RESEARCH&DESIGN
The Quarterly of the AIA Research Corporation

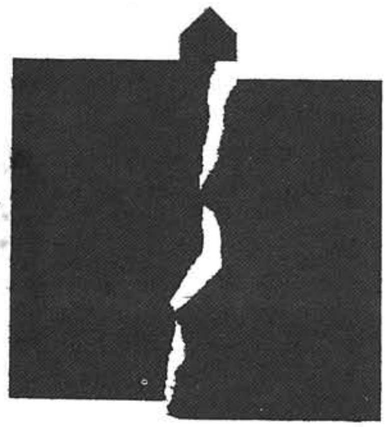
Seismic Design

COMMENTARY

Advancing the state of our art

The principal focus of this issue of *Research & Design* is seismic design, a concern of primary importance to all architects. Linked as it is to the security of the built environment and the physical safety of the people who inhabit that environment, it's hard to conceive of any issue more crucial to our livelihood. Yet earthquakes and the hazards they pose remain, relative to our profession, among the least understood of nature's forces. Until recently, most of us have approached earthquake-resistant design as a problem to be delegated to the engineering professions. Until recently, we have appeared to care little about this issue, and understand less. Fortunately for all of us, this condition is rapidly changing.

Today, architects across the country are becoming interested in, intrigued by, and concerned about seismic forces and their impact on architectural design. It is heartening to know that our profession is beginning to recognize the implications of our design decisions on building shape, configuration, land use, site development, materials, and structural concepts—and their impact on the safety of users. We are standing on the threshold of an understanding of seismic forces and their impact on design, and the field presents ripe and fertile ground for architects to investigate and research.



I'm personally pleased that the AIA Research Corporation has become one of the leaders in this critical area of architectural investigation. It's particularly interesting to note the juxtaposition of this issue of *Research & Design* with the first issue, which focused on solar architecture. Many of the traditional methods of attacking seismic design and energy conservative design are counterproductive and technically incompatible with each other. Energy conserving buildings have a built-in advantage when they are constructed of heavy masonry or other massive materials. Those same materials make seismic resistance difficult to achieve; light, ductile systems that tolerate movement and are capable of absorbing higher forces are better suited. It's this kind of apparent contradiction that points up the profession's need to be deeply involved in this kind of research.

Historically, architectural research has been accomplished only through experimentation with actual building construction. This has been a slow and costly process. In too many instances, it has allowed manufacturers to take the lead in establishing new technical directions for our profession. I think the time has come for us to promulgate new knowledge for our own profession. I think it's time for our offices, our universities, our practitioners, and our students to recognize the obligations and the opportunities inherent in broadening our traditional role in the construction industry. We're faced with a golden opportunity to advance our standing and prestige through research, not only in the construction industry but in society as a whole. So I respectfully suggest that you read very carefully this issue of *Research & Design*—and future issues—to see if perhaps it isn't appropriate that all of us in the profession become involved in advancing the state of our art by becoming involved in research.

Elmer E. Botsai, FAIA, President
The American Institute of Architects

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Cover: Photograph by Cy Merkezas

NOTEBOOK

News of research and design

User feedback, Oxford style

Post-occupancy afficionados . . . here's another resource to add to your list. The Oxford Architectural Research Team is involved in research aimed at designing new buildings more responsive to the needs of various user groups—particularly elderly people. Researchers R. Newman, M. Jenks, and V. Bacon are studying more effective systems for bringing user feedback into the briefing and design processes. The group has done other interesting studies on housing for the elderly. For more information, contact the Oxford Architectural Research Team, Dept. of Architecture, Oxford Polytechnic, Headington, Oxford, 0X3 OBP, England.

Going solar in Turkey

Mete Turan and Ibrahim Canbulat of the Middle Eastern Technical University in Ankara have begun work on an intensive test of passive solar design requirements for Turkey, together with a test of different collectors and storage systems. The construction of study models has been completed and actual measurements of solar radiation have begun. A report on performance criteria and cost analysis is due at the end of the year. Anyone interested may contact Turan or Canbulat at the Faculty of Architecture, METU (ODTU), Ankara, Turkey.

Inner-city, Swiss style

If you're interested in international research, AIA/RC has two items for you. *The Utilization of Inner-City Green Open Space* and *Pedestrian Factors and Considerations in the Design or Rebuilding of Town Centers and Subways,* both by Dietrich Garbrecht, are available upon request from AIA/RC. Rather than sending you on a postal wild goose chase through Switzerland, we'll photocopy these papers and send them to you for $2 each to cover postage and copying. Orders should be accompanied by payment (make checks payable to AIA/RC). If you'd like to contact the author directly, write to Garbrecht at Prognos-AG, Postfach, CH-4011 Basel, Switzerland.

Fussgangerbereich (pedestrian zone) in the Alstadt (old town) of Munich.

Creating supportive environments

What effect can the living environment have on the mentally retarded? The Institute for Man and Environment at the University of Massachusetts in Amherst has conducted a 3-year research project to assess this impact. Analyses of the data suggest changes in the physical and social environment that may be supportive of normal behavior for the developmentally disabled. The final project report should be ready by June. The Institute also has a series of technical reports on the same topic, available now (see Abstracts). Contact: Christopher Knight at the Institute for Man and Environment, University of Massachusetts, Amherst, Mass. 01003.

Fulbright-Hays awards

Architectural educators and practitioners may be able to take advantage of several new opportunities for international research and teaching. The Council for International Exchange of Scholars coordinates the Fulbright-Hays and similar programs (details are available from the Council at 11 Dupont Circle, Suite 300, Washington, D.C. 20036). This year the Council's announcements include an opportunity to teach architectural theory and design at the University of Jordan in Amman from September, 1978 to June, 1979, and several short-term visiting lectureships in a list of countries that includes Morocco, Tunisia, Egypt, Israel, Jordan, Syria, Kuwait, United Arab Emirates, Saudi Arabia, Yemen, Iran, Afghanistan, Pakistan, Nepal, India, and Sri Lanka. Not all those nations will offer architectural openings, but the program should be worth investigating.

Milwaukee's finest

The School of Architecture and Urban Planning at the University of Wisconsin/ Milwaukee has published a new report series called *Publications in Architecture and Urban Planning.* The series includes full length reports, papers, and reprints of faculty articles on design for the handicapped, energy research

and conservation, planning theory, post-occupancy evaluation, environment/behavior research, and several other topics. For a complete list, contact the school at P.O. Box 413, Milwaukee, Wisc. 53201.

