University of Illinois Department of Civil and Environmental Engineering, Spring/Summer 2007, p. 21.

14 Hardy Cross (1888–1959), who developed the most widely used moment distribution method of the 1930s and for some decades later, had academic affiliations with Harvard, Brown, and Yale universities in his career, but he is mostly known for his research and teaching influence while on the faculty of the University of Illinois (1921–1937). During his years at Illinois he published "Analysis of Continuous Frames by Distributing Fixed-End Moments" (*Proceedings of the American Society of Civil Engineers*, May, 1930). A practical method for analyzing how bending moments flowed through frames that had rigid or moment-resisting joints greatly facilitated the use of reinforced concrete and steel construction.

15 *The Gate: The True Story of the Design and Construction of the Golden Gate Bridge,* BackinPrint.com, 2000; originally published in 1986 by Simon and Schuster.

tough to get recognition for Ellis, but finally, recently, it occurred.[16]

After Ellis was fired he couldn't go back to Illinois because there was no space for him, so he went to Purdue.

It isn't that surprising that a big engineering establishment like Illinois would be involved in the construction of the big bridge out on the West Coast. Russell Cone, an Illinois graduate, had a major role as the head engineer managing the construction. I already mentioned that Wilbur Wilson worked on the material engineering aspects of the steel. Others who got their engineering degrees from Illinois who worked on the Golden Gate Bridge were Charles Kring, John Blondin, Charles Clarahan, Edwin Davenport, and W. Bernard Dickman. You might call it an Illinois bridge built in California.

Reitherman: When earthquake engineering entered a growth phase in the 1950s and especially the 1960s and 1970s, it is also not surprising that Illinois was centrally involved. It took a major engineering school with a strong graduate and research program to get involved in that new field, and Illinois was one of the few meeting that description.

Hall: Talbot Laboratory was an important part of the success of the modern engineering activities at Illinois. Tests were done on all kinds of structural topics—riveted, bolted, and welded connections, for example, and columns. Static tests of course, but we also developed dynamic loading devices. When the new civil engineering building, with its Newmark Laboratory, was completed, we were fortunate to acquire a modern shake table used heavily for years for earthquake engineering studies.

I have to give a lot of credit for the success of the Civil Engineering Department to the staff. David Lange was our Shop Superintendent for the early years of my laboratory research. Doyne Proudfit was the Departmental Secretary when Newmark was chair. In my case, Susan Warsaw had that role, beginning in 1984, and in addition she handled security matters for John Haltiwanger and me, winning a national award in the process.

16 A plaque commissioned by the American Society of Civil Engineers was placed at the Golden Gate Bridge on its 75th anniversary in 2012.

Chapter 6

Nathan M. Newmark

Newmark once started to tell me about his first consulting job. I asked him what he meant by a consulting job and he said, "It means I got paid for it."

Hall: Newmark[17] once started to tell me about his first consulting job. I asked him what he meant by a consulting job and he said, "It means I got paid for it." That first consulting job was an earthquake engineering topic. Newmark was retained by the Bureau of Reclamation to study the damping in the intake towers for Hoover Dam. This was about 1933, Newmark's second year in his graduate studies, and he did this consulting work under the watchful eye of Professor Harald Westergaard.[18]

Reitherman: Westergaard's name comes up in the literature as an early researcher in earthquake engineering concerning dams,

17 For more detail, see the Appendix, Nathan M. Newmark.

18 Harald Malcolm Westergaard (1888–1950), not to be confused with the economist Harald L. Westergaard, specialized in concrete research topics as well as dynamics. His 1933 paper on "Earthquake shock transmission in tall buildings," *Engineering News-Record*, Vol. 11, No. 22, is one of the earlier publications on earthquake structural dynamics.

but I never knew Newmark was involved with him so early.

Hall: A lot isn't generally known about Newmark. Some of that is because of the classified nature of some of his work. A lot of the studies he did, as well as some of the ones I did, can't be made public, so few know about them. I'll try to fill in a few details, though you'll note blank spots because of sensitive nature of some projects.

Prior to World War II, the University of Illinois didn't really have a place for Newmark, but he was so brilliant that the president of the university made a place for him. Newmark stuck around but then he disappeared in the war. A part of his wartime work was spent in Hawaii, for the OSRD, the Office of Scientific Research and Development, which superseded the National Defense Research Committee, or NDRC. OSRD was a place for the scientists and the engineers who the U.S. government didn't want going into the military. They wanted them to work on the war effort, but not get killed out in the field. There were several hundred of these people. Merit White was one of them, incidentally.

Hanson: I didn't know that. He was a professor at the University of Massachusetts.

Hall: Bob Hansen[19] of MIT was also one of the OSRD group who is now deceased, and we talked quite often.

Hanson: Was Housner one of the engineers in the OSRD?

Hall: Yes. George Housner was one of those people. You know something about him?

Hanson: A little bit. He was in North Africa planning bombing tactics.[20]

Hall: Concerning these war years, Newmark only told me he was sworn to secrecy for life. I think he came back to Illinois in 1945. I don't think he was gone overseas more than nine months actually.

While a graduate student, Newmark was close to Cross, Westergaard, Richart, and Shedd. He was really a product of the teaching of Cross and Westergaard in many respects. I never met Cross, unfortunately. Newmark and Cross would walk home and they'd go to the Southside Park in Champaign where they'd sit for hours talking. By the time of the Second World War, Cross had left Illinois and was at Yale.

As World War II came on, Professor Westergaard had gotten a commission as a commander in the Navy and, instead of being on constant duty during the war, he worked out a deal with the Navy that when they needed him, he would go down to Washington and work for them for a while. He did it about nine times.

19 Robert Joseph Hansen was a professor at the Massachusetts Institute of Technology who, along with MIT colleagues, authored an early textbook on blast and seismic dynamic loads (C. Norris et al., *Structural Design for Dynamic Loads*, McGraw-Hill, New York, 1959).

20 George W. Housner, "Operations Analysis Section, Fifteenth Air Force, History 1943–1945," California Institute of Technology, March 1996.

Development of Computers

Hall: As time went on, computers enter the story. Newmark did historic computational work in engineering before that day arrived, then was made the head of the Digital Computer Laboratory when it was developing the ILLIAC II computer.[21] ILLIAC was derived from work done by John von Neumann at Princeton. Newmark said von Neumann was the smartest person he ever knew, which is saying something. Computers were actually not only being designed at universities in that era, they were being built at the universities.

As I was going through the stages of a student, I was first using a slide rule and later a Marchant calculator. The Marchant was hand-operated, and then we shifted to the later model that was operated by an electric motor. By 1962, we had ILLIAC II in operation. That ILLIAC II system had punched paper tape in machine language as input. When I bought my HP 35 hand-held calculator in 1972 for $400, it did more than the university's big ILLIAC II had done. That little calculator was the world's first scientific hand-held calculator, having trigonometric functions and exponents.

I remember one time a Navy captain came to see our research on submarine hulls. Instead of producing impressive computer results for his visit, the ILLIAC machine just died—that was the end of the day. [laughter] I mentioned that we did a lot of experimental work on models of submarine hulls, putting shock pressures on them, needing to move our research out to the airport at a new facility to do the work.

Then quickly we went into the IBM system, with punch cards. And then up the line into direct input.

Hanson: The transition went from machine language to FORTRAN.

Hall: Then things moved very fast. Parallel computers got more and more powerful. Burroughs got into the computer field. The University of Illinois has remained a big force in the realm of developing the most advanced computers, including the Blue Waters Supercomputer, the fastest in the world at present. It is built on Cray technologies. While most people remember Newmark as an engineer, he was also the first director of the university's Digital Computer Laboratory from 1947 to 1957, which later evolved into the Department of Computer Science.

An event sticks in my memory about how sophisticated computing is no substitute for a sound engineering understanding of a problem. Dr. Fisher, from Westinghouse, one of the sharpest analysts in mechanics, was at a meeting at the National Academy of Sciences. We were reviewing a model of a large parabolic reflector related to aerospace and defense that had 130 degrees of freedom. When the speaker concluded, Fisher commented, "I

21 "ILLIAC II, at its conception in the mid-1950s, represented, together with some other independent design projects of the same period, the spearhead and breakthrough into a new generation of machines." Quoted from *ACM Computing Reviews* by William J. Hall in "Nathan M. Newmark: A Model of Engineering Creativity," p. 153, in *No Boundaries: University of Illinois Vignettes*, edited by Lillian Hoddeson, University of Illinois Press, Urbana and Chicago, IL, 2004.

know something about one-degree-of-freedom systems. Two-degree-of freedom systems can get tricky. But 130 degrees of freedom? How can you understand that? And note that you have 19 eigenvalues that are negative numbers. Something must be wrong."

Newmark always took the opposite approach: first, he worked to understand the problem, and then he found the simplest way to solve it.

Torre Latinoamericana in Mexico City

Hall: I remember Newmark talking to Emilio Rosenblueth one day and Emilio asking why Newmark only analyzed the first few modes of the 44-story building. Newmark said that most of the action was in those first modes. He could have gone on to analyze many more modes, but he had the sense to know it was not useful. Emilio Rosenblueth, now deceased, was one of the brightest individuals I have ever known. Later he and Newmark wrote the well-known seismic design textbook together.[22]

Reitherman: What was Newmark's precise role in the design of the Torre Latinoamericana?

Hall: The Zeevaert brothers, Leonardo and Adolfo, were the chief designers. One handled the foundation, the other the steel superstructure. Newmark was the seismic criteria consultant. They were ahead of the field in putting simple measuring devices in the building.

Reitherman: Like the mechanical device that could measure story drift?

Hall: Exactly.

Gateway Arch in St. Louis

Hall: Newmark was called in as the Gateway Arch was being erected in St. Louis. They didn't want any buckling of even a slight degree, because the polished metal exterior surfaces functioned as a stressed structural skin. I think that the way he figured out the solution was just a matter of simple mechanics involving a stiff structural crown. (I wasn't involved in that project.)

Newmark also consulted on a building in Montreal and one in Vancouver that were near railroads so they were subject to vibration.

Newmark's Engineering Approach

Hall: A few days before Newmark's death, while I was visiting him in the hospital, he said, "Bill, the contributions for which I shall be remembered were very, very simple." Simple perhaps, but powerful and highly useful contributions as I shall try to briefly describe. Having worked closely with him on many major projects, I understood perfectly what he was telling me. At an early age he had learned from Harald Westergaard, his favorite teacher in theoretical and applied mechanics at the University of Illinois, that the way to approach a problem was to learn all there is to learn from previous work, and then mold and shape it into approaches, with additions of your own effort, that can be easily understood by other

22 Nathan M. Newmark and Emilio Rosenblueth, *Fundamentals of Earthquake Engineering*, Prentice-Hall, Englewood Cliffs, NJ, 1971.

engineers, and thus advance the knowledge and applicability for use by the profession.

One of the best examples of that occurred early in my career. It resulted in a draft published in 1953, but in final form it became an ASCE paper on blast published in 1956.[23] Briefly, Newmark had studied the German literature on the subject that had been published from World War I through World War II, as had I. He had heavy correspondence with Westergaard on the subject, who at the time was at Harvard, carried out additional theoretical research and physical testing in Talbot Laboratory, and then melded the information into one of the most powerful papers published during that period. It influenced practice in military facility design in a major way, and it formed the basis for significant additional research and applications to this day in national defense efforts as well with regard to other kinds of dynamic loading.

In 1962 he published a paper based on his years of work on numerical procedures[24]. He considered this paper to be one of his best papers, but it did not win an award as he believed it should have. I compiled references to most of his published papers in a book dedicated to him in 1977 and authored largely by his former students.[25] Anyone reading through that list has to be impressed with the wide range of important contributions he made.

Newmark's 1962 paper set the stage for him and me to later work on *Earthquake Spectra and Design* in the Earthquake Engineering Research Institute monograph series.[26] It was finished by me in 1982 about two years after Newmark had passed away. This monograph is found on bookshelves worldwide, and it is still in use today for many diverse applications.

Beginning in 1972 there was a major effort to upgrade seismic design provisions for structures and to obtain better information on materials and their use. Newmark was appointed Technical Director of a national project to modernize the seismic code, which culminated in the ATC-3 report.[27] From the UIUC, in addition to Newmark, Mete Sozen

23 "Nathan M. Newmark, "An Engineering Approach to Blast Resistant Design," *Transactions*, ASCE, Vol. 121, pp. 45–64, 1956.

24 Newmark, N.M., "A Method of Computation for Structural Dynamics," *Transactions* ASCE Paper No. 3384, Vol. 127 (Part 1), pp. 1406–1435 (with discussion), 1962.

25 William J. Hall, "Nathan M. Newmark: Biography," in *Structural and Geotechnical Mechanics*, Prentice-Hall, 1977. Newmark's published works are also listed in the appendix to this volume. His papers, like those of William Hall, are in the collection of the Grainger Engineering Library at the University of Illinois at Urbana-Champaign.

26 *Earthquake Spectra and Design*, Earthquake Engineering Research Institute, Oakland, CA 1982.

27 *Tentative Provisions for the Development of Seismic Regulations for Buildings*, NBS special Publication 510, NSF Publication 78–8, June 1978.

and I were heavily involved in that project from 1972 to 1978.

Nathan Newmark was one of the founding members of the National Academy of Engineering in 1964. He received honorary degrees from Rutgers University (1955), University of Notre Dame (1969), and University of Illinois (1978). Among many other significant awards were the following: National Medal of Science from President Lyndon B. Johnson (1969); Washington Award (1969); John Fritz Medal (1979); plus numerous awards from ASCE, ACI, and other societies and groups. He was the author or coauthor of about 250 books, technical papers and major reports.

From 1968 to 1981, he was heavily involved with the Nuclear Regulatory Commission in developing design criteria, and reviewing plant design criteria for about 70 nuclear power plants. In 1970, Newmark was selected to be the intermediary between the oil companies and the U. S. government on the important matters of seismic design associated with the design and construction of the Trans-Alaska Pipeline. He asked me to assist him. We can talk a little more about those projects later.

Newmark's Teaching

Hall: We should always remember that Newmark was an educator as well as a person who practiced engineering. For a student who really wanted to study in depth, Newmark went out of his way to make that possible. He educated and trained a large group of brilliant students who later in life assumed major leadership positions in the U.S. and overseas.

Chapter 7

Nuclear Power Plant and Critical Facility Design

That seismic review criteria report caught on like wildfire and has been used all over the world.

George Housner

Hall: After George Housner worked on TID-7024,[28] I began a connection with him. The big thick report was developed for the U.S. Atomic Energy Commission, and his section in it was how to devise an earthquake spectrum. He was giving advice for nuclear production reactors, not power-generating reactors. Production reactors produce fuel for things like nuclear submarines and material for nuclear weapons. Newmark and I were working on the commercial side of the nuclear field, on the design of nuclear power-generating plants. About that time, I think it's around 1960, we were into the spectra business, which I can elaborate on later.

28 U.S. Atomic Energy Commission, *Nuclear Reactors and Earthquakes*, August 1963. George Housner was the lead consultant, while others such as Charles Richter, Dean Carder, William Cloud, and Karl Steinbrugge also made contributions.

When did you start your graduate work at Caltech, Bob?

Hanson: I started in 1961.

Hall: You must have been pretty close to Jennings and Iwan, as well as Housner?

Hanson: Yes, they were all there at that time. Because about that time we were having a round robin on spectra, do you remember? Michigan, Berkeley, Illinois, Vancouver—anybody that was doing anything with analyzing strong motion records was part of it.

Hall: We all had a package of data, which of course meant a lot of IBM punch cards. The process was for everyone to calculate their spectra and then compare them, for various levels of damping and so on. I was on the sidelines. Norby Nielsen was one of the Illinois faculty involved. These comparisons were an eye opener for me. This was when earthquake spectra started to really gain attention. Those of us working on military matters already knew about shock spectra, but earthquake ground motion spectra began to be investigated with that military research background in the 1960s.

By spectra, we mean either the response spectra derived from the earthquake ground motion record, or more than one of them, or the design spectra in which that information is adapted for design use. And we were starting with four different versions of the 1940 El Centro record—there were comparisons even at that stage.

I was in a group with Newmark whose job was to evaluate the pros and cons of the nuclear industry's practices. Newmark began working for the U.S. Nuclear Regulatory Commission in 1962 and asked me to help him part-time with the review of Preliminary Safety Analysis Report documents for planned new plants. These were documents three to five inches thick that we reviewed, primarily for the seismic aspects. Over the next 18 years, we worked for the NRC on dozens of reactors, and I probably worked on ten more after Newmark died. At first, it was educational for me, but in time it became somewhat routine. The nuclear industry was like many military technical subjects, and also like the Trans-Alaska Pipeline, where codes and standards didn't exist to cover everything. Most of the nuclear plants are owned by companies, whereas we were working for the Nuclear Regulatory Commission.

Sometime later, George Housner latched onto me, because he had been working on some of the production facilities. These are places like Hanford, Savannah River, Oak Ridge, Rocky Flats—under the oversight of the Atomic Energy Commission, which was merged into other agencies in the 1970s. I did some work with George until I started consulting for the Defense Nuclear Facilities Safety Board for about ten years in the 1980s.

Ground Motion Studies for Nuclear Power Plants

Hanson: Let me step back for a moment, to the 1960 Chile earthquake, and to the Fourth World Conference on Earthquake Engineering held in Santiago, Chile in 1969. I told Mete Sozen a little story that he had never heard. Let's see if you've heard it. The 4WCEE was set up so that papers were submitted to a given

session, with a coordinator for each session. That coordinator would react to or comment on the papers. Newmark wrote a paper stating that the acceleration spectra worked well. Ray Clough submitted a paper that the constant displacement portion of the spectra worked well. The session chair sent Clough's paper back to Newmark to review and Newmark's to Clough to review, saying, "These can't both be right." It turned out that Newmark was focused on short-period structures, while Clough was working on tall apartment buildings.

Hall: I think that story is correct. The paper Newmark and I wrote in 1969[29] set the tone for how we did spectra in the future. This paper quickly was transmitted throughout the world

Hanson: Your 1969 paper was really the basis for the EERI monograph you and Newmark wrote, *Earthquake Spectra and Design.*

Hall: Newmark once told me, "Bill, I've never won a prize for any paper I've written that I thought was worthwhile." [laughter] The EERI monograph was related to the one we wrote for the nuclear industry.[30] The version for the nuclear industry we presented at the 4WCEE was written primarily for the existing, older plants. That seismic review criteria report caught on like wildfire and has been used all over the world.

Of course, the nuclear plant ground motion studies were also relevant to seismic design in general. Newmark and I published work in the 1960s and 1970s that illustrated a simple way to plot design spectra, for example.[31] Those publications, which are now four or five decades old, are still used.

After the 1960 Chile conference and the paper Newmark and I wrote, the U.S. Nuclear Regulatory Commission provided some money for a study of consistent use of spectra, and John Blume, Roland Sharpe, Nate Newmark, and I went to work. It resulted in another influential paper.[32]

Reitherman: What about your work for an agency overseeing a different kind of nuclear facility, defense plants manufacturing nuclear materials?

29 Nathan Newmark and William Hall "Seismic Design Criteria for Nuclear Reactor Facilities," *Proceedings of the Fourth World Conference on Earthquake Engineering,* International Association for Earthquake Engineering, Vol. II, pp. B4-37–B4-50, 1969.