Homebuying: Popular to contrary belief

New York-based researchers Frost & Sullivan Inc. report that contrary to popular belief, American families are not being priced out of the home ownership market, and that even during the 1975 recession 60 per cent of the nation's 56 million-plus families earned enough to buy a median ($44,000) single family home. Today, F&S estimates, 48 million married couples earn more than $17,000 a year, and more than 30 million top $20,000—enough to afford a $50,000 home. The median price for new houses sold during the first half of 1977 was $47,750, and housing costs—as a percentage of income—have declined from 29 per cent in 1965 to 19 per cent in 1975. The firm also reports that despite rising energy costs, buyers continue to prefer larger homes; two-bedroom residences are declining in popularity, four or more bedrooms increasing in market share.

Our town

Researchers in Australia are studying the effect a town's shape can have on the way it's perceived by its inhabitants. The study is looking at towns in Australia, South America, and Canada. Patterns are beginning to emerge from the research even though the towns under scrutiny have significant cultural differences. At the moment the data is being processed; findings should be available soon. For more information, contact Richard G. Fitzhardinge, University of New South Wales, Box 1, Kensington, N.S.W., 2033, Australia.

Be prepared

Sometimes it's really nice to be tied down, especially if you're a mobile home in a tornado. As an architect, you may be responsible for providing safety for residents through better mobile home design. Two studies have recently been completed on lack of preparedness in disaster situations. One study by Philip Jackson (University of Kansas) addresses high risk areas that haven't developed tornado policies to any degree. A similar study focusing on Illinois is the work of Thomas O. Langston of Southern Illinois University. Copies of these studies are available from Natural Hazards Observer, IBS #6, University of Colorado, Boulder, Colorado, 80309. Titles: *An Investigation of the Spatial Aspects of Tornado Hazard and Mobile Housing Policy in Kansas,* Philip L. Jackson, 115 pp., $5. *Tornadic Wind Effects and Mobile Homes: The Human Response to Damage Mitigation Equipment and Storm Shelters,* Thomas O. Langston, 65 pp., $3.

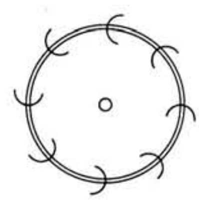
A mobile home in the wake of a Midwestern tornado.

On the air

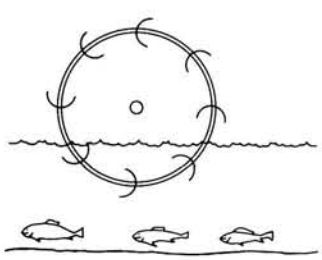
In an effort to bring some of the most recent results of architectural research to the attention of both the public and the nation's policymakers, the AIA Research Corporation is sponsoring a four-minute program called "New Dimensions in Architecture" every Tuesday evening for 26 weeks on WGMS-FM, Washington, D.C.'s most popular classical music/fine arts radio station. Most of the shows in the January-June series present short conversations (between WGMS Program Director Mike Cuthbert and a guest) on topics ranging from an overview of architectural research and national policy (the guest was AIA/RC President John Eberhard) to new research advances in passive solar energy, solar building codes, climate-conscious architecture, energy conservation, and seismic design (Charles Thiel, director of the National Science Foundation's earthquake research, was the guest). The short and informal conversations are aired at 6:44 P.M., a very special time in Washington's radio day, when late-working federal employees (including top-level agency executives and members of Congress and their staffs) are driving home, and the rest of the radio station's well-educated, high-income audience is relaxing before dinner. With the series halfway over, the radio station's listenership statistics indicate that a substantial proportion of Washington's federal and private sector decisionmakers are learning about the interest architects have in some of the nation's most pressing environmental problems.

It came through the mail

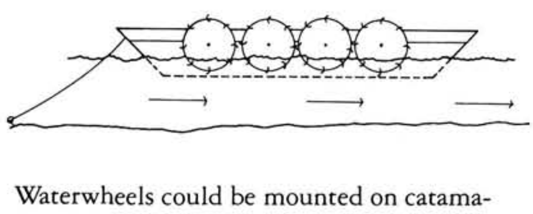
The following proposal arrived at AIA/RC last February. It was sent from Portland, Ore., where the debate over waterways and nuclear power generation rages more hotly than in most other places, and where the governor of the State of Washington, Dixy Lee Ray, recently asked, in rhetorical comparison of nuclear power plants to smaller-scale generation, whether the voters would rather their power be generated by an elephant or by 20,000 fleas. We offer this alternative proposal to you here because it impresses us, not only with its simplicity and sagacity, which will be evident, but with the refreshing altruism of its authors—Edison Plummer, gunsmith, locksmith, and inventor, and brother Herschell, architect, of Englund, Plummer & Associates—who said of their modest proposal, "We have nothing to sell or expect any other reward other than to have a commitment to solve the energy needs of the nation." Their proposal:



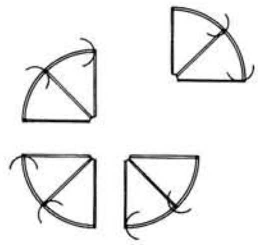
Waterwheels are a neglected source of energy.



Waterwheels do not interrupt fish or boat movements or have a negative impact on stream flow.



Waterwheels could be mounted on catamaran-type floats for large rivers or on pilings for small streams.



Standard designs could be mass produced using plastic, metal, wood, or ferro-cement by auto, aircraft, boat, and general manufacturers. Why aren't waterwheels used more? Dams and high-speed turbines are a more effective way of generating power, but we have used most of the acceptable dam sites. We are still expecting nuclear power to solve its waste problem. The nation has *not* made a commitment to utilize *all* possible energy sources. We have many thousands of miles of rivers and streams suitable for waterwheel installation. Given the choice between an elephant and 20,000 fleas, perhaps the time for the flea has arrived.

Is your feedback accurate?

If you've ever heard a client say, "That's not what I thought it would look like!" maybe David Sandahl and Kurt Blunck can help you out. Architectural presentation media are crucial to an architect, crucial for getting feedback from clients and users when a project is still in the early design stages. Sandahl and Blunck are examining the accuracy of that feedback by evaluating responses to spatial settings that have been portrayed in different media. Their results, due out in June, may influence the way you present your proposals in the future. The two researchers are at the Dept. of Architecture, University of Oregon, Eugene, Ore. 97403.

Researching architects

Architects are not only conducting more research; they're the subjects of more of it too. The Association of Collegiate Schools of Architecture's *Journal of Architectural Education* has just come out with a fascinating special issue on "Research on the Profession," guest-edited by sociologist and Princeton visiting professor in architecture and planning Robert Gutman. The issue's several articles document a great deal of research on where architectural graduates go after they get their sheepskins, and what they do when they get there. The question becomes important when surveys like the one conducted by ACSA and the University of Michigan Center for the Study of Higher Education reveal that only 50 per cent of architectural graduates may actually register to practice. The special issue is available for $3 from ACSA, 1735 New York Ave., N.W., Washington, D.C. 20006. . . . A recent survey by the Association of Student Chapters/AIA came

Damage wrought by hurricane-force winds.

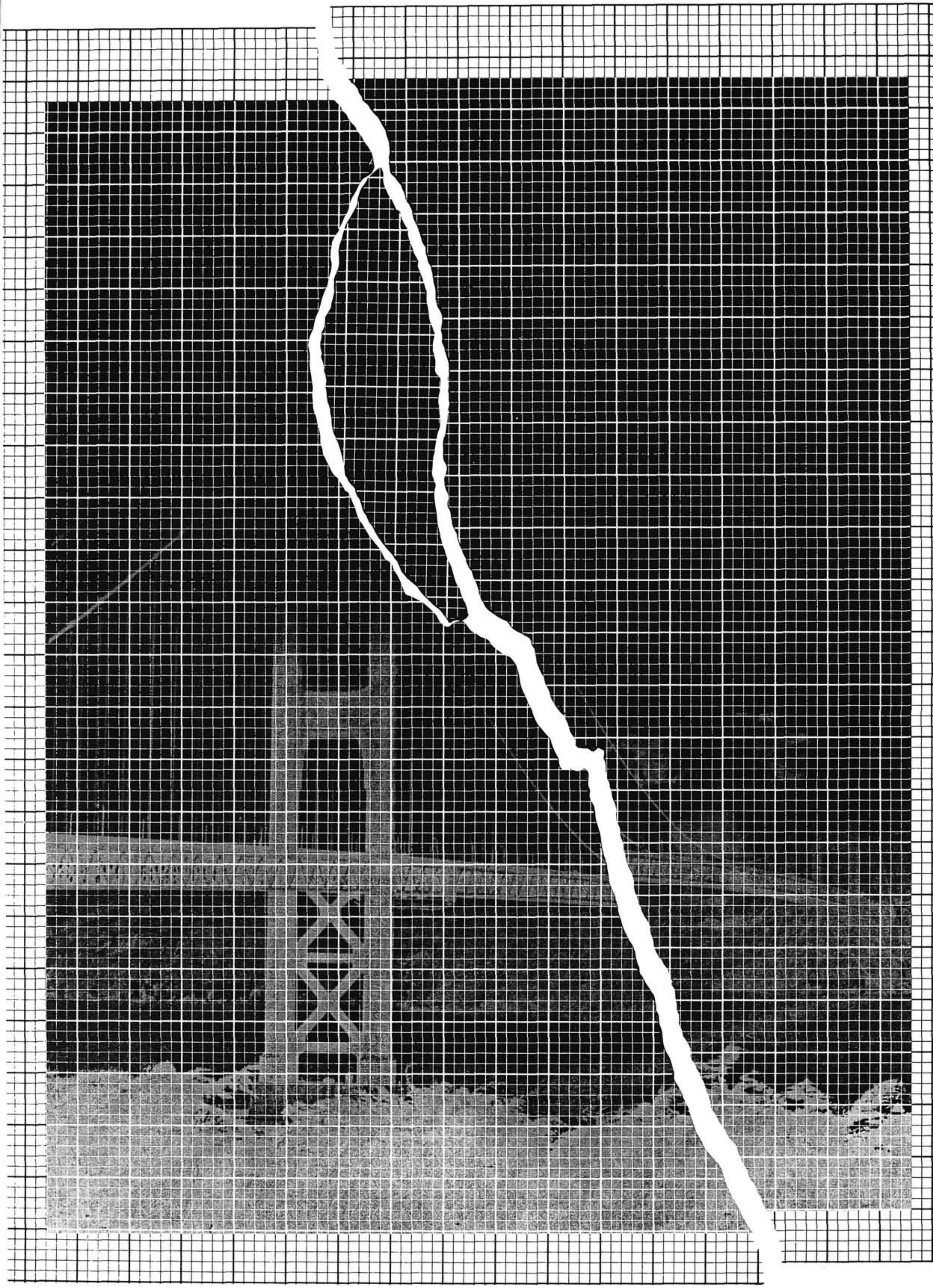
up with similar figures, finding that almost half of architectural graduates from 1970 on are employed in what ASC/AIA calls "non-traditional areas"—everything from museums, banks, and insurance companies to public health departments. The results are available for $10 to AIA members, $15 to others, from ASC/AIA at AIA headquarters in Washington, D.C. . . . And while we're on the subject: Every two years the National Science Foundation conducts a public survey to find out how ten of the nation's leading professions rank in the public eye. The results of the 1974 survey revealed that architects ranked a respectable fourth in the esteem of the American people, topped only by physicians, scientists, and engineers. Now the results of the 1976 survey have been released, and they hold some startling revelations. Architects have slipped into fifth place on the list of ten, losing the number four spot to an unlikely, if upwardly mobile profession—the ministry. Physicians, scientists, and engineers still top the list. Bankers and lawyers have continued a downhill slide that began with Watergate, finishing sixth and seventh respectively in the latest survey. Businessmen (and women) are also taking a drubbing in the esteem game; they remain in ninth place, behind corporate accountants. And still dwelling in the cellar, even when these pre-Tongsun Park figures were compiled, are members of Congress. Their image problems just won't seem to go away.

High winds and housing

Until Mother Nature decides to do something about hurricanes, buildings in many regions will have to be designed to resist the effect of extreme winds. The National Bureau of Standards has put together a five volume series describing the results of a 3½ year research study to develop improved design criteria for low-rise buildings in such climatic regions. The project was sponsored by the State Department's Agency for International Development. Volume 1 gives background on the project's activities, accomplishments, results and recommendations. Volume 2 presents a methodology to estimate design wind speeds and a guide to determine wind forces. Volume 3 is a guide for improved use of masonry fasteners and timber connectors. Volume 4 furnishes a methodology to estimate and forecast housing needs at a regional level. Socioeconomic and architectural considerations for the Philippines, Jamaica, and Bangladesh are presented in Volume 5. The volumes are for sale from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Order catalog #C13.29/2:100-1 through 5 at $1.50 per volume.