30 Nathan Newmark and William Hall, *Development of Criteria for Seismic Review of Selected Nuclear Power Plants*, U.S. Nuclear Regulatory Commission, 1978.

31 Nathan M. Newmark and William J. Hall, "Special Topics for Consideration in Design of Nuclear Power Plants Subjected to Seismic Motions," *Proceedings of the IAEA Panel on Aseismic Design and Testing of Nuclear Facilities*, Japan Earthquake Engineering Promotion Society, Tokyo, pp. 114–119, 1969; Nathan M. Newmark and William J. Hall, "Development of Criteria for Seismic Review of Selected Nuclear Power Plants," Report NUREG/CR 0098, U.S. Nuclear Regulatory Commission, Washington, DC, 1978.

32 N.M. Newmark, J. A. Blume, and K. K. Kapur, "Seismic Design Spectra for Nuclear Power Plants," *Proceedings of the ASCE Journal of the Power Division*, Vol. 99, No. PO2, pp. 282–303, November 1973.

Hall: I made a couple of trips with George Housner to consult on such facilities, places that made nuclear materials for weapons for example, as distinct from generating electric power. From 1985–1998 I was a consultant to the Defense Nuclear Facilities Safety Board. All of that work was done in Washington, DC, because it was highly sensitive, so you won't find any of my work publicly available.

Chapter 8

Research for Defense Facilities and Blast-Resistant Design

About three years later, Newmark ran into my office shouting, "It worked." I said, "What worked?"

Blast Effects on Structures

Hall: Beginning in 1957, Newmark and I undertook an accelerated schedule of work to prepare a report on soil and rock dynamics effects caused by nuclear blast. The first draft was immediately applied to underground critical facilities. It's unusual to see your engineering research so quickly applied, but there was a real need and our work filled it.[33]

From then til the mid 1960s, Newmark collaborated with three MIT professors: Robert (Bob) Hansen, Miles Holly, and John

33 A declassified version was published in 1962: *Preliminary Design Methods for Underground Protective Structures,* Report AFSWC-TDR-62–6, Air Force Special Weapons Center, Kirtland Air Force Base, NM.

Biggs. They had a joint venture doing special work for the Department of Defense, which led to a manual called *Protective Construction Review Guide*. At Illinois, John Haltiwanger and I were heavily involved. The collaboration worked beautifully.

Reitherman: Some of that research evolved into the short course taught at MIT in 1956 on different kinds of dynamic loads, and a related book[34] Say a few words to compare blast engineering with earthquake engineering, since you have done so much work in both fields.

Hall: Blast-related dynamics are normally monotonic in the initial application of the loading, much like strong winds. Earthquakes, of course, are different in that motions are normally cyclic.

We worked on a variety of special projects for the government that related to blast effects. We were working with lots of government laboratories and agencies and involved in field tests where you would set off explosives to test full-scale structures. Over the years, the list of organizations Newmark and I provided advice to, together or independently, got rather long: Defense Nuclear Agency, U.S. Army Office of the Chief of Engineers, U.S. Army Waterways Experiment Station, U.S. Army Construction Engineering Research Laboratory, Naval Civil Engineering Laboratory, U.S. Navy Bureau of Ships, Office of Naval Research, Stanford Research Institute, Lawrence Livermore National Laboratory.

34 C.H. Norris et al., *Structural Design for Dynamic Loads*, McGraw-Hill, New York, 1959.

Civil Defense

Hall: The engineering know-how involved in protecting military facilities was also related to protecting the civilian population, and all of us at Illinois were also involved in civil defense research and instruction. I was invited twice to be a principal member of the Eugene Wigner studies group that resulted in some important work.[35] Wigner had received the Nobel Prize for his nuclear physics work. He had come to the U.S. in 1930 from Hungary. The studies were called Harbor and Little Harbor.

In a public service role, I gave many lectures in the evening on civil defense throughout Illinois and sometimes at the university.

Non-Defense Blast Work

Hall: There were also non-defense applications for the blast work Newmark and I did.

In 1963 Newmark and I undertook a special study[36] on the effects of an accidental internal explosion in Zero Power Reactor Cells 4 and 5 at Argonne National Laboratory. As part

35 E.P Wigner, W. J. Hall, et al., "Civil Defense–Project HARBOR Summary Report," Publication 1237, NAS-NRC, Washington, DC, 1964.

36 "Design Criteria for Reactor Cells Building 315, Argonne National Laboratory–Appendix I," and "Summary of Calculations Concerning Containment Capacity of Cells 4 and 5 of Building 315 of the Argonne Fast Critical Facility–Appendix J," in "Safety Analysis Report," W.Y. Kateo et al., editors, Argonne National Laboratory Report 6271, 1963.

of that study, we developed some special techniques, largely based on transient velocity loadings as distinct from acceleration loadings. These were never formally published, just one of the Argonne Laboratory reports.

Around 1970 two pharmaceutical companies asked us to advise on the design of a protective structure approximately 25 by 25 feet in plan and 40 feet high with a frangible roof. Inside would be a crucible reactor in which hypergolic substances were mixed. The goal was to provide protection for the employees in case one of these blew up—as had happened, we were advised. I designed and detailed the reinforced concrete containment down to the tie wires, not just the reinforcing bars. At the corners where reflections are significant, the reinforcement was especially critical.

About three years later, Newmark ran into my office shouting, "It worked." I said, "What worked?" He said one of these reactors had blown up, the explosion vented as planned, and there were no cracks in our structure. I remember him commenting how rare it is to design for extreme loads and then get the proof positive that the design worked.

About this same time, early to mid 1960s, we undertook at the University of Illinois many studies of loading rate effects. This was, of course, related to blast loads since they happen very quickly. Loading rate studies had been done previously, but when we were doing our research, the results for steel and reinforced concrete structures were quite variable and hard to quantify.

Reitherman: Let me interject for the record that the R. N. Wright, Richard Wright, who co-authored one of those loading rate papers with you, [37] became prominent in the earthquake program of the National Bureau of Standards (now National Institute of Standards and Technology) after finishing his doctoral work at Illinois.

Applying Defense Research to Other Civil Engineering Problems

Hall: In 1984, I was asked to provide testimony to the Science and Technology Committee of the U.S. House of Representatives.[38] The late Representative George E. Brown, Jr., from southern California, was the lead member of Congress in that subject area. I touched on several topics, but among them the way research that originates in one area often pays off in another. You can see from my career how military research ended up having earthquake engineering and other applications, for example. Representative Brown heard I was in the building and was so interested in what I had said that he called me back in the afternoon for a private discussion of the matter. Specialized military-related work isn't usually

37 R. N. Wright and W. J. Hall, "Loading Rate Effects in Structural Steel Design," *Structural Division Journal*, ASCE, Vol. 90, No. ST5, pp. 11–37, 1964.

38 "Statement of Dr. William J. Hall, Professor of Civil Engineering, Head, Department of Civil Engineering, University of Illinois, Urbana, IL," Hearings before the Subcommittee on Investigation and Oversight and the Subcommittee on Science, Research and Technology, 98th Congress, Second Session, May 23, 1984, No. 141, pp. 213–232.

covered by the usual construction codes, and over time, through the publication of that research and consulting work, improvements in civilian structural engineering codes and practice come about.

From 1950, the first year of my graduate study at the University of Illinois, until about 2010, Newmark earlier and I later regularly had financial support provided from the Air Force, Navy, Defense Nuclear Agency, Maritime Agency, Coast Guard, and many other units and groups located within those agencies. In the earlier years such support underwrote our analytical and physical testing programs in our civil engineering laboratory. It was quite different from what everyone is used to now: there was no NSF funding for civil engineering research in those early years. In recent years, financial support has been provided to our department from other Department of Defense entities. These funds in part supported research into such topics as brittle fracture research, model blast tests, inelastic behavior in steel and concrete beams and shells, and structural connections.

The spinoff benefits of the military-related work included very direct and immediate ones at the university. It brought in funds for research and resulted in work mostly disseminated through open publications by our students and faculty. In some cases, Newmark, Haltiwanger, Merritt, and I were contracted as consultants to provide the Defense Department groups and their laboratories with advice on applications, (work which was often classified), such as advising and observing laboratory and field tests and providing direct applications to permanent field design and construction.

Through our efforts and contacts we often were able to bring in large amounts of funding for our research programs and thereby support graduate students. All through my career I have had some connection and involvement with such activities.

Chapter 9

Research on Steel Design

In World War II the Navy and the Maritime Service had a lot of trouble with fractures in steel hulls, but they didn't advertise it. Sometimes a ship would crack apart when it was just sitting at the dock.

Hall: A major research effort was mounted in the 1950s on propagation and arrest of brittle fracture in wide steel plates. In World War II the Navy and the Maritime Service had a lot of trouble with fractures in steel hulls, but they didn't advertise it. Sometimes a ship would crack apart when it was just sitting at the dock. There was a large group of people involved in this research. Work was done at the U.S. Navy Bureau of Yards and Docks, Brooklyn Naval Shipyard, Naval Research Laboratory, and Brown University. Later on, work was sponsored by the Welding Research Council, ESSO, and AMOCO. We thought about how to stop a fracture once it started, although you wanted to prevent it from beginning in the first place. If a fracture did get started, what were its characteristics? How did it run? Why would the propagation slow down or stop? Stan Rolf was one of the engineers involved in that line of research.

Later on, I was chair of a national advisory board ad hoc committee on fracture mechanics applications in naval and merchant marine vessels. This was under the auspices of the National Research Council. The papers I wrote on that topic span from the 1950s through the 1970s. During that period I branched out into the nuclear power plant, seismic design spectra, and pipeline fields, but I stayed involved in the fracture mechanics field that was so important to naval and cargo vessels. The papers I wrote with Stan Rolfe in 1961[39] and with W.J. Nordell in 1965[40] were especially influential. This work also led to a book[41] that I co-authored with some experts from other countries. Kihara was from Japan, Soete from Belgium, and Wells from the United Kingdom. Buried within it is a summary on the exhaustion of ductility, mostly based on work at Brown University; that really should be given more research attention, because it is an important topic.

We went to Washington one time to meet with someone from the Navy to discuss the problems of fractures in aircraft carrier decks. After a three-hour meeting, I left him with notes on my proposed solution. The next year I met him at another meeting and he said they had applied that solution to carriers and the solution was working.

Reitherman: Can you describe that solution?

Hall: It was pretty simple. The goal was the reduction of runaway fractures in steel structures. The solution involved a series of slots and holes. As the fractures run, you get a big release of energy. You have to have enough flexibility, enough give at a slot or hole, to keep the fracture from running on. There was nothing magical about it. It was just what I had learned in the laboratory. In my steel plate fracture laboratory work, I must acknowledge the invaluable instrumentation effort by V. J. McDonald in measuring and recording high-speed fracture effects of running brittle fractures.

Of course, you try to understand crack initiation, but it is still a very difficult problem. A crack may begin to propagate from a small flaw. Crews would install clevises and other hardware through the ship's deck, and hulls could have scratches. The ship's structure can be highly stressed, and in cold weather, even sitting at the dock, a fracture had sometimes been initiated.

I got called in later as a special advisor to the National Research Council group that was doing research on naval vessels. We were part of a group of knowledgeable people in the military and in the universities who reduced the incidence of ships' hulls cracking.

Much later, after the 1994 Northridge Earthquake, I was the chair of the advisory committee to the SAC Steel Project, the

39 "Strain Field Associated with Brittle-Fracture Propagation in a Wide Steel Plate," *Experimental Mechanics*, SESA, Vol. 1, No. 9, pp. 113–119.

40 "Two Stage Fracturing in Welded Mild Steel Plates," *Welding Journal*, AWS, Vol. 44, No. 4, Res. Suppl., pp. 182s-192s.

41 W.J. Hall, H. Kihara, W. Soete, and A.A. Wells, *Brittle Fracture of Welded Plate*, Prentice-Hall, Englewood Cliffs, NJ, 1967.

project funded by the Federal Emergency Management Agency that was set up to reduce to an acceptable level brittle fractures of welded steel moment-frames.

Chapter 10

Earthquake Engineering Research and Consulting

The effect of the fault rupture was to shorten that segment of the Trans-Alaska Pipeline by six feet. I've described the pipeline as a 792-mile-minus-six-feet-long pipeline.

Reinforced Concrete Codes

Hall: Mete Sozen, bless his soul, re-wrote the seismic part of the American Concrete Institute structural code at the same time Newmark and I were doing nuclear power plant work in the 1960s and 1970s. Mete needs to get a gold star for what he accomplished.

Reitherman: ACI 318 is now a lengthier and more complex document.

Hall: One of my big complaints is that all the codes and standards, including the International Building Code, are almost unusable because they are too big. Their procedures are difficult to follow.

Reitherman: Usually a document that has been around for a long time, and has been institutionalized in codes and practice, is hard to change. How did the seismic provisions in ACI 318 get changed so rapidly?

Hall: Mete was a good politician as well as an engineer. And it was obvious that reinforced concrete seismic design needed a major updating based on research such as was done at Illinois, and because of poor performance in several earthquakes. Mete was responsible for much of the ACI code revision work during the time when ATC-3 was being produced.

NBS Compendium on Hazard-Resistant Design, ATC-3

Hall: In 1972, a conference called Building Practices for Disaster Mitigation took place in Boulder, Colorado. Newmark and I wrote one of the chapters [42] at the time we were starting to develop modern methods of dynamic analysis that the code people could put into a form that would, many years later, evolve into the NEHRP Recommended Provisions. The work for the National Bureau of Standards was the forerunner of ATC-3, *Tentative Provisions for the Development of Seismic Provisions for Buildings*,[43] which in turn led to the *NEHRP Recommended Provisions for Seismic Regulations for New Buildings*[44]. In the ATC-3 project, Rol Sharpe was the director. At the Fifth World Conference on Earthquake Engineering in Rome, Newmark and I articulated our vision for what we called a rational approach to seismic design.[45] The ATC-3 project had the same aim. Up to then, seismic design standards had done the best job they could given the level of knowledge, but they were an accumulation of rules of thumb and empirical information.

The Trans-Alaska Pipeline

Hall: Newmark was chosen around 1970 or 1971 to be the Department of the Interior's key engineer on technical issues such as seismic design to mediate between the government and the oil industry consortium building the pipeline. He immediately asked me to help, and Illinois geotechnical professors Ralph Peck and Alfred Hendron were also later involved. Private sector consultants included Lloyd Cluff, a geologist, and Douglas Nyman, an expert on oil and gas pipelines. Seismologist Bruce Bolt was involved in that too, and the Department of the Interior had many staff assigned to the project as well.

Newmark and I were involved in virtually all aspects of this 48-inch-diameter steel pipeline extending from Prudhoe Bay, at the north

42 Nathan Newmark and William Hall, "Procedures and Criteria for Earthquake Resistant Design (Part II)," *Building Practices for Disaster Mitigation,* National Bureau of Standards, Washington, DC, 1973.

43 Applied Technology Council, Redwood City, CA, 1978.

44 Building Seismic Safety Council, Washington, DC, 1985.

45 "A Rational Approach to Seismic Design Standards for Structures," *Proceedings of the Fifth World Conference on Earthquake Engineering,* International Association for Earthquake Engineering, Vol. 2, pp. 2266–2275, 1974.

edge of Alaska, to the ice-free port at Valdez, 792 miles to the south. The background for the project goes back to 1968 with the discovery of the huge petroleum reserves that could be extracted along the Arctic Ocean. Then, a strong impetus for more energy self-sufficiency for the country followed the Arab Oil Embargo of 1973, which was a side effect of the 1973 Arab-Israeli War. The construction phase of the pipeline was 1974 to 1977. For the next several decades, it was the largest privately funded project in the history of the world.

Newmark wrote the seismic design guidelines, and we both produced a lot of reports, some on the ground shaking hazard[46] as well as surface fault rupture.[47] You have to realize that there were absolutely no standards to refer to for how to design a 48-inch-diameter oil pipeline, let alone one crossing areas of permafrost, severe cold weather, and earthquake faults. This was a great example of technology transfer.

Hanson: What about the pipeline's crossing of the Denali Fault, which ruptured in 2002?

Hall: Let's first think about the oil going through the pipeline. A friend of mine, the late Harold Peyton, was sent to Russia to see how they did pipelines in cold climates. Warm oil is flowing through the pipe coming up from the ground at about 180 degrees Fahrenheit, and it cools down to about 115 degrees, and you blend it with other oil in such a way that it won't turn to a thick gel in the wintertime, because then it cannot be pumped. So Peyton came back and said the Russians have been doing a zig-zag configuration above ground. For the Trans-Alaska pipeline, half is above ground, half below ground. And there would be large areas of below-ground ice in the permafrost areas. That zig-zag configuration was one source of inspiration for the above-ground portion.

The other was when I showed Newmark some pictures of pipelines crossing a fault near Parkfield, California, where the pipelines were curved like snakes, and Newmark said, that's what we should do.

The portion of the pipeline below ground was not sensitive to shaking. Above ground, in the zone of surface fault rupture, the pipeline was designed such that the hardware could fall off a particular short segment of the pipeline and the pipeline would just sag a little. That's exactly what it did in the 2002 magnitude 7.9 Denali Earthquake. Where the pipeline crossed the Denali fault, it was designed to accommodate 18 feet of horizontal offset and 4 feet of vertical offset, which was about the way the fault behaved when it ruptured in 2002. The effect of the fault displacement was to shorten that segment of the Trans-Alaska Pipeline by six feet. I've described the pipeline as a 792-mile-minus-six-feet-long pipeline. [laughter] The pipeline did not buckle or leak, and 66 hours after the earthquake, the oil was flowing again.

46 "Seismic Design Spectra for the Trans-Alaska Pipeline," *Fifth World Conference on Earthquake Engineering,* International Association for Earthquake Engineering, Rome, Italy, vol. 1, pp. 554–557, 1974.

47 "Pipeline Design to Resist Large Fault Displacement," *Proceedings of the US National Conference on Earthquake Engineering,* University of Michigan, Ann Arbor, MI, pp. 415–425, 1975.

The Alaska experience was valuable for advancing the field of earthquake-resistant design of pipelines in general. It resulted in an important document, "Guidelines for the Seismic Design of Oil and Gas Pipeline Systems." It was a project headed by Douglas Nyman and published by TCLEE, the Technical Council on Lifeline Earthquake Engineering, ASCE, in 1984.

Highway Bridges

Hall: Newmark and I also applied our seismic design work to highway bridges. The seismic design provisions in the U.S. are basically those published by the American Association of State Highway and Transportation Officials, AASHTO. We published some work that helped modernize seismic design provisions for those kinds of structures. In 1979, we published "Seismic Design of Bridges–An Overview of Research Needs," in an ATC compilation, which was related to the 1981 publication of ATC-6.[48]

National Academy of Engineering

Hall: At age 42, I was one of the youngest people ever elected to the National Academy of Engineering. You're in the Academy, Bob [Hanson], so you know the system. I was elected in 1968, that's the fifth class in the NAE. In the late 1950s and the 1960s, in addition to the military work and consulting work on structures, I was heavily involved in other areas. One was in the Department of Commerce on high-speed transportation. I was working on fracture problems in naval ships, with experts on materials topics. I was exposed, when I look back on it, to probably half the NAE membership at that time. There were a lot of people in the academy who knew me and my work. At that time I was extensively involved in several National Research Council projects, so apparently my name and work was known there too. But I didn't know how my election happened, which is the way it's supposed to be. It's a confidential process, right Bob [Hanson]?