Coming Up:

24-27 April: Bahrain. Middle East Solar Technology Exhibition and Conference. Contact: Hugh Johnson, Soltech 78, Arabian Exhibition Management, 11 Manchester Square, London, WIM 5AB, England.
3 May: Washington, D.C. and nationwide. Sun Day, a national celebration of solar energy, from the people who first brought you Earth Day in 1970, to be highlighted by teach-ins, conferences, local fairs, and rallies, all aimed at eradicating the myth that solar is an "exotic" technology. Contact: Solar Action, 1028 Conn. Ave., N.W., Washington, D.C. 20036.
11-13 May: Boulder, Colo. Short course on Technical Design of Solar Thermal Systems for Buildings. Contact: Center for Management and Technical Programs, Univ. of Colorado, Boulder, Colo. 80309.
26-30 May: San Antonio, Texas. Fourth International Congress on Religion, Architecture, the Arts, and Environment. Contact: Religious Communities for the Arts, 287 Park Avenue South, New York, N.Y. 10010.
4-6 Dec.: Miami Beach, Fla. The 1978 Winter Simulation Conference, a three-day gathering of professionals interested in computer simulation, including the kind displayed at AIA's '77 convention. Co-sponsored by NBS. Contact: Dr. N. R. Nielson, Information Science Library (J-1041), SRI International, 333 Ravenswood Ave., Menlo Park, Calif. 94025, tel. 415/326-6200.



Seismic Design

There is an adage often mentioned by architects experienced in the rigors of seismic design. "Earthquakes rarely kill people directly," it goes. "Buildings do." With National Science Foundation funding and a growing bank of geophysical research behind them, more than a few members of the profession are working to render that epigram obsolete.

A few years ago, the British Broadcasting Corporation (BBC) produced a documentary film in which San Francisco was referred to as "the city that waits to die." Now that isn't the nicest thing anyone has said about the city by the bay, but the film was about San Francisco's faults, not its virtues. The ominous reference to imminent death was no more than an accurate reflection of the penchant Americans—and much of the rest of the world—have for thinking about San Francisco when we think about earthquakes.

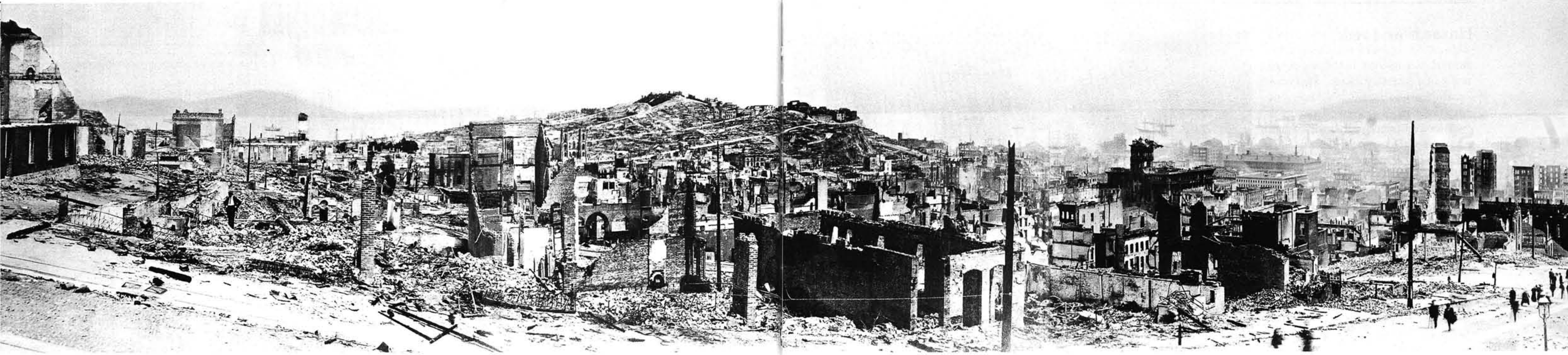
San Francisco has flourished in the 72 years since it was devastated by earthquake and fire in 1906, as has most of California. Both have done so in spite of California's position astride one of the most potent and dangerous fault networks in the world. Fully aware of their high-risk environment, Californians blissfully populate landfill-sited highrises, fault-threaded neighborhoods, and landslide-prone canyons, while the rest of the nation waits, as it has waited since 1906, for the other shoe to drop, for the cataclysm that seers ridiculously predict will send San Francisco and the rest of the state cascading into the Pacific.

It's clear that California dominates our thinking about earthquakes in this country. It may be this suspenseful and slightly macabre sense of waiting for destiny that helps make it so. Still, California is one of the most seismically active states in the union; with Hawaii, Alaska, and westernmost Washington, it is part of the geologically volatile "Ring of Fire" that surrounds the Pacific. It's also the most thoroughly researched seismic region in the U.S.; the bulk of our geophysical research into earthquakes is conducted there. In fact the nation dates almost all of its formal investigation of seismic phenomena back to California in 1933, when the last in a seven-year swarm of earthquakes devastated Long Beach and generated the first serious federal effort to learn about earthquakes.

But California doesn't deserve sole possession of our earthquake consciousness. Two of the most severe earthquakes in the history of the United States have occurred east of the Rockies—some distance east in fact. On August 31, 1886, most of Charleston, S.C. was shattered in an earthquake *at least* as strong as the one that struck San Francisco in 1906. Generated 12 miles below the surface of the earth, that shock was felt along the entire length of the East Coast—as far north as New York, where the jolt was particularly strong, and Boston—and far west of the Appalachians. Only the fact that a few of the city's water mains remained intact saved Charleston from the post-earthquake fate that befell San Francisco 19 years and eight months later—awesome destruction by fire.

Still stronger was a swarm of three earthquakes, each of them equally intense, that occurred between December, 1811 and February, 1812 near New Madrid, Mo., a small settlement on the shores of the Mississippi just north of Memphis, Tenn. America's heartland was sparsely populated then; the only witnesses to the event were a few settlers, trappers, and native Indians. But their accounts tell of great walls of water coursing down the Mississippi, of ground swells rolling across the land like ocean waves, and of New Madrid's utter destruction when the village sank 13 feet from its perch on a bluff above the river. The impact of the New Madrid earthquake was felt over an

Illustration by Libby Dorsett



area covering two million square miles, encompassing part or all of 34 states, and geologic evidence indicates today that the event altered forever the topographic shape of America's midsection.

The risk is nationwide

The National Oceanic and Atmospheric Administration's most recent map of seismic activity shows only the southeasternmost part of the U.S. to be free of seismic hazard. Boston, Providence, and Buffalo—three cities in the news of late because of their suffering in other kinds of natural disasters—share a high propensity for seismic activity. So do Charleston, St. Louis, Memphis, and Seattle. The Mississippi and St. Lawrence river valleys are high risk areas, and parts of Maine, Vermont, New Hampshire, New York, Kentucky, Tennessee, Illinois, Missouri, Arkansas, Oregon, Utah, Montana are all prone, on the frequent evidence of history, to earthquakes. Of 50 states, 39 have experienced seismic activity, some of its severe. And of 200 million Americans, more than 70 million live in areas threatened with the risk of an earthquake.

Yet we persist in focusing our seismic attentions solely on California. It's easy to understand the public's predelection for West Coast seismic phenomena; not only is it where most of the earthquakes happen, it's where researchers are conducting much-heralded work in earthquake mitigation and prediction. Elsewhere in the nation, earthquakes are far less frequent, usually less severe, and rarely mentioned in a research context. So we *hear* more about California, and we wait for San Francisco's demise.

But architects can't afford to accept that misconception, cannot succumb to the media blitz that has convinced America east of the Rockies that California, Alaska, and Hawaii are the only places in the nation that an earthquake of serious consequence can happen. We know now that earthquakes pose serious risk to life and property throughout most of the nation, and that knowledge creates a responsibility that cannot be ignored by the profession. For architects, the crystalline truth of the issue remains that earthquakes rarely kill people directly; buildings do.

The profession has for a long time declined the key responsibilities for seismic design, passing them along instead to the structural engineer and other members of the building team in good faith that the proper expertise lies there. But as California architect and outspoken AIA President Elmer Botsai has said, the earliest decisions in the design process can have more to do with a building's seismic safety than any others.

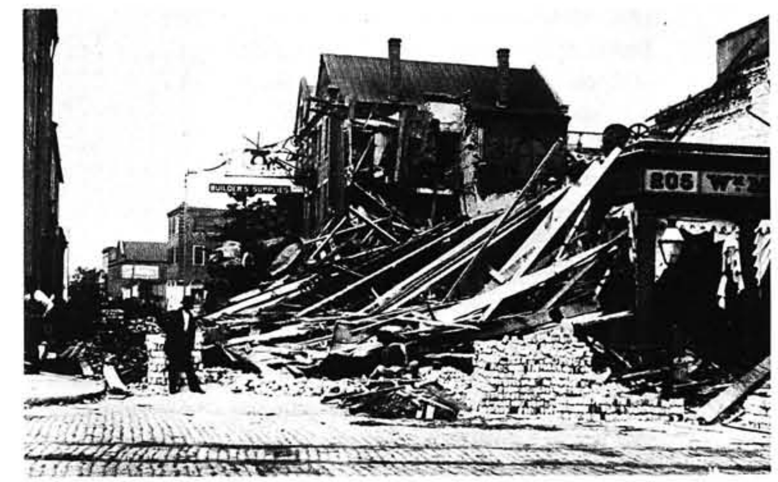
"The architect," Botsai says, "plays the major role in determining the building's shape, form, configuration, basic structural system, materials, and nonstructural systems and components. Can it be a structural failure when the architect designs a building that allows the structural engineer very little latitude or economic choice in designing an earthquake-resistant structural system?

"How many," he asks, "are really failures of architectural concepts?"

Researching seismic design

The earthquakes of the last 15 years have taught many lessons. For architects, one of the most interesting of the lot—highlighted during earthquakes in Anchorage (1964) and Managua (1974)—has been that structures designed to withstand the stress of an earthquake have done just that; they have remained standing during and after the shaking. But the architectural, nonstructural components of those surviving buildings have often suffered nearly complete destruction. In the wake of both the Alaska and Nicaragua earthquakes, total damage costs—related primarily to nonstructural elements—were assessed at up to 70 percent of the replacement cost for buildings *still standing* after the event. The hazards to life safety associated with this kind of component failure make

(continued on page 12)



The shaking during San Francisco's 1906 earthquake was worst in areas of heavy soil overburden, but the fire that ensued destroyed much of the rest of the city, as the panoramic photo at top illustrates. San Francisco Mayor Schmitz toured the ruins by auto after being forced from the devastated, if picturesque, City Hall, at left. Charleston, S.C. (above) suffered extensive building damage during its 1886 earthquake, but was saved from fire.

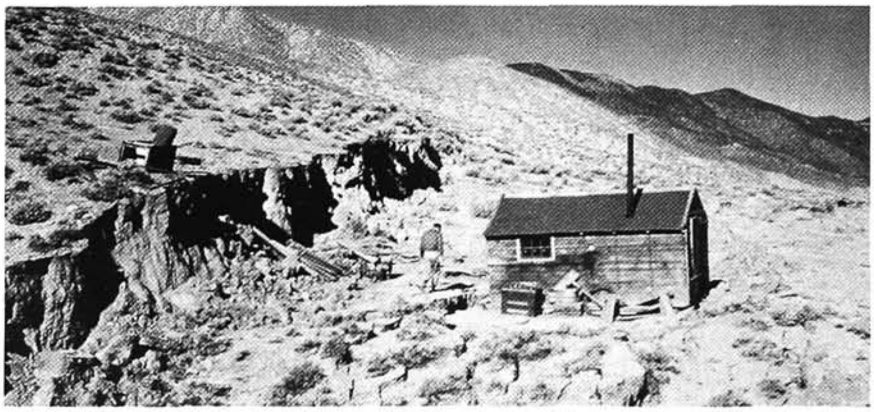
Hazards and risk

Seismologists generally bracket the surface effects of an earthquake into four broad categories: Surface faulting, ground shaking, ground failure (which results from the shaking), and tsunamis—seismic sea waves. Each kind of effect carries a particular kind of risk for the built environment.

Surface faulting

Surface faulting may be the most spectacular geologic effect of an earthquake, the kind of action we first envision, but it doesn't necessarily pose the greatest threat to buildings. Faulting isn't a uniform phenomenon, and consequently it's difficult to forecast. The surface along a fault zone may or may not rupture during an earthquake; we don't have the ability to predict that yet. If rupture does occur, it may be very limited or it may extend, as happened near San Francisco in 1906, over hundreds of miles; we can't predict that either. The faulting can occur in a sharp line or be distributed across a fault zone, and it can result in horizontal or vertical displacement, or both.

Our ignorance on the subject extends to deciphering the damage risk for structures on or near a fault as well. No building should be sited on a fault, but some buildings can be safely sited tens of feet from a fault. Others—certain highrises for example—may not withstand even minor ground deformation and shouldn't be located within several hundred feet. The research on types of surface faulting, which are many, and their impact on structures has produced only two general rules: First, any structure sited directly astride a fault when it ruptures will be severely damaged, at least; second, there is no validity to the notion that siting close to a fault is necessarily less safe than siting some distance away—for some structures, the danger is greater at greater distance.



Above and left, examples of vertical faulting (1954 earthquake, Dixie Valley, Nev.) and horizontal fault slipping (on the San Andreas fault north of San Francisco, 1906). At right, the 1964 Alaska earthquake generated a landslide on this school site (top) and settlement beneath this Anchorage street, both 80 miles from the epicenter.

Ground failure

Ground failure poses significantly greater hazards to structures simply because it occurs more often than faulting, and it threatens even the most sensibly-designed shake resistant building.