Hanson: You're not supposed to know. Beyond having a member recommend you, the others in the academy then have to make the decision. Speaking of honors and awards, we should mention that you have received EERI's Housner Medal, as well as several honors from ASCE, including the Huber, Newmark, , Duke, and Howard awards.[49]

48 *Seismic Design Guidelines for Highway Bridges*, Applied Technology Council, Redwood City, CA, 1981.

49 "Biography," in *The Art and Science of Structural Engineering: Proceedings of the Symposium Honoring William J. Hall*, Prentice Hall, Upper Saddle River, NJ, 1993.

Chapter 11

Family and Avocations

My mother loved the ocean, and she particularly loved Carmel. In the 1970s, Elaine and I made a point of going there after New Year's, almost every year.

Reitherman: How about a few questions related to home life and non-engineering interests? You've mentioned that you've spent time in the Boundary Waters Canoe Area. What and where is that?

Hall: It's in northern Minnesota. My wife, children, and I went fishing at a lodge there that is no longer in existence, usually in August.

Reitherman: What about the early photo of you taken at Carmel, California?

Hall: I was four months old. My mother loved the ocean, and she particularly loved Carmel. In the 1970s, Elaine and I made a point of going there after New Year's, almost every year. And then every other year we rented a big house and took the whole family (13 of us).

Hanson: Tell us about your children.

Hall: We have three children. Martha married Matthew Sigler, and they have a son, Andrew, our grandson, and a daughter Laura, our granddaughter. James, our son, married Melody O'Brien. And our younger daughter, Carolyn, married Larry Vandendriessche, and they have two daughters, Helen and Lynn, our granddaughters.

Hanson: Do they live in the vicinity?

Hall: No. Martha lives in North Carolina, Carolyn in Ohio, and James in Tennessee.

Reitherman: What about this photo of Lake Tachen?

Hall: It's about 30 miles from here. Lake Tachen is a four-acre pond. Our uninsulated cabin is in 1.7 acres of woods. It's just a summer cabin. It's a place to get away from it all. The owner of the surrounding land, three sons who inherited it, decided to forego farming on it and made it a nature reserve.

Reitherman: What about other travels and vacations?

Hall: We used to travel a lot. We particularly like Scandinavia, Scotland, and Ireland. New Zealand and Australia were also fun. These are countries where the drinking water is of good quality, one of the basic criteria for a nice place to visit. Our favorite trip was to Israel.

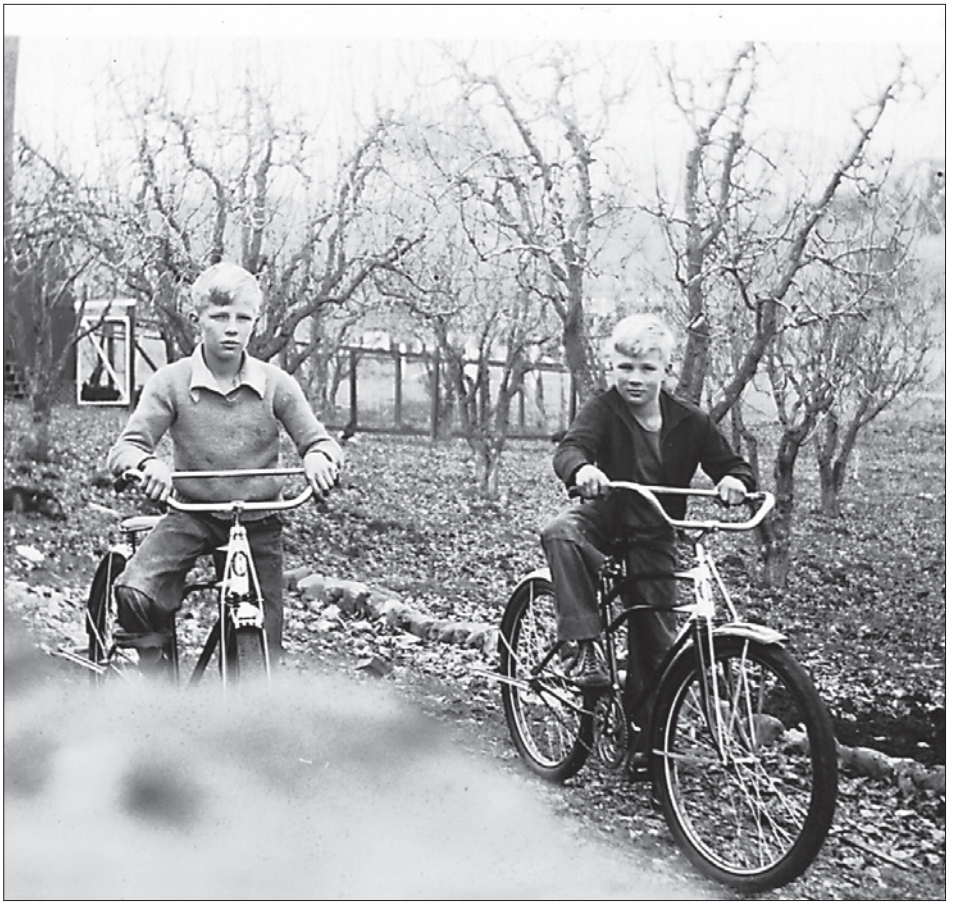
Reitherman: What about Elaine's musical activities?

Hall: She majored in music at the University of Kansas. Now in her 80s, she still takes lessons. She plays a lot in community programs like in elderly homes. She is in an audition-only ensemble, mostly retired professionals. She practices every day. I have a deep sense of gratitude for the wonderful way she raised our children when I had a busy schedule. To her, I want to say THANKS—and put that in all caps.

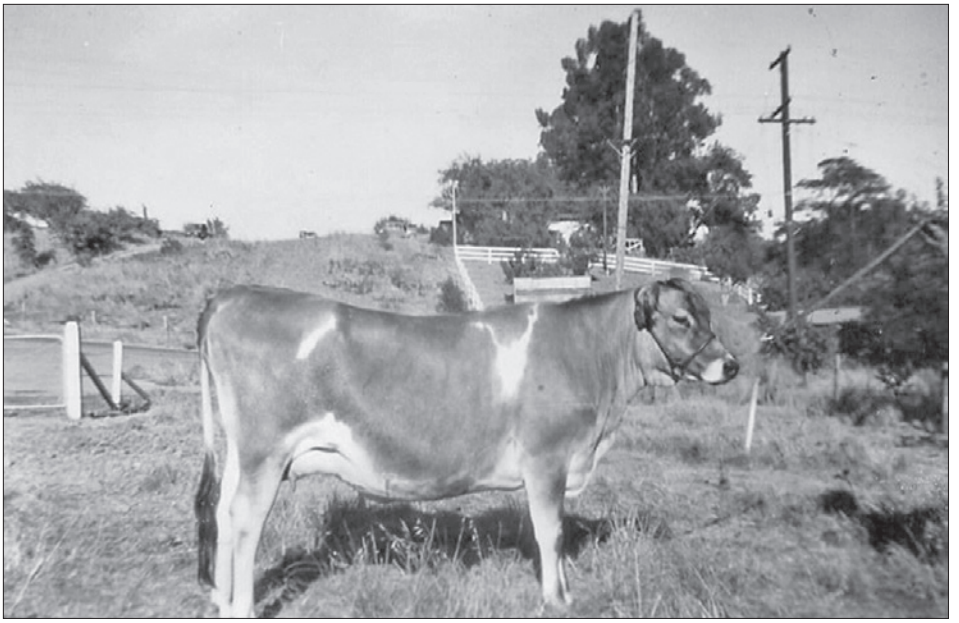
Photographs of William J. Hall



The house in Lafayette, California where Bill Hall grew up, as it looked in 1940 with a partial view of the large pear orchard in the foreground.



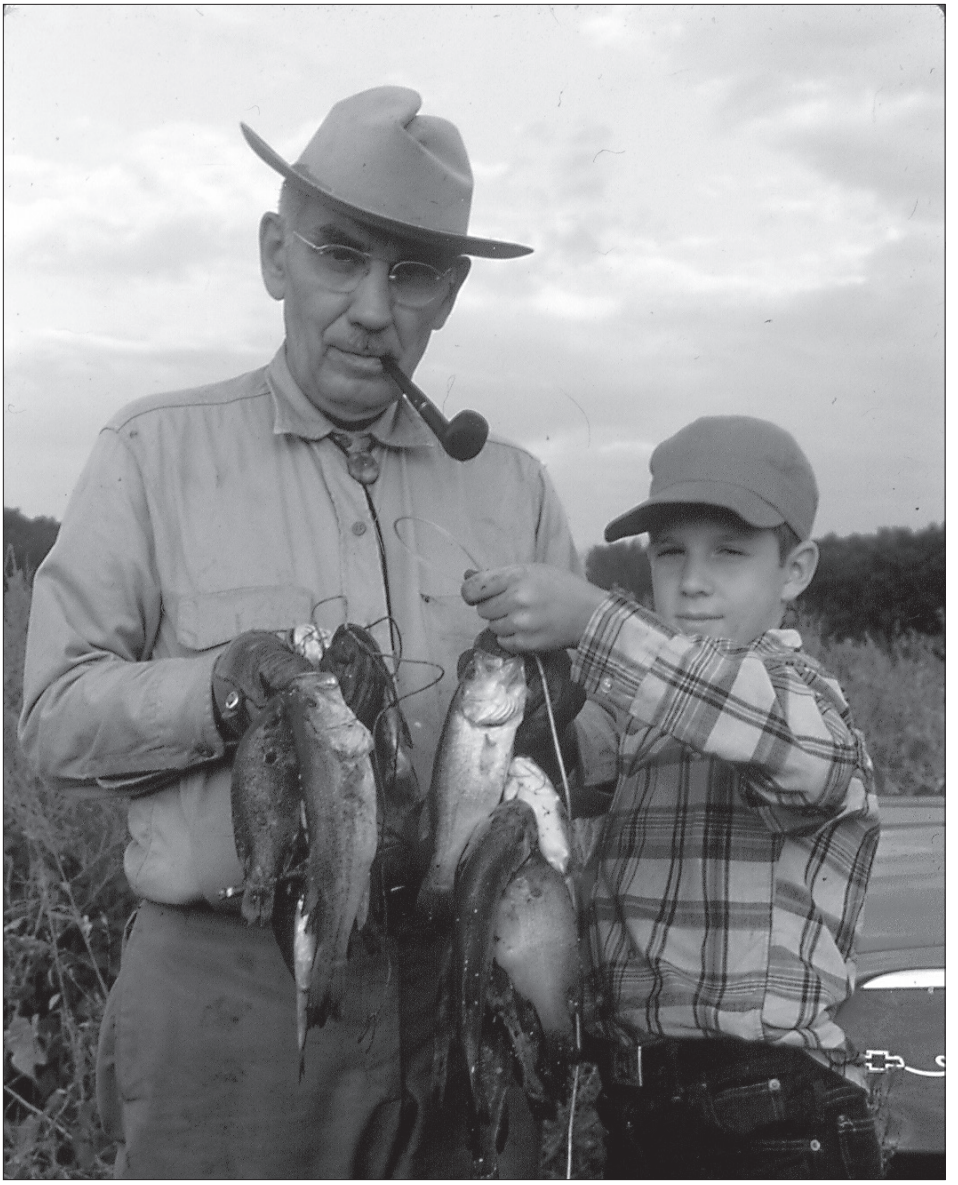
Bill, left, with his younger brother Hubert ("Hub") on their Christmas bicycles, 1937, at the small ranch in Lafayette, California.



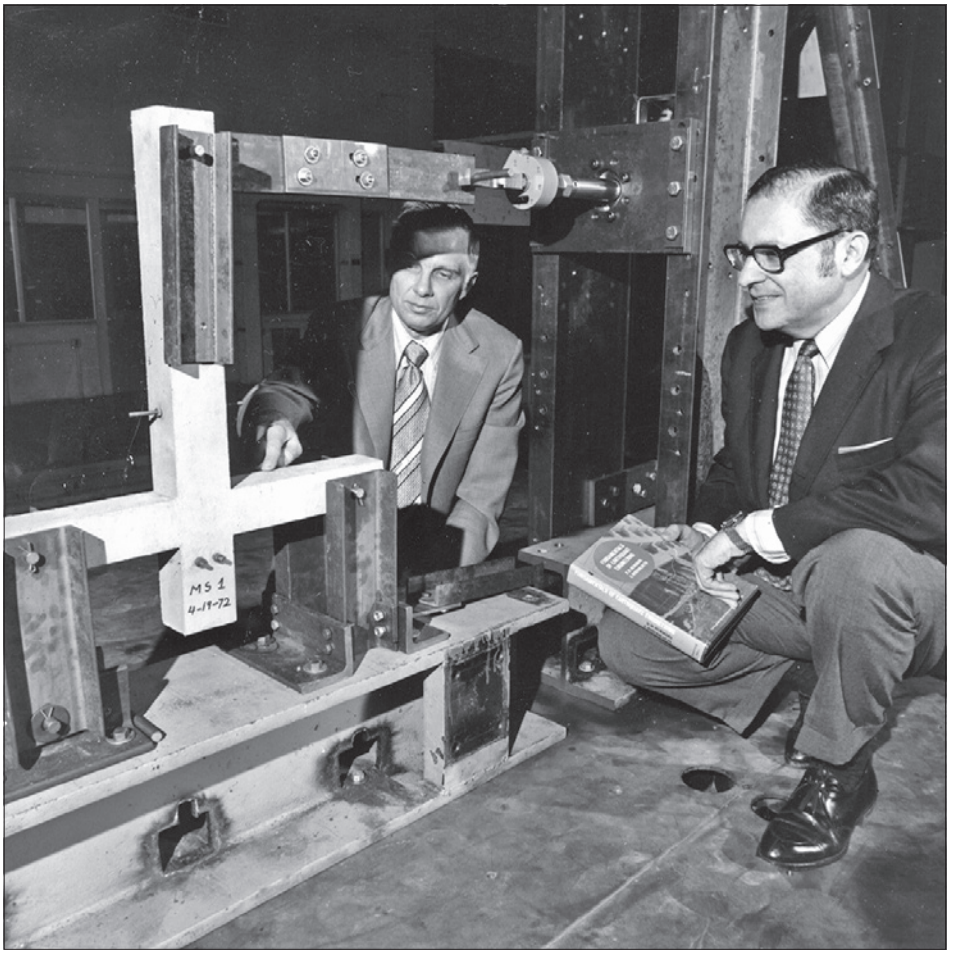
Bill's purebred Jersey heifer, named Fanita of Venadura, won him a gold medal for Jersey cow showmanship at the 1940 California State Fair, when he was 14.



Mary and Eugene Raymond Hall in 1973 with their sons. Left to right: Bill, Hubert, and Ben.



Eugene Raymond Hall, with grandson James (Elaine and Bill's son), after a fishing trip at Little Bull Creek, Kansas.



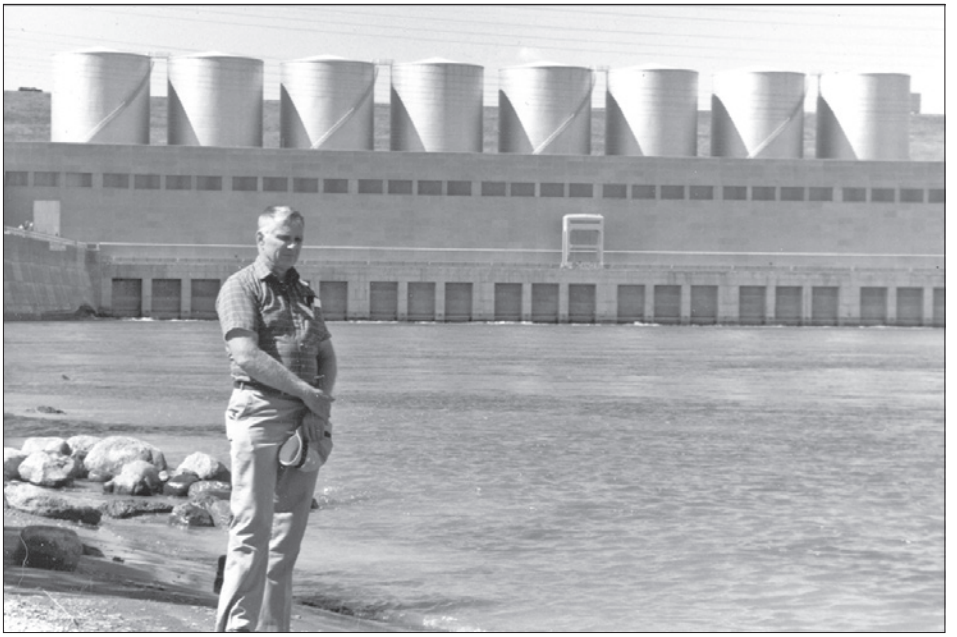
Hall, left, with Nathan Newmark in Talbot Laboratory, 1972. (Newmark is holding the textbook he co-authored with Emilio Rosenblueth, ***Fundamentals of Earthquake Engineering****, published the previous year.)*



Hall standing in front of the newly constructed Trans-Alaska Pipeline.



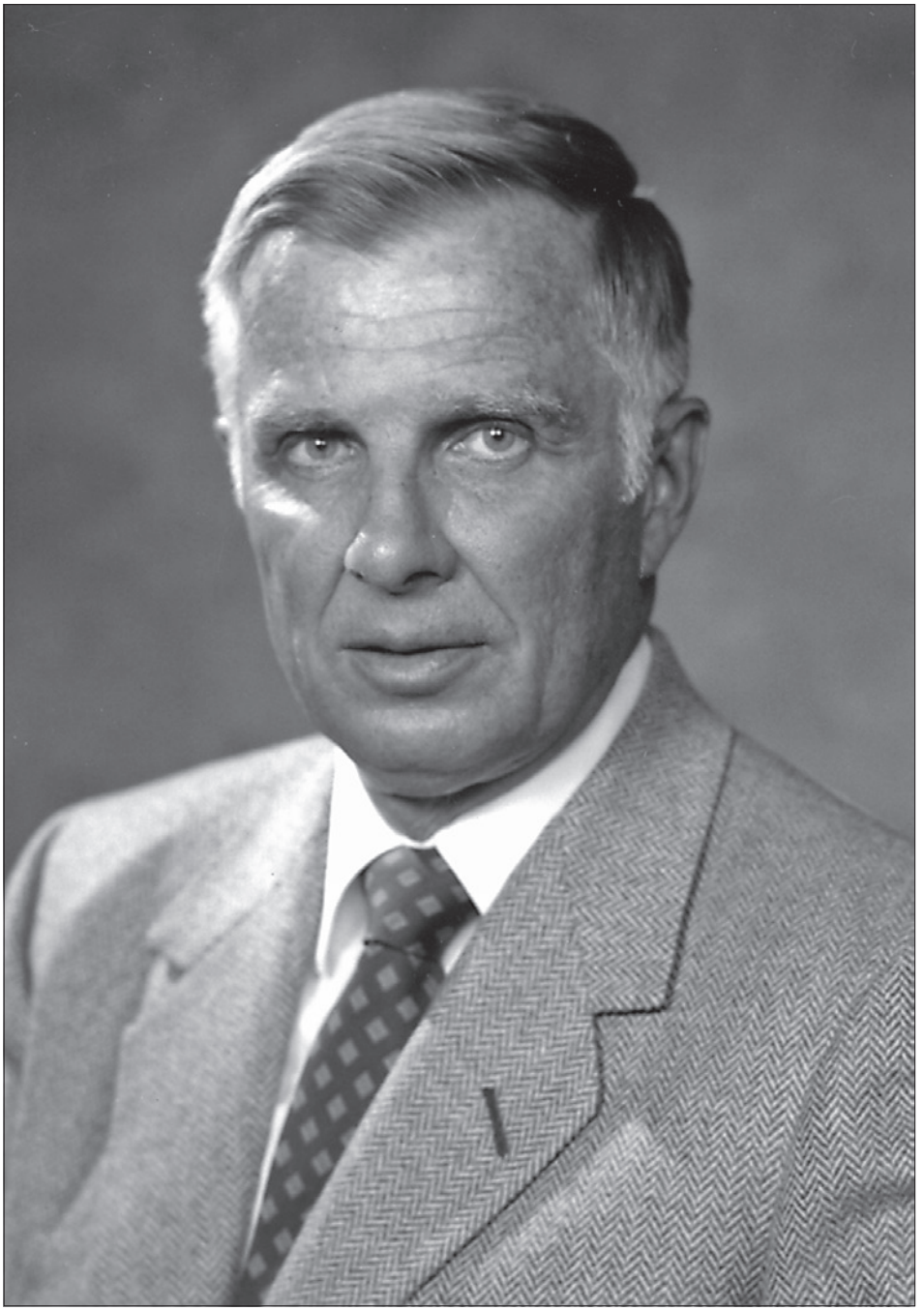
Newmark and Hall observing construction of the Trans-Alaska Pipeline over Thompson Pass, 1972.



Hall at Garrison Dam, North Dakota, examining the dam's surge tanks for the Army Corps of Engineers.



Elaine and Bill Hall with walleye and northern pike caught in the Kawishiwi River, northern Minnesota, 1980.



Hall when he was Head of Civil Engineering at the University of Illinois Urbana-Champaign from 1984 to 1991.



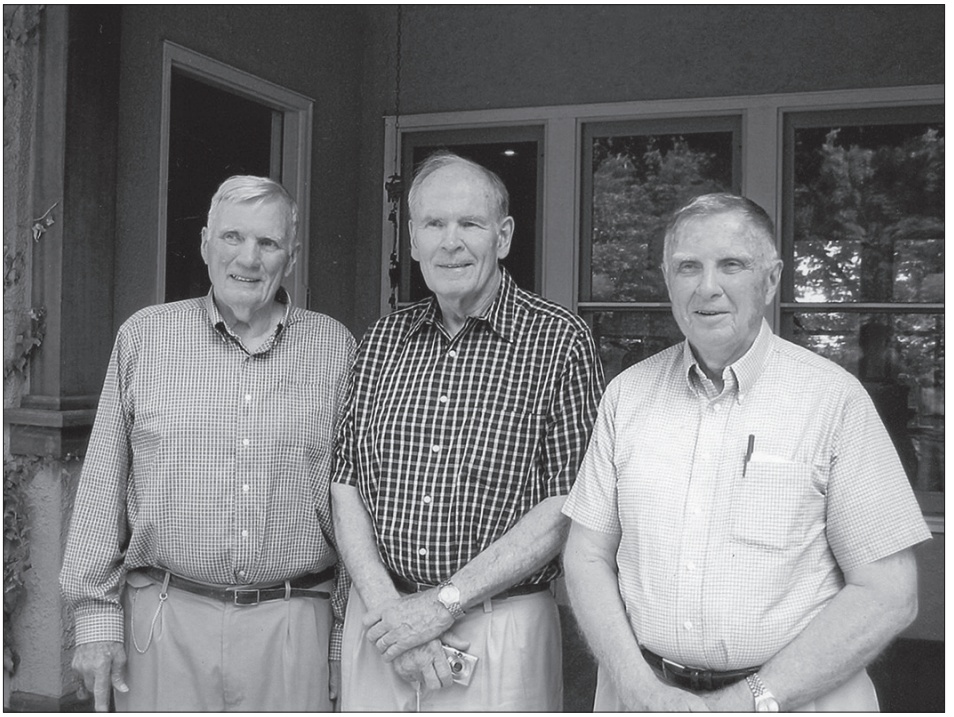
Hall and grandson Andy Sigler on the steps of Talbot Laboratory, University of Illinois at Urbana-Champaign, 1990. Bill had his graduate student office in the building and did extensive testing there. Andy later received his degree in electrical and computer engineering from the university.



A 1994 photo of University of Illinois graduate student classmates who began their studies in August of 1949 under Nathan Newmark. Left to right: Doug Wright, Dean Collins, Sam Errera, Shel Cherry, Bill Becker, and Bill Hall.



Bill, right, and his brother Ben fishing in the Queen Charlotte Islands, British Columbia, 1997.



The Hall brothers in a 2007 photo.
Left to right: Hubert, Ben, and Bill.



Bill and Elaine Hall at their cabin at Lake Tachen, Illinois, 2010.



Family reunion at Carmel, California in 2013. Elaine and Bill are front row, center. Other family members, left to right: Jim Hall (son); Tim Logan, married to granddaughter Laura (Sigler) Logan; Melody (O'Brien) Hall, married to son Jim; Laura (Sigler) Logan, granddaughter; Matt Sigler, married to daughter Martha; Martha (Hall) Sigler, daughter; Andy Sigler, grandson; Helen Vandendriessche, granddaughter; Lynn Vandendriessche, granddaughter; Carolyn (Hall) Vandendriessche, daughter; Larry Vandendriessche, married to daughter Carolyn.

Appendix

Nathan M. Newmark:

A Model of Engineering Creativity

The following chapter by William Hall, "Nathan M. Newmark: A Model of Engineering Creativity," published in *No Boundaries: University of Illinois Vignettes,* edited by Lillian Hoddeson, copyright 2004 by the Board of Trustees of the University of Illinois, is used here by permission of the University of Illinois Press.

WILLIAM J. HALL



CHAPTER 10

Nathan M. Newmark:

A Model of Engineering Creativity

In the early 1950s, Nathan M. Newmark, one of the twentieth century's leading educators and engineers in civil engineering, asked a graduate student assistant who had expressed opinions about some research findings, "Where did you learn that?" "In a book," the student responded. Newmark, who would in 1956 be appointed head of the Department of Civil Engineering at the University of Illinois, replied: "If all you know is what is in a book, you are in great difficulty."

Over the course of his career, Newmark developed many simple yet powerful and widely used methods for analyzing complex structural components and assemblies under a variety of loading conditions, and for calculating the stresses and deformations in the soil beneath their foundations. He contributed to achieving a better understanding of the behavior of structural materials under various environments, including fatigue and brittle fracture, and of structures subjected to impact, periodic excitation, wave action, wind, blast, and earthquakes. He also developed techniques for designing and carrying out simple numerical procedures, initially

using the slide rule, later mechanical calculators, and still later electronic computers. Newmark's contributions to the University of Illinois and the engineering profession were enormous. His unceasing devotion to research, his noteworthy and continuing contributions to the betterment of structural engineering practice, and his leadership in engineering education, teaching, and professional activities have had a profound influence on civil engineering worldwide.

EARLY LIFE

Newmark was born on September 22, 1910, in Plainfield, New Jersey. He was the oldest of Abraham S. and Mollie (Nathanson) Newmark's three children; the other two were Nathan's sisters, Isabelle and Vera. That Nathan was a boy was of great significance in the family, especially on his mother's side, for his mother was the oldest of seven sisters. His father, well read in Hebrew, Yiddish, and English, was quite a philosopher. The family subsisted mostly on his mother's work as a seamstress and her odd jobs for people done out of the house. Nate's father's work went from farming in Fayetteville, North Carolina, and Fair Lawn, New Jersey (near Paterson), to a grocery business after the farms failed.

Education was of prime importance in the Newmark household. A precocious child, Nate excelled in school, despite the family's many moves and his many changes of school. His kindergarten teacher recognized his special abilities, even then, and called him "Dr. Nate." In seventh grade, in Fayetteville, North Carolina, Nate won the "Observer Composition Contest," with an essay on "Why I Want to be a Farmer When I am Grown." Attending Eastside High School in Paterson, New Jersey, Nate graduated as valedictorian at the age of fifteen. Highly proficient in all his studies, he was also a voracious reader. He worked on the farm during his high school vacations and as a salesperson in a specialty food store on Saturdays. After Nate finished high school, the family moved back to Plainfield. His family relationships were close; the girls depended on Nate for help with their homework, games, and problems. In later years, Nate saw to it that his two sisters received a college education.

When Newmark received a scholarship to attend Rutgers University, he matriculated in chemistry. Nate's father, who maintained an interest in scientific farming, felt that his son should study agriculture, as Rutgers had an excellent school of agriculture. But the story has it that Nate's Uncle Julius Newmark, a Rutgers graduate who worked as a civil engineer for the New Jersey highway department, finally persuaded Nate's father to let his

son major in civil engineering. In 1930, Nate graduated from Rutgers with Special and High Honors in Civil Engineering.

The reputation that Newmark developed as a civil engineering student is suggested by the passage that accompanies Newmark's picture in the Rutgers yearbook of 1930: "The sages on Mount Olympus were filled with grief and despair. Three of their number, Archimedes, Galileo, and Newton, had been sorely wounded by a dragon in the guise of a problem in mathematics. No one on Mount Olympus dared attack it. The wise men were assembled by order of Plato to decide what to do. Suddenly, in their midst a spirit from the earth appeared, enveloped in a cloud of smoke (this is a pipe dream). 'I'll solve your problem,' spake the spirit. 'Who are you?' shouted Leibnitz. Came the ready answer, 'Newmark of Rutgers.' Then Nate woke up."

THE UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

In 1930, following his graduation from the Rutgers school of civil engineering, Newmark accepted a fellowship from the civil engineering department at the University of Illinois. This was the first of a long succession of positions that Newmark held at the University of Illinois, a succession that would extend over half a century. According to Newmark, a Rutgers faculty member who was familiar with the College of Engineering at Illinois strongly urged him to do graduate work at the University of Illinois because of its reputation for having a strong faculty in civil engineering. Newmark took the advice. On August 6, 1932, during this period at Illinois, he married Anne Mae Cohen, then a secretary in the Department of Theoretical and Applied Mechanics.

As early as 1867, the trustees of the new Illinois Industrial University had identified the Department of Civil and Rural Engineering as an element of the College of Engineering. The department became operative in 1868 when the university opened its doors.[1] It later assimilated the Department of Municipal and Sanitary Engineering to form the Department of Civil Engineering. The list of distinguished faculty associated with this department over the years includes such nationally prominent professors as John S. Crandell and Carroll C. Wiley (in highways); James J. Doland (in hydraulics); Harold E. Babbitt (in municipal and sanitary engineering); Charles A. Ellis, Wilbur M. Wilson, Hardy Cross, and Thomas C. Shedd (in structures); Herald M. Westergaard (in mechanics), Arthur N. Talbot (in public health, reinforced concrete, and railroad engineering); Frank E.

Richart (in reinforced concrete); and Herbert F. Moore (in materials). These individuals were among the leading engineering educators of their time and worked on many of the important projects of their period. They were well known for their research because it was applicable to practice, and for their research reports and textbooks, which were used nationally and internationally.

As a case in point, one day about 1962, shortly after Newmark took over as head of the Department of Civil Engineering, Joseph Pettit, dean of engineering at Stanford University (and later president of the Georgia Institute of Technology), approached Newmark about coming to Stanford as head of civil engineering. I well recall that in the midst of these discussions, to my great surprise, Joe Pettitt appeared in my office and asked, " . . . what is it that makes the University of Illinois Civil Engineering Department have such a strong reputation?" I responded, "All schools have buildings and books, but we have been blessed from the beginning with an extremely qualified and well known faculty, as well as excellent staff and students." I pointed out that the wide use of textbooks authored by the faculty at the university, as well as their publications arising from research that was central to civil engineering practice, contributed both to the reputation and to the desire of talented individuals to be part of the University of Illinois.

A succinct statement about Newmark's activities in his early years at Illinois appears in a 1942 report. The report refers to Newmark's work as "outstanding" in the field of civil engineering and explains that he was appointed a research graduate assistant in the Engineering Experiment Station, where he worked for two years under Professor Wilbur M. Wilson (who ran the experimental work in Talbot Laboratory) and then for two more years under Professor Hardy Cross, continuing his studies under Wilson and Professor Herald Westergaard.

Newmark was awarded his doctorate in 1934, with a thesis titled "Interaction Between Rib and Superstructure in Concrete Arch Bridges." A large-scale model of the type of bridge he analyzed in his doctoral thesis was built in Talbot Laboratory for physical study under the guidance of Wilson and Richart. Newmark's acknowledgment in the thesis gives credit to Cross for supplying some unpublished leads for carrying out the analyses; the "star-loaded" final doctoral committee consisted of Cross as chair, Richart, Shedd, Westergaard, and Wilson. Because Newmark's work with all his three professors—Wilson, Cross, and Westergaard—was outstanding, Wilson recommended that a permanent position be created for him on the civil engineering staff of the Engineering Experiment Station. In his letter to

support Newmark for this postdoctoral appointment, Westergaard wrote, "I believe that his appointment will be a contribution to the solution of the difficult problems of future distinction of the University. His intellectual capacity is rare, his personality attractive. He is among the few who can be rated as truly brilliant." Cross and Wilson echoed these accolades.

The Engineering Experiment Station had been established in 1903–5 to manage research activities for the college, especially those conducted in its many laboratories, and to handle publications reporting on the work. It was no accident that Newmark was supported with Experiment Station funds ("soft money" in today's definition), given that he was so active in research.

In the materials on Newmark preserved in the Grainger Engineering Library are copies of two reports by Newmark written in the 1930s. One was a brief report in July 1931 to the chief design engineer of the Bureau of Reclamation, Department of the Interior, on the topic of abutment movements in arch dams. (This report came from Plainfield, New Jersey, obviously while Newmark was home after his first year of graduate work.) The second report, a product of what Newmark referred to later as "my first consulting job" (interpreted by him as the first engineering task for which he received payment), was to the Bureau of Reclamation in 1933; it dealt with the effect of damping on seismic vibration response of the twin water intake towers for Boulder Dam.[2]

Appointed initially as a research assistant, Newmark rose to research assistant professor in 1941, and he was in 1943 appointed research professor of civil engineering with tenure, skipping the intermediate rank of associate professor. The "research" in the title indicated that his salary was paid from research (i.e., soft) funds and he was not on the tenure track. Interestingly, Newmark was granted tenure in 1943 under what must have been special circumstances. The precise reason for skipping the intermediate rank is not known, but one can surmise that his prodigious research efforts in many areas, and possibly his World War II efforts, figured in the decision.

Through Newmark's work at the university and nationally, and through his efforts to place faculty and alumni on key committees and boards, the department and university activities surrounding Newmark flourished. Although many of his activities were consultative in nature, whenever possible he would write journal papers for applications by others. Many of his consultating efforts led to major research projects in the department, including support for graduate students.

In 1956 Newmark was appointed head of the Department of Civil Engineering, a position he held until 1973, when he became professor of civil

engineering and professor in the Center for Advanced Study (the latter largely honorary at this late stage of his career). In the years before he became the department head, Newmark had aggressively led the department's structural research program in Talbot Laboratory. When he took over the headship, he applied the same aggressive leadership and support to all units of the department. His efforts in this regard were greatly enhanced by the numerous outstanding and nationally known faculty in the department, many of whom over time became members of the prestigious National Academy of Engineering.

In the years during which Newmark served as the department's head (1956–73), John Haltiwanger was the associate head, handling undergraduate student matters. I was responsible for graduate student and research matters. Newmark granted us great latitude, both in our handling of administration and in our dispersing of funds. The three of us were in close communication; Newmark always passed on major matters. Recently Haltiwanger and I realized that under Newmark's leadership we were never once criticized for any of our actions. Newmark was willing not only to delegate responsibility but to grant authority to fulfill the responsibilities for operation that he had delegated. The reputation and stature of the department, which had been great almost since the department's founding, rose to new heights under Newmark's leadership.

It seems appropriate to describe some of the broad interests and involvement of Newmark in the engineering programs in which he made major contributions. His engineering contributions, although far-reaching, focused largely, but not solely, on areas denoted as dynamics, namely, effects of blast, shock, and earthquake on the response and performance of structures and buried systems. He chaired or served on dozens of national committees that provided direction for national efforts in these technical areas, including related educational activities.

Unbeknownst to many who knew Newmark, he and his many colleagues contributed importantly, especially in later years, in areas dealing with the properties and behavior of materials. Among the many examples that could be cited are projects on welding procedures for steel that aided structural strength, investigations into brittle fracture propagation and arrest in steel that contributed to the solution of the merchant (and naval) ship fracture problem, work in metal fatigue that enhanced the life of highway bridges, and investigations into properties of soil and rock as they influenced the basic understanding of whole new fields of practical research within structural dynamics and soil dynamics.

For Newmark's extensive service related to the military, he was awarded the President's Certificate of Merit in 1948. During World War II, he was a consultant to the National Defense Research Committee and the Office of Field Service of the Office of Scientific Research and Development headed by Vannevar Bush of MIT. Part of his national service time was spent in the Pacific war zone, but his activities are not in the public record. Later, in addition to serving on numerous Department of Defense boards and panels, he made crucial technical contributions to the development of the Minute Man and MX missile systems. In addition, he and his colleagues helped to develop procedures for design, analysis, and vulnerability assessments, and for military protective systems of all kinds, including structures, tunnels, and associated systems. He was a member of many influential committees affecting U.S. defenses, including the Gaither Committee in 1957, under President Dwight Eisenhower, which looked at strategic defense, as well as boards for the Office of the Chief of Engineers, the Air Force Space and Missiles System Organization, the Defense Atomic Support Agency, the Defense Intelligence Agency, and the Office of the Secretary of Defense.

Beginning in 1949, Newmark served as principal consultant on the seismic design of the forty-four-storied Latino Americana Tower in Mexico City, a highly seismic region of the world. At the time it was constructed in the early 1950s, the Latino Americana Tower was nearly twice the height of the tallest buildings then existing in Mexico City. Since the foundation of the building was to be located in the caldera, the region of the city located in the bowl of an ancient volcano, and had to rest on deep deposits of lacustrine clay, it was necessary to conserve weight as much as possible. Thus the height of the building and its weight limitation, plus its location in this seismically active region, made it imperative that detailed consideration be given to earthquake forces and deformations.