Liquefaction is a key spark for ground failure. It occurs when the vibrations of an earthquake force water upward through the ground, saturating sandy soil and reducing its support capacity to that of quicksand (tap wet sand on the beach with your foot and you'll witness the process). The result: Buildings literally sink into the earth, or topple over as several structures did during the 1964 earthquake in Niigata, Japan. In the Alaska earthquake of the same year, 500 feet of an Anchorage housing development 80 miles from the epicenter slid into the sea when inland sand lenses underwent liquefaction.

Settlement and landslides, other types of ground failure, may be sparked by sub-surface liquefaction. Or they can occur when shaking densifies loose landfill or backfill. Clay soil is also prone to sliding under its own weight, an event often aided by pre-earthquake erosion. Designing against these hazards usually involves anchoring a structure deeply into the ground, or manipulating a site to avoid the possibilities of failure.

Ground shaking

Ground shaking is clearly the most common hazard in an earthquake, and the most complex to understand and design against.

The factors that determine ground motion are plentiful. Distance from the epicenter doesn't necessarily dissipate it; shorter period (rapid) vibrations tend to die out over distance, but longer period vibrations travel farther, retain their power, and tend to vibrate in dangerous resonance with tall buildings capable of extensive swaying. Thus did the Alaska earthquake epicentered in Prince William Sound wreak havoc on tall buildings when low-frequency waves reached Anchorage, 80 miles away.

Soil conditions have a crucial bearing on ground motion. Rock has certain basic characteristics of frequency, acceleration, velocity, and amplitude, all of which determine the way it reacts to earthquake vibration. But those basic characteristics are modified by the depth of soil overburden; deeper soil increases the amplitude of those waves that reach the earth's surface, and emphasizes longer dominant periods of vibration—the kinds of vibration that most threaten tall buildings.

The total impact of soil condition on ground motion depends on the type of material in each stratum of the ground, the depth of each type, and the total depth to bedrock. But experience teaches that small, rigid buildings may perform better on softer ground. A tall, flexible building on soft ground may be more in tune with the low-frequency, long-wave shaking liable to occur there, risking greater damage. On rock or firm ground, tall buildings may not be as severely affected as a rigid building that reacts in harmony with rapid ground motion. For these reasons, a site-structure resonance factor—the relationship between the oscillation period of the structure and that of the ground on the site—should be included in the formula for determination of possible earthquake hazard.

It's also important to note that an earthquake doesn't generate only one or two frequencies of vibration. An earthquake is really a series of fault slips; if you drop several pebbles into a pond and watch the ensuing concentric ripples cross and modify each other, you'll get a feeling for the shaking motion of an earthquake. Seismic waves are omnidirectional, and when they reach a structure on the surface they may be irregular, both vertical and horizontal in plane, and occurring through a range of frequencies for an unpredictable time span.

Tsunamis

Tsunamis may be the most dreaded of earthquake effects, and there is little an architect can do about the phenomena save urge intelligent land-use planning.

A tsunami is generated when a coastal or undersea shock sets off a landslide or significant shaking on the sea floor. The disturbance sends waves travelling out at roughly 600 miles per hour. The waves travel deep in the open ocean—a ship can pass over one without incident—until they reach shallow coastal water and are forced to the surface. Then, separated by seconds, minutes, or hours, the waves rise to heights ranging upward of 50 feet and strike the coastline.

The size and power of each wave is determined by the shape of the sea floor, the shape of the coastline, and the direction of the wave, and those elements can total awesome strength. Freighters weighing thousands of tons have been lifted from their berths and deposited several blocks inland; entire towns have been washed off the map, thousands perishing; in 1964, one wave scoured an Alaska coastal mountain down to bare rock—at a height of 1,700 feet. The only positive aspect of the whole terrifying phenomenon is the fact that we now know which areas of coast are subject to tsunamis; international warning systems exist today to warn residents in susceptible areas as soon as an earthquake likely to generate seismic sea waves happens. Still, in susceptible Pacific, Atlantic, and Caribbean coastal areas, tsunamis have often been ignored in building codes. Intelligent land use planning there could begin to protect against all but the worst disaster.

"The final measure of a well-constructed building is the safety and comfort that it affords its occupants. If, during the earthquake, they must exit through a shower of falling light fixtures and ceilings, maneuver through shifting and toppling furniture, stumble down dark corridors and stairs, and then be met at the street by falling glass, veneers, or facade elements, then the structure cannot be described as a safe structure."
—From Ayres, Sun, and Brown's report on nonstructural damage to buildings during the 1964 Alaska earthquake.

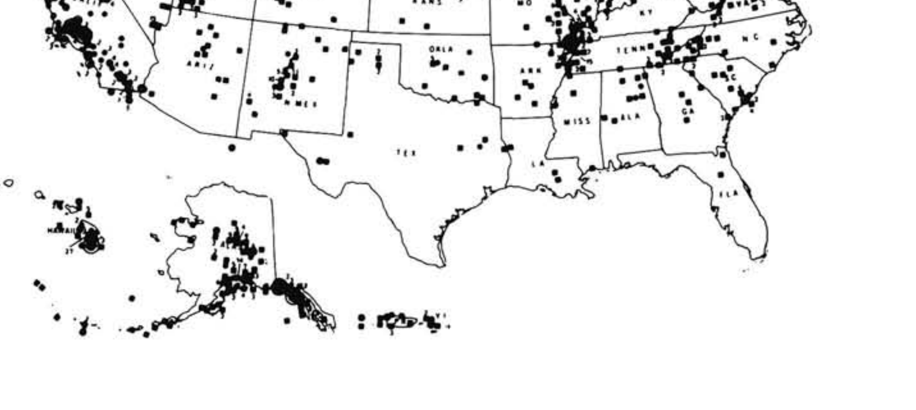
doubly clear the fact that we have succeeded in one area of seismic design, but fallen far short of a final solution.

The effect an earthquake can have on a building is an extraordinarily complex thing, an equation riddled with variables that relate to every conceivable aspect of architectural and structural science. One side of this cause-and-effect equation—the geophysical side—is being explored by seismologists, geologists, and other physical scientists. Their research, usually conducted under the banner of the U.S. Geological Survey, is aimed at gaining a better understanding of the causes of earthquakes and the nature of their action, in the hope that we may soon be able to predict, and perhaps prevent, earthquakes in life-threatening circumstances. The other side of the equation—the building side—is becoming the focus of more and more research in the design professions, architectural, planning, and engineering alike. There, the goal is to determine exactly what designers can do to mitigate the potential for damage from an earthquake.

With funding from the National Science Foundation's Research Applied to National Needs Program, the AIA Research Corporation (AIA/RC) has conducted four projects of research in seismic design, and is currently working on a fifth. Each of AIA/RC's projects has borne traits common to all of its work: Pursuit from a distinctly architectural point of view, and accomplishment by practicing designers with skills and experience in the field who are supported with federal funds subcontracted through AIA/RC. Not standard laboratory research, AIA/RC's work in seismic design has involved a painstaking sifting of all the structural and geophysical information that comprises what we know about earthquakes. In each project, the goal has been to shape that information in such a way that practicing architects will have, for the first time, access to an architecturally-developed toolbox for seismic design.