Newmark undertook the seismic analysis with the assistance of one of his graduate students, the late Emilio Rosenblueth, who took his doctorate in 1951. Special story displacement instruments were installed in the tower to measure story deformations when the building is subjected to high wind or earthquake loading. In 1957, one year following the completion of construction and occupancy of the building, a major earthquake shook the tower with close to the maximum ground motions for which it had been designed and constructed. To recognize the successful structural performance of the tower during the earthquake, a plaque was mounted on the building naming the individuals responsible for the design. In 1985



Nathan Newmark with the Latino Americana Tower, Mexico, D.F., in the background, following the 1957 Mexican earthquake where the building's perfomance was as designed.

a slightly larger earthquake occurred and the building successfully withstood that earthquake too, again demonstrating that the height of a soundly designed and constructed building need not be severely limited in active seismic regions.

Newmark also played a pivotal role in the development of computers at the University of Illinois (see chapter 15). The actual introduction of computers into government, industry, and educational institutions did not begin in a major way until after World War II. Illinois was a leader in both the building and use of computers. The three key leaders in the University of Illinois's endeavor formally began their efforts in 1947 when William Everitt was the head of the Department of Electrical Engineering, Newmark was head of Civil Engineering, and Louis Ridenour was dean of the Graduate College. Newmark headed a committee to develop the program at the University of Illinois.

In 1949, with a push from the U.S. Army Ballistic Research Laboratory at Aberdeen Proving Ground in Baltimore, the University of Illinois took on the construction (from scratch) of two identical computers: the ORDVAC, for the U.S. Army, and a duplicate of the ORDVAC, the ILLIAC, for the University of Illinois. The design of the computer logic was largely due to John von Neumann of Princeton University, a national figure in mathematics about whom Newmark told me several times, "He was by far

the most brilliant man I ever met." Coming from Newmark that was quite an endorsement. Both computers were extremely reliable and heavily used. An indication of the computer group's reputation later appeared in *Computing Reviews*: "ILLIAC II, at its conception in the mid-1950s, represented, together with some other independent design projects of the same period, the spearhead and breakthrough into a new generation of machines." The subsequent ILLIAC machines that were designed and constructed at the University of Illinois led the way into parallel computing. Newmark was the first director of the Digital Computer Laboratory (1947–57), which over time evolved into the Department of Computer Science.

Newmark also worked on nuclear power plants. Beginning in 1964, he was a consultant to the U.S. Nuclear Regulatory Commission on how seismic analysis affects the design and construction of power plants for the nuclear power industry. All told, he had input into the design and review of more than seventy-five nuclear power plants and several research reactors. Many publications related to the seismic design of new and existing nuclear power plants and became a staple for the analysis, design, and evaluation of such plants and related industries around the world and are still in use today.

Newmark was selected to be the engineer overseeing both the governmental and corporate seismic design projects associated with the Trans-Alaska Pipeline (TAPS) during its design and construction. This major engineering project, with a pipeline traversing almost 800 miles (N-S) across Alaska, with a dozen pump stations, was accorded special seismic design attention because of the 1964 Alaskan earthquake centered between Anchorage and Valdez. This earthquake affected buildings and landforms, causing changes in elevation of as much as thirty feet in the general Prince William Sound region, including Anchorage, Alaska. The U.S. government and the State of Alaska joined to establish stringent stipulations covering the design and construction of the pipeline so as to protect the environment to the fullest extent possible.

It was a major stroke of good luck that the timing of the development of the seismic criteria for the TAPS caused it to fall into the formative stages of the Applied Technology Council effort. As such, not only did the seismic loading criteria employed in the TAPS design turn out to be "modern," even by today's standards, but equally (perhaps more) important, the design and construction employed high-quality materials and construction practices that were at the forefront of practice at the time, and were almost identical to that which would be employed today. This project was at the time of construction the most costly privately constructed project in

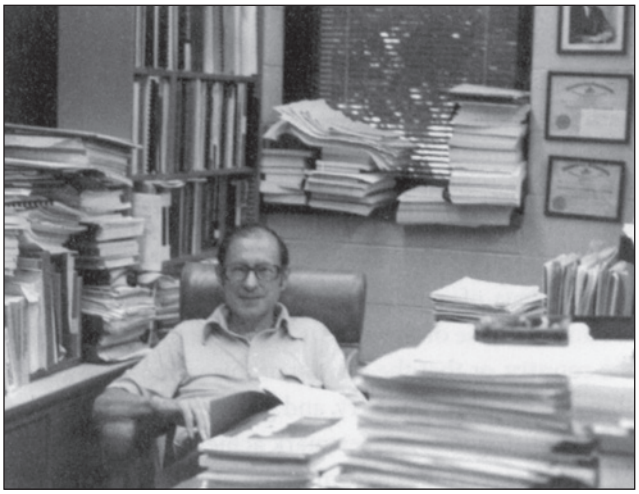
the history of the world. Today it falls behind by that measure only one other project, the Channel Tunnel project connecting England and France. So far the pipeline has performed admirably.

From 1974 to 1978, Newmark held principal technical responsibility for the development of the Applied Technology Council's Recommended Tentative Seismic Design Provisions for Buildings (so-called ATC-003). These recommendations, developed with the coordinated efforts of more than eighty engineers, seismologists, and building code officials, were published in 1978; for the first time modern approaches to seismic design were put forward. In large part, they are still reflected in current National Earthquake Hazard Reduction Program provisions, as well as in current building codes and industrial practice, such as the design of the TAPS.

Newmark's university instruction over the years tended to center on analysis concepts, primarily on the applications of dynamics in analysis, design, and construction. His lectures usually consisted of technically concentrated theoretical presentations that required detailed study of one's notes afterward to comprehend the concepts. I remember one version of the following incident (a slightly different one was recalled by a colleague). A student asked, "Dr. Newmark, in the last lecture you used alpha for the variable for . . . but in this lecture you used alpha to stand for another variable . . . why?" Answer: "Over the years I find that if I use the same term for different variables, often a lot of stuff cancels out, and the equations are simpler!" (great laughter). Another example: "Dr. Newmark, in the last lecture you employed alpha for variable . . . , while in this lecture you are using omega for the same variable . . . why?" Answer: "Doing this keeps both you and me awake, otherwise it would be boring!"

At the University of Illinois, Newmark was the adviser or coadviser for ninety-three doctoral candidates, and he served in many important leadership capacities. He has the distinction of having held the longest appointment to date on the UIUC Campus Research Board, one of the organizations responsible for placing Illinois among the great research institutions of the world. Newmark's vision and foresight played no small role in the success of this effort.

Newmark also played a major role in many important technical activities of the major American engineering societies. He was an honorary member of most of them. Within the American Society of Civil Engineers (ASCE), he was a founding member of the Engineering Mechanics Division and won five major awards from this society; he was a prime mover in the development of the society's computer application activities. In 1975 Newmark's former students established in his honor the annual ASCE



Dr. Newmark in his office ca. 1973, pondering which pile to search for a specific project activity.

Newmark Medal. He was also a founding member of the National Academy of Engineering in 1964 and he was elected to membership in the National Academy of Sciences in 1966. Throughout his entire career he was active as a leader and participant in National Research Council endeavors. In 1968 Newmark received the National Medal of Science from President Lyndon B. Johnson, and in 1969 he received the Washington Award—jointly awarded annually by the major engineering societies of the United States. In 1979 Newmark was presented the John Fritz Medal, an all-engineering society award, thereby joining the distinguished company of such former John Fritz medallists as George Westinghouse, Alexander Graham Bell, Thomas Alva Edison, George Goethals, Orville Wright, Guglicimo Marconi, and Herbert Hoover. He was accorded honorary doctoral degrees by four institutions.

Newmark authored more than 200 papers, books, and chapters. The complete collection of his formal publications resides in Grainger Engineering Library and Information Center at the University of Illinois.[3] He was coauthor, with John A. Blume and Leo Corning, of *Design of Multi-Story Reinforced Concrete Buildings for Earthquake Motion* and with Emilio Rosenblueth, a former student, of *Fundamentals of Earthquake Engineering*.[4] He authored or coauthored dozens of technical reports that were widely distributed nationally and internationally, many of great significance to the profession.

Newmark possessed an unusual ability to attract young people to the field of civil engineering. He was able to guide, but not direct, their thinking and inspire them with the confidence needed for undertaking new and varied tasks. He also insisted that they receive appropriate recognition for their accomplishments. Engineers, young and old, who came in contact with this man sensed the intellectual and educational challenge he offered them. His penetrating insight, his keen engineering judgment, and his genuine interest in people were a constant source of inspiration to all who had the privilege of working with him. It is no accident that there grew up around him one of the most active research centers in civil engineering in the country, or that the alumni of this group have assumed broad leadership in education, industry, and government throughout the world.

On retiring in 1976, Newmark achieved the rank of professor emeritus of civil engineering. The University of Illinois awarded him the honorary degree of doctor of science in 1978. The citation read, in part, "His influence on engineering education has been extensive. Graduate study in structural engineering today bears his indelible imprint as a result of the large group that he attracted to Illinois to work with him, and because of the more than ninety Ph.D.'s for whom Professor Newmark was advisor or co-advisor. His style, combining rigorous analysis with a sophisticated appeal to experience and intuitive leaps, while inimitable, has provided generations of graduate students with a model of engineering creativity at its best."

A few days before Newmark's death, he told me, "The things I will be remembered for were very, very simple." Simple, often, but invariably powerful and useful. Newmark passed away in Urbana, on January 25, 1981. On February 19, less than a month after his death, in commemoration of Newmark's contributions to the university, the board of trustees of the University of Illinois renamed the Civil Engineering Building the Nathan M. Newmark Civil Engineering Laboratory.

NOTES

1. For details, see I. O. Baker and E. E. King, *A History of The College of Engineering of the University of Illinois, 1868–1945* (Urbana, 1945), Part 1.
2. This report actually is a discussion of a Westergaard report. Westergaard was a principal consultant on the dam.
3. The following five publications are examples of the range of his contributions: "A Distribution Procedure for the Analysis of Slabs Continuous over Flexible Beams," *Illinois Engineering Experiment Station Bulletin* 304 (1938); "An Engineering Approach to Blast-resistant Design," *Transactions, ASCE* (1956); "Effects of Earthquakes on Dams and Embankments," Fifth Rankine Lecture, Institute of Civil Engineers, London, Geotech-

nique, 1965; with W. J. Hall, "Development of Criteria for Seismic Review of Selected Nuclear Power Plants," U.S. Nuclear Regulatory Commission, Report NUREG/CR-0098, 1978; with W. J. Hall, "Earthquake Spectra and Design," monograph, Earthquake Engineering Research Institute, 1982.

4. Nathan Newmark, John A. Blume, and Leo Corning, *Design of Multi-Story Reinforced Concrete Buildings for Earthquake Motion* (Chicago: Portland Cement Association, 1961); Nathan Newmark and Emilio Rosenblueth, *Fundamentals of Earthquake Engineering* (Englewood Cliffs, N.J.: Prentice-Hall, 1971).

Appendix

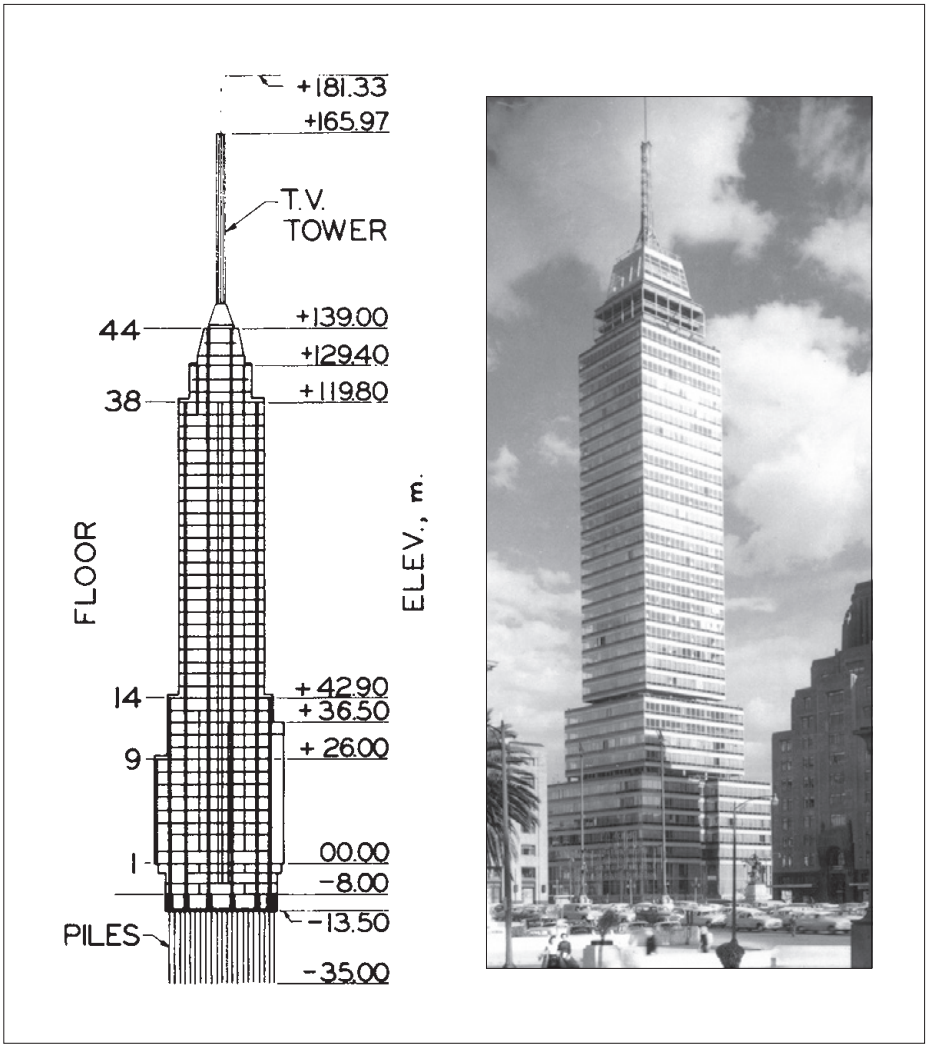
Photos of Nathan M. Newmark



Nathan Newmark as a young professor at the University of Illinois at Urbana-Champaign (courtesy of the University of Illinois).



Newmark in the 1960s (Courtesy of the University of Illinois).



Section showing the steel framing and a photo of the Torre Latinoamericana, for which Newmark was the consultant who produced the seismic loading criteria. From L. Zeevaert and N. Newmark (1956), "Aseismic Design of Latino Americana Tower in Mexico City," Proceedings of the World Conference on Earthquake Engineering, Earthquake Engineering Research Institute, Oakland, CA (by permission of EERI).



Newmark, center, with Professors George Sinnamon, left, and Robert Mosborg, looking at a model of the new civil engineering building to be built in 1967 at UIUC, which was named after him (courtesy of the University of Illinois).



Newmark at the section of the Trans-Alaska Pipeline that crosses the Denali Fault. The photo was taken during construction, prior to the 2002 earthquake. The crooked layout of the pipeline allowed it to accommodate the ground deformation anticipated from surface faulting (courtesy of William Hall).

Appendix

Selected Articles about Nathan Newmark

Fletcher, Stacey (1996). "Nathan Newmark," *Structural Engineering Forum Magazine*, Vol. 2, No. 1, May–June.

Hall, William J. (1981). "Nathan M. Newmark: 1910-1981," Biographical Memoir, National Academy of Sciences, Washington, DC.

Hall, William J. (1981). "Nathan Mortimore Newmark (1910-1981)," *Bulletin of the Seismological Society of America*, Vol. 71, No. 4, pp. 1384-1386, August.

Hall, William J. (2004). "Nathan M. Newmark: A Model of Engineering Creativity," in Lillian Hoddeson, editor, *No Boundaries: University of Illinois Vignettes*, University of Illinois Press, Champaign, IL.

Weingardt, Richard G. (2007). "Nathan M. Newmark: Structural Dynamics Innovator Extraordinaire," *STRUCTURE Magazine*, December.

List of Publications by Nathan M. Newmark

The publications are in a collection at the Grainger Engineering Library, University of Illinois Urbana-Champaign.

1. Newmark, N.M., "A Study of Patterns of Abutment Movements in an Arch Dam Corresponding to Some Simple Patterns of Abutment Thrusts," Technical Memorandum, U.S. Bureau of Reclamation, June 1931.

2. Wilson, W.M., and N.M. Newmark, "The Strength of Thin Cylindrical Shells as Columns," *Ill. Eng. Exp. Sta. Bull. 255*, (45 pp.), 1933.

3. Newmark, N.M., "Interaction between Rib and Superstructure in Concrete Arch Bridges," Univ. of Ill. Doctoral Dissertation, Printed Abstract, (12 pp.), 1934.

4. Richart, F.E., and N.M. Newmark, "The Strength of Monolithic Concrete Walls," *Ill. Eng. Exp. Sta. Bull. 277*, (34 pp.), 1935.

5. Newmark, N.M., "Simplified Computation of Vertical Pressures in Elastic Foundations," *Ill. Eng. Exp. Sta. Cir. 24*, (19 pp.), 1935.

6. Newmark, N.M., and R.E. Copeland, "Structural and Economic Studies of Monolithic Concrete Walls for Dwellings," *Proceedings ACI*, Vol. 31, pp. 478-498, 1935.

7. Newmark, N.M., Discussion of "Analysis of Multiple Arches," by Alexander Hrennikoff, *Proceedings ASCE*, Vol. 61, No.5, pp. 724-726, 1935. Also, *Transactions, ASCE*, Vol. 101, pp. 407-410, 1936.

8. Newmark, N.M., "A Half Century of Progress in Foundation Theory," Ill. Soc. of Eng. Golden Jubilee Souvenir Program, pp. 144-152, January 1936.

9. Newmark, N.M., and R.E. Copeland, "Review of Strength Tests on Monolithic Concrete Walls for Residences," *Concrete*, Vol. 44, No.2, pp. 13-14, Feb. 1936.

10. Newmark, N.M., Discussion of "Distribution of Stresses Under a Foundation," by A.E. Cummings, *Proceedings ASCE*, Vol. 62, No.4, pp. 536-541, 1936. Also *Transactions ASCE*, Vol. 101, pp. 1115-1117, 1936.

11. Newmark, N.M., Discussion of "The Relation of Analysis to Structural Design," by Hardy Cross, *Proceedings ASCE*, Vol. 62, No. 4, pp. 536-541, 1936. Also *Transactions*, ASCE, Vol. 101, pp. 1395-1400, 1936.

12. Newmark, N.M., "Interaction Between Rib and Superstructure in Concrete Arch Bridges," *Proceedings ASCE*, Vol. 62, No.7, pp. 1043-1061, 1936. Author's Closure to Discussion, Vol. 64, No. 2, pp. 341-343, 1938. Also *Transactions ASCE*, Vol. 103, pp. 62-88, (with discussions), 1938.

13. Newmark, N .M., Discussion of "Graphical Distribution of Vertical Pressure Beneath Foundations," by Donald M. Burmister, *Proceedings ASCE*, Vol. 63, No.6, pp. 1098-1101, 1937. Also, *Transactions ASCE*, Vol. 103, pp. 321-324, 1938.

14. Newmark, N.M., "Estimating Earth Pressures," *Engineering News-Record*, Vol. 120, No. 1, pp. 23-24, 1938.

15. Newmark, N.M., Discussion of "A Simple Method for the Computation of Temperatures in Concrete Structures," by Roy W. Carlson, *Proceedings ACI*, Vol. 34, pp.·104-1-104-5, 1938.