The first of AIA/RC's seismic projects took a sizeable step in that direction. It produced *Architects and Earth-*
(continued on page 14)

Above, downtown Managua in March, 1974, after earthquake debris was removed. Several structures, including the Banco Central building (left) and the Banco de America tower, survived the earthquake. But damage required that the Banco Central building be reduced to two or three stories; the building to the right of the tower has been razed. At right, the National Oceanic and Atmospheric Administration's 1970 map of significant U.S. earthquakes.



Legend
- Intensity V-VII
- Intensity VII-VIII
- Intensity VIII-IX
- Intensity IX-X
- Intensity X-XII

Designing against damage

On the weight of evidence from recent earthquakes, we know that architects can, when designing with seismic risk in mind, design structures that will actually withstand the stresses of an earthquake and remain upright throughout. So researchers in the field are moving toward the next logical goal—mitigating the damage earthquakes cause even in buildings that survive the shaking.

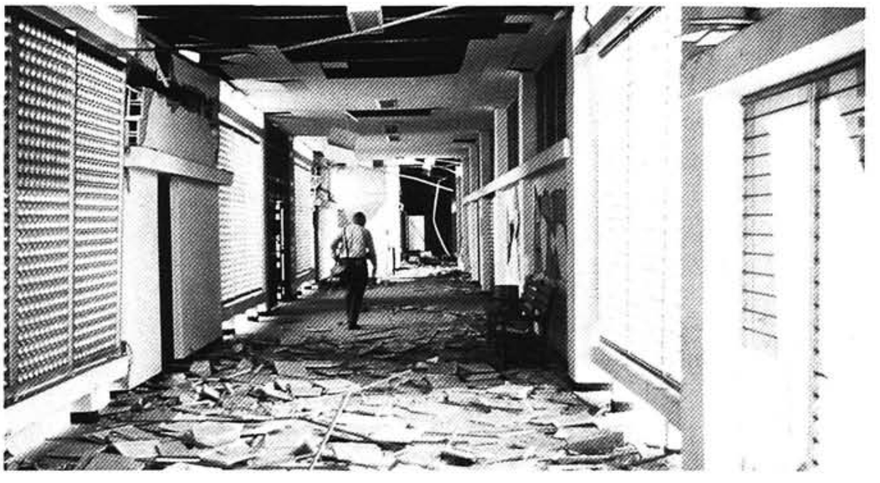
Seismic design research is premised, as all research must be, on the articulation of a set of problems to be solved. In *Architects and Earthquakes,* the problem-set involved with designing against building damage is set out as a series of six design requirements addressing issues that, up to now, have been defined as secondary in importance. Today, they represent the new agenda for seismic research and design.

Requirement #1: Protection of occupants within, and the public adjacent to, a building during an earthquake.

Assuming that the basic structure doesn't collapse, building occupants are still exposed to toppling furniture, equipment, falling cabinets and bookshelves. Wall-mounted objects can be hurled down; suspended ceiling components can fall, bringing light fixtures, sprinkler heads, and other elements down. Door frames may be bent and jammed shut. Partitions may collapse. Flooding and torn utility lines may create secondary hazards of electrical shock or fire. Racking walls may bend window frames and shatter glass. Outside, falling glass, parapets, facade panels, and other elements are obvious hazards. Building components and systems must be designed with these dangers in mind, and with building population densities considered in the process.

Requirement #2: Disaster control and emergency subsystems must remain operable after an earthquake.

Designers must consider the prospect that there will be casualties within buildings, and that people will be unable to escape. These people, and the building itself, will be subjected to secondary hazards—fire, electrical injury, flooding. Alarm systems, sprinkler systems, and utility-safety systems are all particularly vulnerable to damage and should be designed to survive an earthquake intact.



Requirement #3: Occupants must be able to evacuate a building quickly and safely as soon after the earthquake as safety permits.

Acknowledging the potential for secondary hazards, evacuation of a building should begin as soon as ground motion ceases. But debris from ceilings, partitions, and fixtures may make passage hazardous or impossible. Darkness, flooding, and exposed wiring can make interior corridors and stairways deadly obstacle courses. Elevators are extremely vulnerable to damage. Careful consideration during design should be given to all possible exit routes.

Requirement #4: Rescue and emergency workers must be able to enter the building immediately after an earthquake, encountering minimum interference and danger.

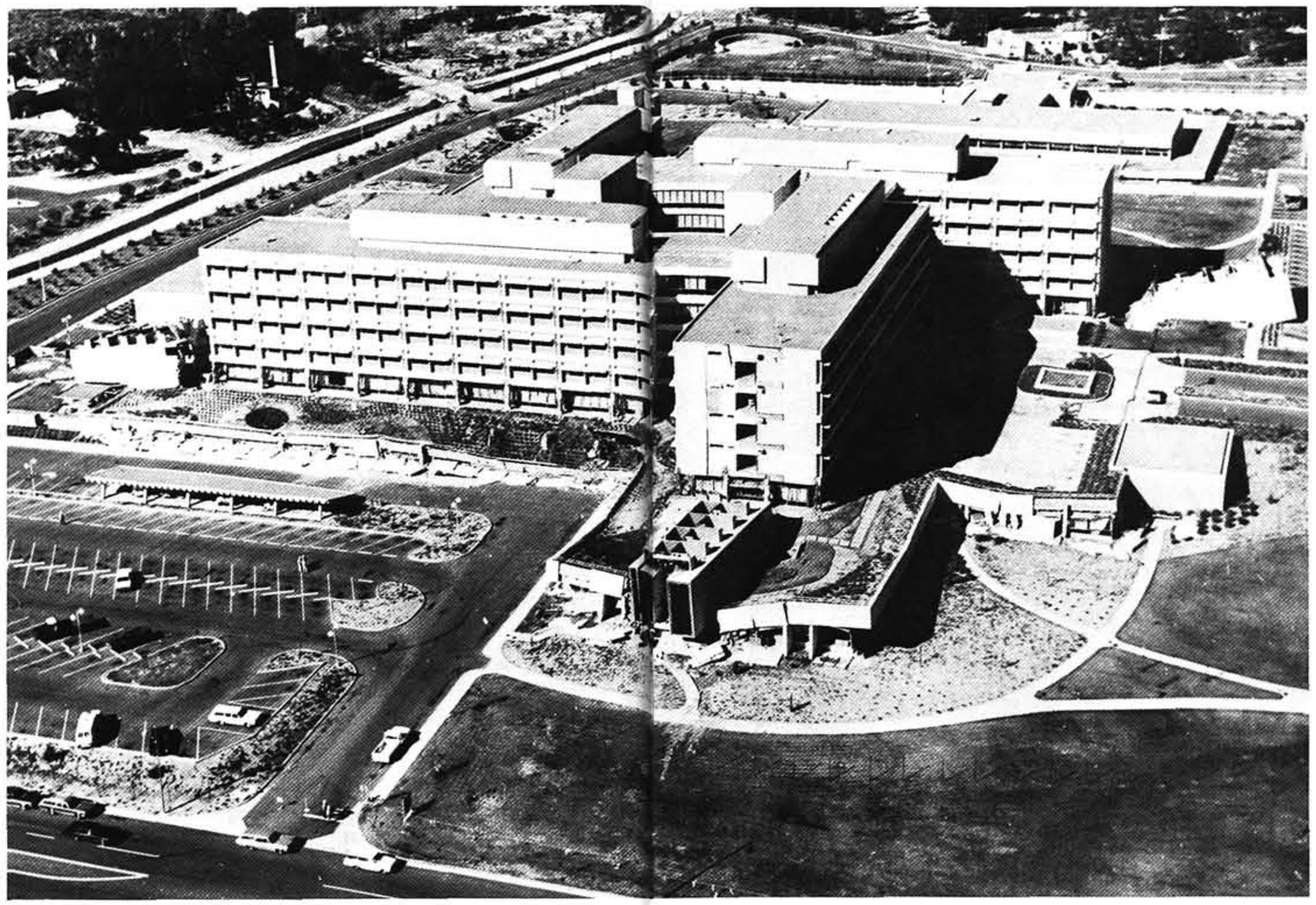
The same obstacles that may prevent building occupants from escaping a building may prevent entry by emergency personnel. They need clear passageways to remove casualties, and they need rapid access to emergency and control subsystems to combat fire, flooding, and other hazards.