16. Newmark, N.M., Discussion of "A Reduction Method for the Analysis of Continuous Beams and Open Frames," by Miklos Hetenyi, *Proceedings ACI*, Vol. 34, pp. 364-4 to 364-5, 1938.

17. Newmark, N.M., "A Distribution Procedure for the Analysis of Slabs Continuous Over Flexible Beams," *Ill. Eng. Exp. Sta. Bull. 304*, (118 pp.), 1938.

18. Newmark, N.M., Review of "Die Knickfestigkeit von Staben und Stabwerken," by Julius Ratzersdorfer, *Journal of Applied Mechanics*, Vol. 6, No. 1, pp. A-47 to A-48, March 1939.

19. Newmark, N.M., and Henry A. Lepper, Jr., "Tests of Plaster-Model Slabs Subjected to Concentrated Loads," *Ill. Eng. Exp. Sta. Bull. 313*, (53 pp.), 1939.

20. Newmark, N.M., "Stress Distribution in Soils," *Proceedings, Conference on Soil Mechanics and its Applications*, Purdue University, pp. 295-303, September 1940.

21. Newmark, N.M., "What Do We Know About Concrete Slabs," *Civil Engineering*, Vol. 10, No. 9, pp. 559-562, 1940.

22. Newmark, N.M., "Note on Calculation of Influence Surfaces in Plates by Use of Difference Equations," *Journal of Applied Mechanics*, Vol. 8, No.2, p. A-92, June 1941.

23. Newmark, N.M., and C.P. Siess, "Moments in I-Beam Bridges," *Ill. Eng. Exp. Sta. Bull. 336*, (150 pp.), 1942.

24. Newmark, N.M., "Numerical Procedures for Computing Deflections, Moments, and Buckling Loads," *Proceedings ASCE*, Vol. 68, No.5, pp. 691-718, May 1942. Also, Reprint No. 23, *Univ. of Ill. Eng. Exp. Sta.*, (28 pp.), 1942.

25. Newmark, N.M., "Influence Charts for Computation of Stresses in Elastic Foundations," *Ill. Eng. Exp. Sta. Bull. 338*, (28 pp.), 1942.

26. Newmark, N.M., and C.P. Siess, "Design of Slab and Stringer Highway Bridges," *Public Roads*, Vol. 23, No.7, pp. 157-164, January-February-March 1943.

27. Newmark, N.M., "Numerical Procedure for Computing Deflections, Moments and Buckling Loads," *Transactions ASCE*, Vol. 108. pp. 1161-1234, 1943.

28. Newmark, N.M., Discussion of "Effects of Radiant Heat on Reinforced Concrete Rigid Frames," by Milan A. Johnston, *Proceedings ASCE*, Vol. 71, No.9, pp. 1431-1433, 1945.

29. Newmark, N.M., C.P. Siess, and R.R. Penman, "Studies of Slab and Beam Highway Bridges, Part I, Tests of Simple-Span Right I-Beam Bridges," *Univ. of Ill. Eng. Exp. Sta. Bull. 363*, (132 pp.), 1946.

30. Richart, F.E. Jr., and N.M. Newmark, "Impact Tests of Reinforced Concrete Beams," *National Defense Research Conference Report No. A-125*, (41 pp.), 1942.

31. Newmark, N.M. and F.E. Richart, Jr., "Impact Tests of Reinforced Concrete Beams, II," *National Defense Research Conference Report No. A-213*, (77 pp.), 1943.

32. Newmark, N.M., "Aerodynamics and Aircraft Design; Part III, Aircraft Materials and Structures," *Report of AAF Scientific Advisory Group*, pp.1 01-116, HQ Air Materiel Command, Wright Field, Dayton, Ohio, May 1946.

33. Newmark, N.M., "Explosives and Terminal Ballistics; Part III, Terminal Ballistics and Destructive Effects," *Report of AAF Scientific Advisory Group*, HQ Air Materiel Command, Wright Field, Dayton, Ohio, May 1946 (document missing from the UIUC collection).

34. Newmark, N.M., "Influence Charts for Computation of Vertical Displacements in Elastic Foundations," *Univ. of Ill. Eng. Exp. Sta. Bull. 367*, (11 pp.), 1947.

35. Siess, C.P. and N.M. Newmark, Discussion of "Reinforced Concrete Columns Under Combined Compression and Bending," by H.E. Wessman, *Proceedings ACI*, Vol. 43, pp. 8-1 to 8-3, 1947.

36. Newmark, N.M., C.P. Siess, and W.M. Peckham, "Studies of Slab and Beam Highway Bridges, Part II, Tests of Simple-Span Skew I-Beam Bridges," *Univ. of Ill. Eng. Exp. Sta. Bull. 375*, (60 pp.), 1948.

37. Colin, E.C., Jr., and N.M. Newmark, "A Numerical Solution for the Torsion of Hollow Sections," *Journal of Applied Mechanics*, Vol. 14, No.4, pp. A313-315, December 1947.

38. Newmark, N.M., "Design of I-Beam Bridges, Highway Bridge Floors, A Symposium," *Proceedings ASCE*, Vol. 74, No.3, pp. 305-330, March 1948.

39. Bruckner, W.H. and N.M. Newmark, "Axial Tension Impact Tests of Structural Steels," *The Welding Journal*, Vol. 28, No. 2, Research Supplement, pp. 67s-88s, February 1949.

40. Siess, C.P. and N.M. Newmark, "Rational Analysis and Design of Two-Way Concrete Slabs," *Journal American Concrete Institute*, Vol. 20, No. 4, pp. 273-315, December 1948.

41. Richart, F.E., Jr., and N.M. Newmark, "An Hypothesis for the Determination of Cumulative Damage in Fatigue," *Proceedings ASTM*, Vol. 48, pp. 767-798, 1948.

42. Newmark, N.M., "Numerical Methods of Analysis of Bars, Plates and Elastic Bodies," *Numerical Methods of Analysis in Engineering*, Chapter 9, L.E. Grinter, ed., The McMillan Company, New York, pp. 138-168, 1949.

43. Newmark, N.M., "A Simple Approximate Formula for Effective End-Fixity of Columns," *Journal of the Aeronautical Sciences*, Vol. 16, No.2, p. 116, February 1949.

44. Newmark, N.M., Review of "Soil Mechanics in Engineering Practice, by K. Terzaghi and R.B. Peck," *Journal of Applied Mechanics*, Vol. 16, No.1, pp. 107-108, March 1949.

45. Newmark, N.M., Review of "Buckling of Curved Sheet in Compression and Its Relation to the Secant Modulus," by E.H. Schuette, *Journal of the Aeronautical Sciences*, Vol. 15, No. 5, p. 262, May 1948.

46. Richart, F.E., Jr., N.M. Newmark and C.P. Siess, "Design of I-Beam Bridges, Highway Bridge Floors, A Symposium," *Transactions ASCE*, Vol. 114, pp. 979-1072, 1949.

47. Bruckner, W.H. and N.M. Newmark, "Axial Tension Impact Tests of Structural Steels," *The Welding Journal*, Research Supplement, Vol. 29, No. 4, pp. 212-216, April 1950.

48. Siess, C.P. and N.M. Newmark, "Moments in Two-Way Concrete Floor Slabs," *Univ. of Ill. Eng. Exp. Bull. 385*, (124 pp.) February 1950.

49. Gossard, M.L., C.P. Siess, N.M. Newmark, and L.E. Goodman, "Studies of Highway Skew Slab-Bridges with Curbs, Part II: Laboratory Tests," *Univ. of Ill. Eng. Exp. Sta. Bull. 386*, (80 pp.), February 1950.

50. Newmark, N.M. and C.P. Siess, "Proposed Design Specifications for Two-Way Floor Slabs," *Journal of the American Concrete Institute*, Vol. 21, No.8, pp. 597-607, April1950. Also, *Proceedings ACI*, Vol. 46, 1950.

51. Siess, C.P. and N .M. Newmark, Closing discussion of paper on "Rational Analysis and Design of Two-Way Concrete Slabs," *Journal of the American Concrete Institute*, Vol. 21, No.4, pp. 316-4 through 316-5, December 1949. Also, *Proceedings ACI*, Vol. 45, 1949.

52. Newmark, N.M. and C.P. Siess, Authors closing discussion to paper on "Proposed Design for Specification of Two-Way Floor Slabs;" J*ournal of the American Concrete Institute*, pp. 608-5 through 608-8, December 1950.

53. Newmark, N.M., "Methods of Analysis for Structures Subjected to Dynamic Loading," Directorate of Intelligence, U.S. Air Force, (95 pp.), 18 December 1950.

54. Newmark, N.M., C.P. Siess, and LM. Viest, "Tests and Analyses of Composite Beams with Incomplete Interaction," *Proceedings Society for Experimental Stress Analysis*, Vol. 9, No. I, pp. 75-92, October 1951.

55. Newmark, N.M., R.J. Mosborg, W.H. Munse, and R.E. Elling, "Fatigue Tests in Axial Compression," *Proceedings American Society for Testing Materials*, Vol. 51, pp. 792-810, 1951.

56. Siess, C.P., LM. Viest, and N.M. Newmark, "Studies of Slab and Beam Highway Bridges: Part III- Small-Scale Tests of Shear Connectors and Composite T-Beams," *Univ. of Ill. Eng. Exp. Sta. Bull. 396*, (133 pp.), February 1952.

57. Newmark, N.M., "Analysis and Design of Structures Subjected to Dynamic Loading," *Proceedings Conference on Building in the Atomic Age*, MIT, pp. 34-47, 1952.

58. Newmark, N.M., "Computation of Dynamic Structural Response in the Range Approaching Failure," *Proceedings Symposium on Earthquake and Blast Effects on Structures*, UCLA, pp. 114-129, 1952.

59. Viest, I.M., C.P. Siess, J.H. Appleton, and N.M. Newmark, "Studies of Slab and Beam Highway Bridges: Part IV-Full-Scale Tests of Channel Shear Connectors and Composite T Beams," *Univ. of Ill. Eng. Exp. Sta. Bull. 405*, (155 pp.), 1952.

60. Newmark, N.M., "The Institute's Research Program-Part III (Riveted and Bolted Structural Joints)," *Proceedings American*

Institute of Steel Construction National Engineering Conference, pp. 24-32, 1952.

61. Hoeltje, W.C. and N.M. Newmark, "Brittle Strength and Transition Temperature of Structural Steel," *Welding Research Supplement*, Vol. 17, pp. 515s-521s, 1952.

62. Newmark, N.M. and A.S. Veletsos, "A Simple Approximation for the Natural Frequencies of Partly Restrained Bars," *Journal of Applied Mechanics*, Vol. 19, p. 563, 1952.

63. Newmark, N.M., "Bounds and Convergence of Relaxation and Iteration Procedures," *Proceedings of the First National Congress of Applied Mechanics*, pp. 9-14, 1952.

64. Newmark, N.M. and E. D'Appolonia, "A Method for the Solution of the Restrained Cylinder under Compression," *Proceedings First National Congress of Applied Mechanics*, pp. 217-226, 1952.

65. Austin, W.J. and N.M. Newmark, "A Numerical Method for the Solution of Plate Buckling Problems," *Proceedings First National Congress of Applied Mechanics*, pp. 363-371, 1952.

66. Newmark, N.M., "What Do We Need to Know About Prestressed Concrete," *Journal American Concrete Institute*, Vol. 24, No.5, pp. 445-456, 1953.

67. Newmark, N.M., "What Do We Need to Know About Prestressed Concrete," *Civil Engineering*, Vol. 23, No. 1, pp. 59-63, 1953.

68. Newmark, N.M., "A Review of Cumulative Damage in Fatigue," *Fatigue and Fracture of Metals*, Chapter 10, MIT and John Wiley, New York, pp. 197-228, 1952.

69. Newmark, N.M., "An Engineering Approach to Blast Resistant Design," *Proceedings 22nd Annual Convention*, Structural Engineers Association of California, pp. 5-1 to 5-18, 1953.

70. Newmark, N.M., "An Engineering Approach to Blast Resistant Design," *Proceedings Separate No. 306*, ASCE, Vol. 79, (16 pp.), 1953.

71. Goodman, L.E., E. Rosenblueth, and N.M. Newmark, "Aseismic Design of Elastic Structures Founded on Finn Ground," *Proceedings, Separate No. 349, ASCE*, Vol. 79, (27 pp.), 1953.

72. Matthiesen, R.B., L.A. Harris, and N.M. Newmark, "Fatigue Properties of Weld Metal," *Welding Research Supplement. Welding Journal*, Vol. 32, No. 9, pp. 441s-453s, 1953.

73. Harris, L.A., R.B. Matthiesen, and N.M. Newmark, "Low-Temperature Bend Test Properties of Bead-on-Plate Welds," *Welding Research Supplement, Welding Journal*, Vol. 32, No. 12, pp. 585s-599s, 1953.

74. Munse, W.H., D.T. Wright, and N.M. Newmark, "Laboratory Tests of High Tensile Bolted Structural Joints," *Proceedings ASCE, Separate No. 441*, Vol. 80, (38 pp.), 1954.

75. Newmark, N.M. and C.P. Siess, "Research on Highway Bridge Floors at the University of Illinois: 1936-1954," *Proceedings, Highway Research Board*, Vol. 33, pp. 30-53, 1954. Also issued as *Univ. of Ill. Eng. Exp. Sta. Reprint No. 52*, 1954.

76. Hoeltje, W.C. and N.M. Newmark, Closing Discussion "Brittle Strength and Transition Temperature of Structural Steel," *Welding*

Research Supplement, Welding Journal, Vol. 33, p. 133-s, March 1954.

77. Newmark, N.M., "Review of Brittle Fracture Research at University of Illinois," *Ship Structure Committee Serial No. SSC-69,* pp. 185-200, 1954.

78. Laupa, A., C.P. Siess, and N.M. Newmark, "Strength in Shear of Reinforced Concrete Beams," *Univ. of Ill. Eng. Exp. Sta. Bull. 428*, 1955.

79. Harris, L.A., G.E. Nordmark, and N.M. Newmark, "Fatigue Strength of Butt Welds in Structural Steels," *Welding Research*, Vol. 20, pp. 83-96, 1954 (same as #89).

80. Newmark, N.M., Closing Discussion, "An Engineering Approach to Blast Resistant Design," *Proceedings ASCE, Separate No. 701*, Vol. 81, (2 pp.), 1955.

81. Hall, W.J. and N.M. Newmark, "Shear Deflection of Wide Flange Steel Beams in the Plastic Range," *Proceedings ASCE, Separate No. 814*, Vol. 81, (30 pp.), 1955.

82. Newmark, N.M. and C.P. Siess, "Research on Highway Bridge Floors at the University of Illinois; 1936-1954," *Univ. of Ill. Eng. Exp. Sta. Reprint 52*, (24 pp.), 1955.

83. Tung, T.P. and N.M. Newmark, "Numerical Analysis of Earthquake Response of a Tall Building," *Bulletin Seismological Society of America*, Vol. 45, pp. 269-278, 1955.

84. Veletsos, A.S. and N.M. Newmark, "A Simple Approximation for the Fundamental Frequencies of Two-Span and Three-Span Continuous Beams," *Proceedings, 2nd U.S. National Congress of Applied Mechanics*, pp. 143-146, 1954.

85. Veletsos, A.S. and N.M. Newmark, "Determination of the Natural Frequencies of Continuous Beams on Flexible Supports," *Proceedings, 2nd U.S. National Congress of Applied Mechanics*, pp. 147-155, 1954.

86. Veletsos, A.S. and N.M. Newmark, "Natural Frequencies of Continuous Flexural Members," *Proceedings ASCE, Separate No. 735*, Vol. 81, (37 pp.), 1955.

87. Weil, N.A. and N.M. Newmark, "Large Plastic Deformations of Circular Membranes," *Journal of Applied Mechanics*, Vol. 22, pp. 533-538, 1955.

88. Goodman, L.E., E. Rosenblueth, and N.M. Newmark, "Aseismic Design of Firmly Founded Elastic Structures," *Transactions ASCE*, Vol. 120, pp. 782-802, 1955.

89. Harris, L.A., G.E. Nordmark, and N.M. Newmark, "Fatigue Strength of Butt Welds in Structural Steels," *Welding Research Supplement, Welding Journal*, Vol. 34, No.2, pp. 83s-90s, 1955 (same as #79).

90. Laupa, A., C.P. Siess, and N.M. Newmark, "Strength in Shear of Reinforced Concrete Beams," *Univ. of Ill. Eng. Exp. Sta. Bull. 428*, (73 pp.), 1955.

91. Munse, W.H., D.T. Wright, and N.M. Newmark, "Laboratory Tests of Bolted Joints," *Transactions ASCE*, Vol. 120, pp. 1299-1321, 1955.

92. Newmark, N.M., "An Engineering Approach to Blast Resistant Design," *Transactions ASCE*, Vol. 121, pp. 45-64, 1956.

93. Newmark, N.M., "An Engineering Approach to Blast-Resistant Design," *Univ. of Ill. Eng. Exp. Sta. Reprint Series No. 56*, 1956.

94. Newmark, N.M., "Analysis and Design of Structures to Resist Atomic Blast," *Bulletin of the Virginia Polytechnic Institute, Eng. Exp. Sta. Series No. 106*, Part 2, pp. 49-77, January 1956.

95. Newmark, N.M., "A Philosophy for Anti-Blast Structural Design," *Proceedings, Conference on "The A-Bomb and Industry*, Armour Research Foundation, pp. 49-62, 1955 (document missing from UIUC collection).

96. Stallmeyer, J.E., G.E. Nordmark, W.H. Munse, and N.M. Newmark, "Fatigue Strength of Welds in Low Alloy Structural Steels," *Welding Research Supplement, Welding Journal*, Vol. 35, No. 6. pp. 298s-307s, June 1956.

97. Tung. T.P. and N.M. Newmark, "Shears in a Tall Building Subjected to Strong Motion Earthquakes," *Proceedings of the World Conference on Earthquake Engineering*, Earthquake Engineering Research Institute, Berkeley, California, pp. 10-1 to 10-11, 1956.

98. Tung. T.P., T.Y. Chen, L.E. Goodman, and N.M. Newmark, "Highway-Bridge Impact Problems, *Highway Research Board Bulletin 124, Vibration and Stresses in Girder Bridges*, pp. 111-134.1956.

99. Veletsos, A.S. and N.M. Newmark, "Determination of Natural Frequencies of Continuous Plates Hinged Along Two Opposite Edges," *Journal of Applied Mechanics*, Paper No. 55- A-11, Vol. 23, pp. 97-102, 1956.

100. Veletsos, A.S. and N.M. Newmark, Closing Discussion, "Natural Frequencies of Continuous Flexural Members," *Proceedings ASCE*, No. ST-5, Vol. 82, pp. 1067-3 to 1067-6, 1956.

101. Weil, N.A. and N.M. Newmark, "Large Deflections of Elliptical Plates," *Journal of Applied Mechanics*, Vol. 23, pp. 21-26, 1956.

102. Zeevaert, L. and N.M. Newmark, "Aseismic Design of Latino Americana Tower in Mexico City," *Proceedings of the World Conference on Earthquake Engineering*, Earthquake Engineering Research Institute, Berkeley, California, pp. 35-1 to 35-11, 1956.

103. Newmark, N.M., "Reinforced Concrete," *Encyclopedia Britannica*, Vol. 19, pp. 79-80, 1957 (document missing from UIUC collection).

104. Newmark, N.M., "Designing for Atomic Blast Protection," *Proceedings, Structural Engineers Association of California*, 25th Annual Convention, pp. 48-56, 1956.

105. Newmark, N.M., "Designing for Atomic Blast Protection," *BuDocks Technical Digest*, Navy Dept., No. 75, pp. 21-30, March-April 1957.

106. Newmark, N.M., "The Effect of Dynamic Loads on Offshore Structures," *Proceedings, Eighth Texas Conference on Soil Mechanics and Foundation Engineering, Special Publication No. 29*, Univ. of Texas Bulletin of Engineering Research, (30 pp.), 1956.

107. Harris, L.A. and N.M. Newmark, "The Effect of Fabricated Edge Conditions on Brittle Fracture of Structural Steels," *Bulletin of the American Railway Engineering Association*, Vol. 59, pp. 245-290, 1957.

108. Chen, T.Y., C.P. Siess, and N.M. Newmark, "Studies of Slab and Beam Highway Bridges: Part VI-Moments in Simply Supported Skew I-Beam Bridges," *Ill. Eng. Exp. Sta. Bull. 439*, (72 pp.), 1957.

109. Hall, W.J. and N.M. Newmark, "Shear Deflection of Wide-Flange Steel Beams in the Plastic Range," *Transactions ASCE*, Vol. 122, pp. 666-687, 1957.

110. Veletsos, A.S. and N.M. Newmark, "Natural Frequencies of Continuous Flexural Members, *ASCE, Vol. 122*,s pp. 249-285, 1957.

111. Brown, C.H., H.O. Banks, F.B. Farquharson, N.M. Newmark, K. Smith, J.B. Wilbur, and A. Ackerman, "Report of Task Committee on Professional Education," *Civil Engineering*, Vol. 28, pp. 111-123, 1958.

112. Newmark, N.M., "Recommended Federal Civil Defense Administration (FCDA) Specifications for Blast Resistant Structural Design (Method A)," *Federal Civil Defense Administration Technical Report TR-5-1*, (6 pp.), 1958.

113. Harris, L.A. and N.M. Newmark, "Effect of Fabricated Edge Conditions on Brittle Fracture of Structural Steels," *Welding Research Supplement, Welding Journal*, Vol. 37, No. 4,p. 137-S.

114. Newmark, N.M., "A Revolution in Design Practice," *Civil Engineering*, Vol. 28, p. 315, 1958.

115. Hansen, R.J., B.G. Johnston, N.M. Newmark, and M.P. White, Discussion of Paper, "Destructive Impulse Loading of Reinforced Concrete Beams," by F.T. Mavis and M.J. Greaves, *Proceedings ACI*, Vol. 54, pp. 815-816, 1958.

116. Newmark, N.M., "Welcome Address," *Proceedings, Conference on Electronic Computation, ASCE*, pp. 1-2, November 1958.

117. Rolfe, S.T., W.J. Hall, and N.M. Newmark, "Brittle-Fracture Tests of Steel Plates Containing Residual Compressive Strain," *Welding Research Supplement, Welding Journal*, Vol. 38, No.4, pp. 169s-175s, April1959.

118. Newmark, N.M., "The Place of the University in the Education of Civil Engineers": a) "Undergraduate Study and the Curriculum," pp. Nl0-11; b) "Postgraduate Education," pp. N18-19; c) "The Place of Engineering Research in Universities," pp. N24-25; d) "Concluding Remarks," *Proceedings, The Institution of Civil Engineers*, Great Britain, Vol. 12, p. N24, April 1959.

119. Newmark, N.M., "A Method of Computation for Structural Dynamics," *Journal Engineering Mechanics Division, ASCE*, Vol. 85, pp. 67-94, July 1959.

120. Newmark, N.M., "Remarks on Analytical Methods for Protective Structural Design," *Proceedings of the Second Protective Construction Symposium (Deep Underground Construction), Report R-341*, Vol. 1, The Rand Corporation, pp. 367-386, March 1959.

121. Newmark, N.M., Discussion of "Solving Structural Mechanics Problems on Digital Computers," by H.J. Greenberg, Structural Mechanics, *Proceedings 1st Symposium on Naval Structural Mechanics*, Pergamon Press, New York, pp. 554-556, 1960.

122. Newmark, N.M., "La Investigacion sobre Estructuras en la Universidad de-Illinois," *Informes de la Construccion*, Institute Tecnico de 1a Construction y del Cementa, Madrid, 4, (4 pp.), 1951 (document missing from UIUC collection).

123. Newmark, N.M., Closing Discussion of "A Method of Computation for Structural Dynamics," by N.M. Newmark, *Journal Struc. Div., Proceedings ASCE*, Vol. 86, No. ST 8, p. 89, 1960.

124. Ang, A.H.S., and N.M. Newmark, "A Numerical Procedure for the Analysis of Continuous Plates," *ASCE Second Conference on Electronic Computation*, Pittsburgh, P A., pp. 379-413, 1960.

125. Newmark, N.M., "Keynote Address - The Future of Civil Engineering Education," *Civil Engineering Education*, ASCE, New York, pp. 21-27, 1961.

126. Jennings, R.L. and N.M. Newmark, "Elastic Response of Multi-Story Shear Beam Type Structures Subjected to Strong Ground Motion," *Proceedings 2nd World Conference on Earthquake Engineering*, Vol. II, Tokyo, p. 699-717.

127. Veletsos, A.S. and N.M. Newmark, "Effect of Inelastic Behavior on the Response of Simple Systems to Earthquake Motions," *Proceedings 2nd World Conference on Earthquake Engineering*, Vol. II, Tokyo, pp. 895-912.

128. Newmark, N.M., "Failure Hypotheses for Soils," Opening Address, *Research Conference on Shear Strength of Cohesive Soils*, ASCE, pp. 17-32, 1961.

129. Anderson, F.E., Jr., R.J. Hansen, H.L. Murphy, N.M. Newmark, and M.P. White, "Design of Structures to Resist Nuclear Weapons Effects," *ASCE Manual of Engineering Practice No. 42*, (150 pp.), 1961.

130. Newmark, N.M. and R.J. Hansen, "Design of Blast Resistant Structures," in *Shock and Vibration Handbook* Vol. III, Chapter 49, C.M. Harris and C.E. Crede, eds., McGraw-Hill, New York, (24 pp.), 1961.

131. Newmark, N.M., "Research and Civil Engineering Education," *Journal of Professional Practice*, Proceedings ASCE, No. PP2, Vol. 87, (14 pp.), October 1961.

132. Lycan, D.L. and N.M. Newmark, "Effect of Structure and Foundation Interaction," *Journal Engineering Mech. Div., Proceedings ASCE*, No. EM5, Vol. 87, (32 pp.), October 1961.

133. Blume, J.A., N.M. Newmark, and L. Coming, *Design of Multi-Story Reinforced Concrete Buildings for Earthquake Motions*, Portland Cement Association, Chicago, (350 pp.), 1961.

134. Sanders, W.W., Jr., W.H. Munse, and N.M. Newmark, "The Lateral and Longitudinal Distribution of Loading in Steel Railway Bridges," *Bulletin of the American Railway Engineering Association No. 566*, Vol. 63, pp. 13-16, September-October 1961.

135. Newmark, N.M., "Remarks on Analytical Methods for Protective Structural Design," *Protective- Construction in a Nuclear Age*, Vol. I, Chapter 20, J.J. O'Sullivan, ed., The MacMillan Co., New York, pp. 329-347, 1961.

136. Hall, W.J., S.T. Rolfe, F.W. Barton, and N.M. Newmark, "Brittle Fracture Propagation

in Wide Steel Plates," *Ship Structure Committee Report No. SSC-131*, National Academy of Sciences, National Research Council, (30 pp.), October 1961.

137. Sinnamon, G.K. and N.M. Newmark, "Facilities for Dynamic Testing of Soils," ASTM *Technical Publication No. 305*, Symposium on Soil Dynamics, p. 38-44, 1962.

138. With others, "Engineering Conference Report Based on Meeting Held at Boulder, Colorado, August 9-15, 1961," *Journal Engineering Education*, Vol. 52, No.9, pp. 624-641, May 1962.

139. Newmark, N.M., "Educacion en Ingenieria," *Ingenieriia*, National University of Mexico, Mexico City, Vol. 32, No. 4, pp. 73-78, October 1962.

140. Newmark, N.M., "A Method of Computation for Structural Dynamics," *Transactions ASCE*, Paper No. 3384, Vol. 127, Part I, pp. 1406-1435 (with discussion), 1962.

141. Newmark, N.M. and J.D. Haltiwanger, "Air Force Design Manual- Principles and Practices for Design of Hardened Structures," *Report SWC-TDR-62-138*, Research Directorate, Air Force Special Weapons Center, Albuquerque, New Mexico, (615 pp.), 1962.

142. Newmark, N.M., W.D. Alexander, R.E. Fadum, E. H9gnestad, W.E. Smith, and D.C. Taylor, "1962 ASCE Research Conference, Report by the Committee on Research, ASCE," *Journal of Professional Practice, Proceedings ASCE*, Vol. 89, No. PP1, pp. 37-91, January 1963.

143. Newmark, N.M., Author's Closure, "Research and Civil Engineering Education," *Journal of Professional Practice, Proceedings ASCE*, Vol. 89, No. PP1, pp. 101-104, January 1963.

144. Newmark, N.M., Introduction to Arches. Continuous Frames, Columns, and Conduits, *Selected papers of Hardy Cross*, University of Illinois Press, Urbana, IL, pp. _vii-x, 1963.

145. Lycan, D.L. and N.M. Newmark, Author's Closure, "Effect of Structure and Foundation Interaction," *Journal Engineering Mechanics Division*, ASCE, Vol. 89, No. EM4, pp. 69-70, August 1963.

146. Newmark, N.M., "Research and Civil Engineering Education," *Transactions ASCE*, Vol. 128, Part V, pp. 1-16, 1963.

147. Newmark, N.M., "Design of Structures for Dynamic Loads Including the Effects of Vibration and Ground Shock," *Symposium on Scientific Problems of Protective Construction*, Swiss Federal Institute of Technology, Zurich, pp. 148-248, July 1963.

148. Newmark, N.M., "Structural Engineering," *Listen to Leaders in Engineering,* Chapter 6, A. Love and J.S. Childers, eds., Tupper and Love, Atlanta, pp. 73-84, January 1965.

149. Newmark, N.M. and W.J. Hall, "Design Criteria for Reactor Cells, Building 315, Argonne National Laboratory," *Appendices I and J, Safety Analysis Report Argonne Fast Critical Facility (ZPR-VI), Argonne National Laboratory Report 6271*, pp. 171-198, December 1963.

150. Newmark, N.M., C.P. Siess, M.A. Sozen, "Moment-Rotation Characteristics of Reinforced Concrete and Ductility

Requirements for Earthquake Resistance," *Proceedings 30th Annual Convention Structural Engineers Association of California*, Yosemite, pp. 54-66, October 3-5, 1963.

151. Newmark, N .M., "The Basis of Current Criteria for the Design of Underground Protective Construction," *Proceedings Symposium on Soil-Structure Interaction*, University of Arizona, Tucson, pp. 1-24, September 1964.

152. Newmark, N.M., "Effects of Earthquakes on Dams and Embankments," Fifth Rankine Lecture, *Geotechnique*, Institution of Civil Engineers, London, Vol. XV, No.2, pp. 139-159, June 1965.

153. Veletsos, A.S. and N.M. Newmark, "Design Procedures for Shock Isolation Systems of Underground Protective Structures, Vol. III, Response Spectrum of Single-Degree-of-Freedom Elastic and Inelastic Systems," *Report RTD TDR 63-3096*, Vol. III, Air force Weapons Laboratory, Albuquerque, New Mexico, (316 pp.), June 1964.

154. Newmark, N.M., W.H. Walker, A.S. Veletsos and R.J. Mosborg, "Design Procedures for Shock Isolation Systems of Underground Protective Structures, Vol. IV, Response of Two Degree- of-Freedom Elastic and Inelastic Systems," *Report RTD TDR 63-3096*, Vol. IV, Air Force Weapons Laboratory, Albuquerque, New Mexico, (212 pp.), December 1965.

155. Newmark, N.M., W.H. Walker and R.J. Mosborg, "Design Procedures for Shock Isolation Systems of Underground Protective Structures, Vol. V, Response Spectra of Multi-Degree- of-Freedom Elastic Systems," *Report RTD TDR 63-3096*, Vol. V, Air Force Weapons Laboratory, Albuquerque, New Mexico, (126 pp.), December 1965.

156. Newmark, N.M., "Design of Model Test Program for a Buried Field Shelter," Report No. 1-110, Waterways Experiment Station, Vicksburg, Mississippi, (108 pp.), May 1965.

157. Newmark, N.M., "Current Trends in the Seismic Analysis and Design of High Rise Structures," *Proceedings of the Symposium on Earthquake Engineering*, University of British Columbia, Vancouver, pp. VI-I to VI-55, September 1965.

158. Newmark, N.M., "State of the Art in Dynamic Analysis and Techniques for the Design of Underground Protective Construction," *Proceedings Symposium on Protective Structures for Civilian Populations*, National Academy of Sciences, National Research Council, pp. 166-179, April 1965.

159. Newmark, N.M., "Notes on Shock Isolation Concepts," in "Vibration in Civil Engineering," *Proceedings of Symposium of the British National Section of the International Association for Earthquake Engineering*, Butterworths, London, pp. 71-82, 1966.

160. Veletsos, A.S., N.M. Newmark, and C.V. Chelapati, "Deformation Spectra for Elastic and Elasto-Plastic Systems Subjected to Ground Shock and Earthquake Motions," *Proceedings Third World Congress on Earthquake Engineering*, Vol. 2, pp. II-663 to II-682, New Zealand, 1965.

161. Newmark, N.M. and W.J. Hall, "Dynamic Behavior of Reinforced and Prestressed

Concrete Buildings under Horizontal Forces and the Design of Joints (Including Wind, Earthquake, Blast Effects)," International Association Bridge and Structural Engineering, pp. 585-613, New York, 9-14 September 1968. French Translation pp. 614-638, German Translation, pp. 639-661.

162. Newmark, N.M., "Prize Bridges of 1967," *Modern Steel Construction*, Vol. 8, No.4, 4th Quarter 1967, American Institute of Steel Construction, New York, pp. 17-20, 1967.

163. Newmark, N.M., "Section 3 Earthquake-Resistant Building Design," *Structural Engineering Handbook*. E.H. Gaylord and C.N. Gaylord, eds., McGraw-Hill Book Company, New York, pp. 3-1 to 3-30, 1968.

164. Newmark, N.M., G.W. Housner, T. Hisada and others, "Aseismic Design and Testing of Nuclear Facilities," Report of Panel, Tokyo, 12-16 June 1967, *International Atomic Energy Technical Report, Series No. 88*, Monograph, Vienna, (49 pp.), 1968.

165. Sozen, M.A., P.C. Jennings, R.B. Matthiesen, G.W. Housner, and N.M. Newmark, "Engineering Report on the Caracas Earthquake of 29 July 1967," Monograph, Committee on Earthquake Engineering Research, Division of Engineering, National Research Council - National Academy of Engineering, National Academy of Sciences, Washington, DC, (217 pp.),1968.

166. Newmark, N.M., "Civil Engineering," in the "Science: Year in Review Section," *The 1969 Britannica Yearbook of Science and the Future*, Encyclopedia Britannica Inc., Chicago, Illinois, pp. 299-300, 1969 (document missing from the UIUC collection).

167. Newmark, N.M., "Problems in Wave Propagation in Soil and Rock," *Proceedings International Symposium on Wave Propagation and Dynamic Properties of Earth Materials*, August 23-25, 1967, University of New Mexico Press, Albuquerque, New Mexico, pp. 7-26,1968.

168. Newmark, N.M., "Relation between Wind and Earthquake Response of Tall Buildings," *Proceedings 1966 Illinois Structural Engineering Conference*, pp.13 7-156, February 1969.

169. Newmark, N.M., "Earthquake Engineering- Learning from Failures," Washington Award Address, Midwest Engineer, Vol. 21, No.7, pp. 10-13, March 1969.

170. Newmark, N.M., "Design Criteria for Nuclear Reactors Subjected to Earthquake Hazards," *Proceedings of the IAEA Panel on Aseismic Design and Testing of Nuclear Facilities*, The Japan Earthquake Promotion Society, Tokyo, pp. 90-113, 1969.

171. Newmark, N.M. and W.J. Hall, "Special Topics for Consideration in Design of Nuclear Power Plants Subjected to Seismic Motion," *Proceedings of the IAEA Panel on Aseismic Design and Testing of Nuclear Facilities*, The Japan Earthquake Engineering Promotion Society, Tokyo, pp. 114-119, 1969.

172. Newmark, N.M., "Structural Synthesis and Design," in *Earthquake Engineering Research*, Chapter 6, Report to NSF by the NAE Committee on Earthquake Engineering Research, National Academy of Sciences, Washington, DC, pp. 199-232, 1969.

173. Newmark, N.M., "Current Trends in the Seismic Analysis and Design of High Rise Structures," in *Earthquake Engineering*, Chapter 16, R.L. Wiegel, ed., Prentice-Half, Inc., Englewood Cliffs, NJ, pp. 403-424, 1970.

174. Newmark, N.M., "Torsion in Symmetrical Buildings," *Proceedings Fourth World Conference on Earthquake Engineering*, Vol. II, Santiago, Chile, pp. A3-19 to A3-32, 1969.

175. Newmark, N.M. and W.J. Hall, "Seismic Design Criteria for Nuclear Reactor Facilities," *Proceedings Fourth World Conference on Earthquake Engineering*, Vol. II, Santiago, Chile, pp. B4-37 to B4-50, 1969.

176. Fenves, S.J. and N.M. Newmark, "Seismic Forces and Overturning Moments in Buildings, Towers and Chimneys," *Proceedings Fourth World Conference on Earthquake Engineering*, Vol. III, Santiago, Chile, pp. B5-l to B5-12, 1969.

177. Sozen, M.A., N.M. Newmark, and G.W. Housner, "Implications on Seismic Structural Design of the Evaluation of Damage to the Sheraton-Macuto," *Proceedings Fourth World Conference on Earthquake Engineering*, Vol. III, Santiago, Chile, pp. J2-137 to J2-150, 1969.

178. Newmark, N.M., "Seismic Response of Reactor Facility Components," in *Symposium on Seismic Analysis of Pressure Vessel and Piping Components*. D.H. Pai, ed., ASME, New York, pp. 1-24, 1971.

179. Amin, M., W.J. Hall, N.M. Newmark, and R.P. Kassawara, "Earthquake Response of Multiply Connected Light Secondary Systems by Spectrum Methods," in *Symposium on Seismic Analysis of Pressure Vessel and Piping Components*, D.H. Pai, ed., ASME, New York, pp. 103-129, 1971.

180. Newmark, N.M. and E. Rosenb1ueth, *Fundamentals of Earthquake Engineering*, Prentice- Hall, Inc., Englewood Cliffs, NJ, (640 pp.), 1971.

181. Steinbrugge, K., N.M. Newmark (and other members of Committee on Earthquake Hazard Reduction), *In the Interest of Earthquake Safety*, Institute of Governmental Studies, University of California-Berkeley, (22 pp.), 1971.

182. Newmark, N.M., "Earthquake Response Analysis of Reactor Structures," *Nuclear Engineering and Design*, Vol. 20, No.2, pp. 303-322, July 1972.

183. Newmark, N.M., "Design Specifications for Earthquake Resistance," in *Civil Engineering Frontiers in Environmental Technology*, (a program of Public Lectures to commemorate the Dedication of Raymond E. Davis Hall), Department of Civil Engineering, University of California, Berkeley, pp. 101-113, 1971.

184. Newmark, N.M. and W.J. Hall, "Seismic Analysis," in *Pressure Vessels and Piping: Design and Analysis*, G.J. Bohm, R.L. Cloud, L.C. Hsu, D.H. Pai and R.F. Reedy, eds., Vol. II, ASME, New York, pp. 1408-1413, 1972.

185. Newmark, N.M. and W.J. Hall, "Seismic Design Criteria for Nuclear Reactor Facilities," Reprinted from Proceedings 4th World Conference on Earthquake Engineering, in *Pressure Vessels and Piping: Design and Analysis*. G.J. Bohm, R.L. Cloud, L.C. Hsu, D.H. Pai and R.F. Reedy, eds., Vol. II, ASME, New York, pp. 1414-1427, 1972.

186. Newmark, N.M., A.R. Robinson, A.H.S. Ang, L.A. Lopez, and W.J. Hall, "Methods for Determining Site Characteristics," *Proceedings International Conference on Microzonation*, NSF-UNESCO-Univ. Washington-ASCE Acad. Mechs., Vol. 1, pp. 113-129, 1972.

187. Newmark, N.M. and W.J. Hall, "Procedures and Criteria for Earthquake Resistant Design," *Building Practices for Disaster Mitigation*, National Bureau of Standards, Bldg. Science Series 46. Vol. 1, pp. 209-236, Feb. 1973.

188. Newmark, N.M., "External Blast, State of Art Report No. 7, " *Fire and Blast*, ASCE-IABSE International Conference on Planning and Design of Tall Buildings, ASCE, New York, pp. 661 -676. 1972.

189. Newmark, N.M. (Chairman) et al., *Earthquake Guidelines for Reactor Siting*, Technical Report Series No. 139, International Atomic Energy Agency, Vienna, (26 pp.), 1972.

190. Newmark, N.M., J.A. Blume and K.K. Kapur, "Seismic Design Spectra for Nuclear Power Plants," *Proceedings ASCE, Journal Power Division*, Vol. 99, No. P02, pp. 287-303, Nov. 1973.

191. Steinbrugge, K.V., G.V. Berg, N.M. Newmark, C.H. Savitt, H.B. Seed, G.H. Sutton, M.D. Trifunac, J.T. Wilson, "Strong-Motion Engineering Seismology - The Key to Understanding and Reducing the Damaging Effects of Earthquakes," National Academy of Sciences, Washington, D.C., (17 + ii pp.), 1973.

192. Newmark, N.M., W.J. Hall, and B. Mohraz, "A Study of Vertical and Horizontal Earthquake Spectra," Directorate of Licensing, U.S. Atomic Energy Commission, Report WASH- 1255, (151 + ii pp.), April1973.

193. Hall, W.J., N.M. Newmark, and B. Mohraz, "Comments on Earthquake Transmission from Basement Rock to Surface," Proceedings, *Fifth World Conference on Earthquake Engineering,* International Association for Earthquake Engineering, Rome, Vol. 1, pp. 737-740, 1974.

194. Newmark, N.M. and W.J. Hall, "Seismic Design Spectra for Trans-Alaska Pipeline," Proceedings, *Fifth World Conference on Earthquake Engineering*, International Association for Earthquake Engineering, Rome, Vol. 1, pp. 554-557, 1974.

195. Newmark, N.M. and W.J. Hall, "A Rational Approach to Seismic Design Standards for Structures," *Proceedings, Fifth World Conference on Earthquake Engineering*, International Association for Earthquake Engineering, Rome, Vol. 2, pp. 2266-2275, 1974.

196. Newmark, N.M., "Interpretation of Apparent Upthrow of Objects in Earthquakes," *Proceedings, Fifth World Conference on Earthquake Engineering*, International Association for Earthquake Engineering, Rome, Vol. 2, pp. 2338-2343, 1974.

197. Hall, W.J., N.M. Newmark, and A.J. Hendron, Jr., "Classification, Engineering Properties and Field Exploration of Soils, Intact Rock and In Situ Rock Masses," Directorate of Regulatory Standards, U.S. Atomic Energy Commission, Report WASH-1301, (256 + vi pp.), May 1974.

198. Haltiwanger, J.D., W.J. Hall, and N.M. Newmark, "Civil Engineering Graduate Education in Evolution," *Civil Engineering Education*, ASCE, Vol. 1, Part 1, pp. 149-156, 1974.

199. Newmark, N.M., "Report of Working Subgroup, Analytical and Numerical Techniques," *Proceedings 3rd National Meeting of the Universities Council for Earthquake Engineering Research*, UCEER, Calif. Institute of Technology, Pasadena, California, pp. 233-235, May 1974.

200. Newmark, N.M., "Panel on Special Structures," *Final Report and Proceedings of a Workshop on Simulation of Earthquake Effects on Structures*, National Academy of Engineering, Washington, D.C., pp. 245-255, 1974.

201. Newmark, N.M., "Overview of Seismic Design Margins," *Workshop on Reactor Licensing and Safety*, Program Report, Vol. 2, No. 1, Atomic Industrial Forum, pp. 63-84, May 1975.

202. Newmark, N.M., "Seismic Design Criteria for Structures and Facilities, Trans-Alaska Pipeline System," *Proceedings U.S. National Conference on Earthquake Engineering*, Earthquake Engineering Research Institute, Ann Arbor, Michigan, pp. 94-103, June 1975.

203. Sharpe, R.L., N.M. Newmark, A. Goldberg, B. Bresler, N.S. Remmer, and N.C. Donovan, "Nationally-Applicable Seismic Design Recommendations - A Progress Report," *Proceedings U.S. National Conference on Earthquake Engineering*, Earthquake Engineering Research Institute, Ann Arbor, Michigan, pp. 77-86, June 1975.

204. Newmark, N.M. and W.J. Hall, "Pipeline Design to Resist Large Fault Displacement," *Proceedings U.S. National Conference on Earthquake Engineering*, Earthquake Engineering Research Institute, Ann Arbor, Michigan, pp. 416-425, June 1975.

205. Hall, W.J., V.J. McDonald, D.J. Nyman, and N.M. Newmark, "Observations on the Process of Equipment Qualification," *Proceedings U.S. National Conference on Earthquake Engineering*, Earthquake Engineering Research Institute, Ann Arbor, Michigan, pp. 495-501, June 1975.

206. Newmark, N.M., "Design of Structures to Resist Seismic Motions," *Proceedings Earthquake Engineering Conference*, Univ. of South Carolina College of Engineering, pp. 235- 275, Jan. 23-24, 1975.

207. Newmark, N.M., "A Response Spectrum Approach for Inelastic Seismic Design of Nuclear Reactor Facilities," *Transactions Third International Conference on Structural Mechanics in Reactor Technology*, Paper K 5/1, Vol. 4, Part K, (14 pp.), Sept. 1975.

208. Hall, W.J., B. Mohraz, and N.M. Newmark, "Statistical Analyses of Earthquake Response Spectra," *Transactions Third International Conference on Structural Mechanics in Reactor Technology*, Paper K 1/6, Vol. 4, Part K, (11 pp.), Sept. 1975.

209. Newmark, N.M., "Effects of Earthquakes on Dams and Embankments," *Milestones in Soil Mechanics, The First Ten Rankine Lectures*, Institution of Civil Engineers, London, pp. 109- 129, 1975.

210. Newmark, N.M., "Nuclear Power Plants," *Structural Design of Nuclear Plant Facilities*, ASCE Specialty Conference, Vol. III, pp. 84-88, 1973 (document missing from the UIUC collection).

211. Hall, W.J., B. Mohraz, and N.M. Newmark, "Statistical Studies of Vertical and Horizontal Earthquake Spectra," The Division of Systems Safety, U.S. Regulatory Commission, NUREG-0003, (128 + ix pp.), January 1976.

212. Newmark, N.M., "Earthquake Prediction and Earthquake Engineering Research," *Proceedings 4th National Meeting of Universities Council for Earthquake Engineering Research*, Report UCEER-4, California Institute of Technology, Pasadena, California, pp. 21-24, 1976.

213. Newmark, N.M. and W.J. Hall, "Vibration of Structures Induced by Ground Motion," *Shock and Vibration Handbook*, Second Edition Chapter 29, Part I, C.M. Harris and C.E. Crede, eds., McGraw-Hill Book Co., New York, pp. 29-1 to 29-19, 1976.

214. Newmark, N.M. and E. Rosenblueth, "Fundamentos de Ingenieria Sismica, *Editorial Diana*, Mexico, (680 pp.), 1976 (document missing from the UIUC collection).

215. "Selected Papers by Nathan M. Newmark," *Civil Engineering Classics*, ASCE, New York, (889 +viii pp.), 1976.

216. Newmark, N.M., "The Future of Earthquake Engineering," *Proceedings Inaugural Symposium John A. Blume Earthquake Engineering Center*, Stanford University, pp. 159-173, September 1976.

217. Sharpe, R.L. and N.M. Newmark, "Extending Seismic Design Provisions for Buildings to the Design of Offshore Structures," *Proceedings Offshore Technology Conference*, Houston, Texas, pp. 177-181, May 1977.

218. Whitley, J.R., J.R. Morgan, W.J. Hall, and N.M. Newmark, "Base Response Arising from Free-Field Motions," *Transactions 4th International Conference on Structural Mechanics in Reactor Technology*, San Francisco, California, Paper K2/15, Vol. K(a), (10 pp.), 1977.

219. Newmark, N .M., "Inelastic Design of Nuclear Reactor Structures and Its Implications on Design of Critical Equipment," *Transactions 4th International Conference on Structural Mechanics in Reactor Technology*, San Francisco, California, Paper K4/1, Vol. K(a), (10 pp.), 1977.

220. Newmark, N.M. et al., "Earthquake Prediction and Hazard Mitigation Options for USGS and NSF Programs," National Science Foundation-RANN and Department of Interior-USGS, A Report Prepared for the President's Science Advisor by an Advisory Group chaired by N.M. Newmark, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., Sept. 1976.

221. Newmark, N.M. and R. Riddell," Statistical Study of Earthquake Response Spectra," *Proceedings 2nd Chilean Conference on Seismology and Earthquake Engineering*, p. B2, 1-15, July 1976.

222. Hall, W.J. and N.M. Newmark, "Seismic Design Criteria for Pipelines and Facilities," in The Current State of Knowledge of Lifeline

Earthquake Engineering, *Proceedings Technical Council of Lifeline Earthquake Engineering Specialty Conference*, ASCE, PP- 18-3A, August 1977.

223. Newmark, N.M., W.J. Hall, and J.R. Morgan, "Comparison of Building Response and Free Field Motion in Earthquakes," *Proceedings Sixth World Conference on Earthquake Engineering*, New Delhi, India, Vol. II, pp. 972-978, 1977.

224. Smilowitz, R. and N.M. Newmark, "Seismic Force Distributions for Computation of Shears and Overturning in Buildings," *Proceedings Sixth World Conference on Earthquake Engineering*, New Delhi, India, Vol. II, pp. 1819-1825, 1977.

225. Newmark, N.M., H.J. Degenkolb, A.K. Chopra, A.S. Veletsos, E. Rosenblueth, and R.L. Sharpe, "Seismic Design and Analysis Provisions for the United States," *Proceedings Sixth World Conference on Earthquake Engineering*, New Delhi, India, Vol. II, pp. 1986-1992, 1977.

226. Newmark, N.M., and W.J. Hall, "Earthquake Resistant Design of Nuclear Power Plants," *The Assessment and Mitigation of Earthquake Risk*, UNESCO, Paris, pp. 198-218, 1978. (ISBN Ref. No. 92-3-101451-X).

227. Newmark, N.M. and W.J. Hall, *Development of Criteria for Seismic Review of Selected Nuclear Power Plants*, U.S. Nuclear Regulatory Commission, NUREG/CR-0098, May 1978.

228. Cornell, C.A. and N.M. Newmark, "On the Seismic Reliability of Nuclear Power Plants," *Proceedings of Topical Meeting on Probabilistic Analysis of Nuclear Reactor Safety,* American Nuclear Society, Vol. 3, pp. XIV.1-1 to XIV.l-14, May 1978.

229. Newmark, N.M., et al, *Tentative Provisions for the Development of Seismic Regulations for Buildings*, Applied Technology Council Report ATC 3-06, NBS Special Publication 510, NSF Publication 78-8, (xxiv + 506 pp.), June 1978.

230. Hall, W.J. and N.M. Newmark, "Seismic Design Criteria for Pipelines and Facilities," *Journal of the Technical Councils of ASCE*, *Proceedings ASCE*, Vol. 104, N~. TC1, pp. 91-107, November 1978.

231. Newmark, N.M., "Earthquake Design Philosophies, Past Developments and Future Trends," *Erdbebengerechtes Bauen*, Swiss Association of Engineers and Architects, SIA Document 31, pp. 59-84, September 1978.

232. Newmark, N.M. and W.J. Hall, "Comments on Inelastic Seismic Capacity of Nuclear Reactor Structures," in *Civil Engineering and Nuclear Power*, ASCE, Vol. II, 21 pp., April 1979.

233. Housner, G.W., N.M. Newmark, F.E. Richart, Jr., H.B. Seed, S.D. Wilson, and R.V. Whitman," Synopsis of Summary Session," *Earthquake Engineering and Soil Dynamics*, ASCE, Vol. III, pp. 1318-1319, June 1978.

234. Newmark, N.M. and W.J. Hall, "Earthquake Resistant Design," in *Structural Engineering Handbook*, 2nd Edition, Section 3, E.H. Gaylord and C.N. Gaylord, eds., McGraw-Hill Book Company, New York, pp. 3-1 to 3-27, 1979.

235. Newmark, N.M., "Earthquake Resistant Design and ATC Provisions," *Proceedings Third Canadian Conference on Earthquake Engineering,*

Vol. I, Chapter 25, pp. 609-651, Montreal, June 1979.

236. Hall, W.J., J.R. Morgan, and N.M. Newmark, "Traveling Seismic Waves and Structural Response," *Proceedings of the Second International Conference on Microzonation*, San Francisco, California, pp. 1235-46, 1978.

237. Smilowitz, R. and N.M. Newmark, "Design Seismic Accelerations in Buildings," *Journal Structural Division*, ASCE, Vol. 105, No. ST12, pp. 2487-2496, December 1979.

238. Riddell, R. and N.M. Newmark, "Force-Deformation Models for Nonlinear Analysis," *Journal Structural Division, ASCE, Technical Notes*, Vol. 105, No. ST12, pp. 2773-2778, December 1978.

239. Hall, W.J. and N.M. Newmark, "Seismic Design of Bridges-An Overview of Research Needs," *Earthquake Resistance of Highway Bridges, Proceedings Applied Technology Council Workshop*, National Science Foundation, pp. 163-181, San Diego, California, January 29-31, 1979.

240. Newmark, N.M., W.J. Hall, R.P. Kennedy, J.D. Stevenson, and F.J. Tokarz, "Seismic Review of Dresden Nuclear Power Station- Unit 2 for the Systematic Evaluation Program," *U.S. Nuclear Regulatory Commission, NUREG/CR-0891*, April1980.

241. Newmark, N.M. and R. Riddell, "A Statistical Study of Inelastic Response Spectra," *Proceedings of the Second U.S. Conference on Earthquake Engineering*, Stanford University, California, pp. 495-504, August 22-24, 1979.

242. Cornell, C.A., N.M. Newmark, and E.H. Vanmarke, *Concluding Report of the Seminar on Probabilistic Seismic Analysis of Nuclear Power Plants*, Bundesanstalt fur Materialprufund (BAM), Monograph, (123 pp.), Berlin, January 1978.

243. Chopra, A.K. and N.M. Newmark, "Analysis," in *Design of Earthquake Resistant Structures*, Chapter 2, E. Rosenblueth, ed., Pentech Press, London, pp. 27-53, 1980.

244. Morgan, J.R., W.J. Hall, and N.M. Newmark, "Response of Simple Structural Systems to Traveling Seismic Waves," *Civil Engineering Series, SRS #467*, Department of Civil Engineering, University of Illinois at Urbana-Champaign, (114 pp.), September 1979.

245. Riddell, R. and N.M. Newmark, "Statistical Analysis of the Response of Nonlinear Systems Subjected to Earthquakes," *Civil Engineering Studies, SRS #468*, Department of Civil Engineering, University of Illinois at Urbana-Champaign, (291 pp.), August 1979.

246. Newmark, N.M. and R. Riddell, "Inelastic Spectra for Seismic Design," *Proceedings Seventh World Congress on Earthquake Engineering*, Vol. 4, pp. 129-136, Istanbul, Turkey, September 8-13, 1980.

247. Newmark, N .M. and R. Villaverde, "Computation of Seismic Response of Light Attachments to Buildings," *Proceedings Seventh World Congress on Earthquake Engineering*, Vol. 5, pp. 343-350, Istanbul, Turkey, September 8-13, 1980.

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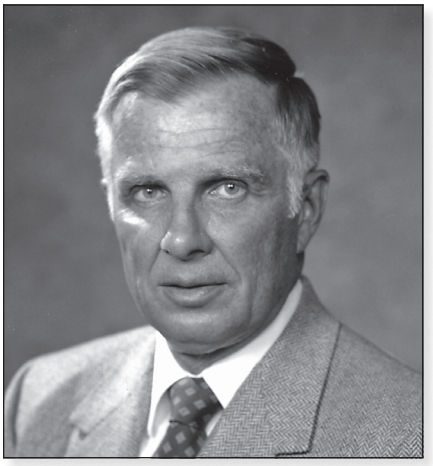
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In this EERI oral history, William (Bill) Hall discusses his early days growing up on a California ranch, beginning college, then serving in the Merchant Marine in World War II. After the war, he completed his undergraduate degree at the University of Kansas and went on to get his PhD at the University of Illinois at Urbana-Champaign, where his advisor was Nathan M. Newmark (see below). Hall has conducted research and consulting projects on earthquake ground motions and structural response, steel design and fracture mechanics, the seismic design of nuclear power plants and the Trans-Alaska Pipeline, and blast-resistant design. He was one of the youngest individuals to be elected to the National Academy of Engineering.

Included as an extensive appendix in this volume is biographical information on Hall's mentor and close colleague at the University of Illinois at Urbana-Champaign, the late Nathan M. Newmark. Professor Newmark developed many widely used methods for analyzing structural components under a variety of loading conditions, and for calculating the stresses in the soil beneath foundations.

Connections, the EERI Oral History series, records the accounts of individuals who were part of important developments in the field, documenting sometimes little-known facts about this history, and recounting their impressions, judgments, and experiences. The Earthquake Engineering Research Institute, a multidisciplinary professional association established in 1948, is proud to tell the story of the development of earthquake engineering through the *Connections* series.

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