Requirement #5: The building must be returned to useful service as quickly as possible.

The total cost of an earthquake is measured in at least two parts—the direct costs in injury, death, and property damage, and the longer-term costs of post-earthquake social disruption and economic loss. The latter can put tremendous demands on a community faced with disruption of business, loss of revenue, and the simultaneous need to divert resources to repair and recovery. Designers must attempt to ensure that certain critical building sub-systems remain intact through an earthquake, among them sewage disposal, potable water supply, electric power, environmental, and communications systems. This represents crucial decision-making at the design level, and should be influenced by relative need—hospitals and emergency centers, for instance, may rank most highly in terms of critical use systems.

Requirement #6: Buildings and personal property within buildings should remain as secure as possible after an earthquake.

One of the most unpleasant problems in this problem-set stems from the fact that looting and vandalism can follow natural disaster. Neither is consoling to property owners or conducive to recovery, and building security components should be designed to remain intact in the aftermath.



Although designed to comply with Uniform Building Code seismic requirements, Olive View Hospital near Los Angeles suffered major damage during the 1971 San Fernando Valley earthquake. The collapse of a concrete canopy immobilized emergency vehicles. Rigid stairtowers, separated from the less rigid main structure by seismic joints, fell at several points. And the flexible first story failed to survive the motion of the rigid structure above it. Still, the building survived, it's seismic design a qualified success.

quakes, a small but substantial primer on seismic design written from an architectural viewpoint. The 90-page primer covers everything from plate tectonics to tsunamis, but its foremost contribution may be its frank discussion of design priorities in a seismic situation.

We know that we can design structures which are likely to "resist" earthquake forces and remain standing in the wake of seismic assault, but which are not "earthquake proof"—able to survive damage-free. It is the damage that is critical because, in the words of the primer, "it disrupts vital functions; it represents economic losses for families and businesses, and most importantly, it threatens injury and death for building occupants and people in the vicinity of buildings." The lesson is that architects must focus attention now "not simply on ensuring the survival of the structural frame," but on preventing critical building damage as well.

The primer makes it clear that designers face a set of serious new challenges in mitigating seismic damage. The demands and requirements of doing more than simply "save the structure" are rigorous (see inset, page 13), and the decisions to be made more numerous. In fact the decision-making process, in which design priorities are set, becomes more crucial than the design process itself.

Designing a building that will be "safe" in and after an earthquake can be expensive for the client. Design technology advances at a rapid pace today; we may soon be able to design and build a structure capable of surviving all but the most devastating seismic action with minimal damage done. But the cost of doing that now would be enormous, and few clients outside of California and Hawaii will consider the risk of an earthquake worth an enormous cost to design against it. So the client is forced to make choices, forced to ask questions. What are the odds of an earthquake affecting my site? How strong is it liable to be? How far do I go to make the building safe for its users? Safe for equipment? What elements of the building are crucial? Power system? Computer terminals? Faced with decisions that will affect both cost and safety, the client is likely to need a lot more seismic information than he has at his disposal. The architect must become the bearer of that information. As the leader of the design/construction team, only the architect can explore the needs and constraints of the client, weigh the anticipated use of the building, balance both of those factors against an intelligent assessment of earthquake risk and hazards, and advise the client on design/safety priorities.

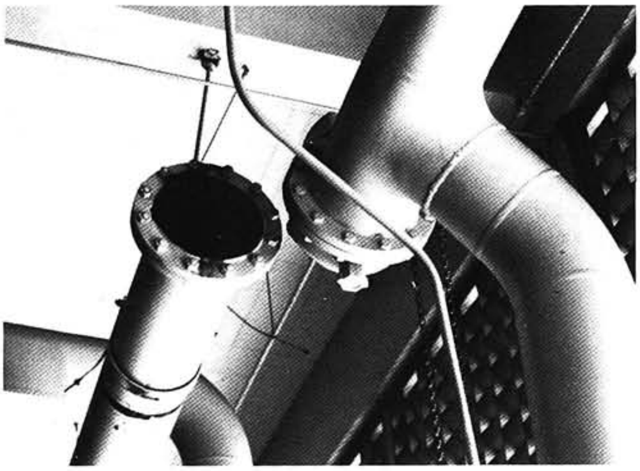
Order out of chaos

The anticipated use of a building is an important part of the design/safety decision-making process, sometimes the most important part. An apartment building bears one set of use-related design criteria, an office building a second set, a post office a third; in each case the architect who is concerned with seismic hazards balances those criteria against seismic risk. But certain buildings planned for very specific uses—hospitals, emergency centers, police and fire stations—carry special criteria into seismic design because of their peculiar relationship to disaster. In an earthquake, these buildings—and the specialized personnel who use them—become most essential precisely when they are most threatened. They exist to bring order out of chaos, but to do that they must be able to function, and to ensure that puts a very special burden on the architect.

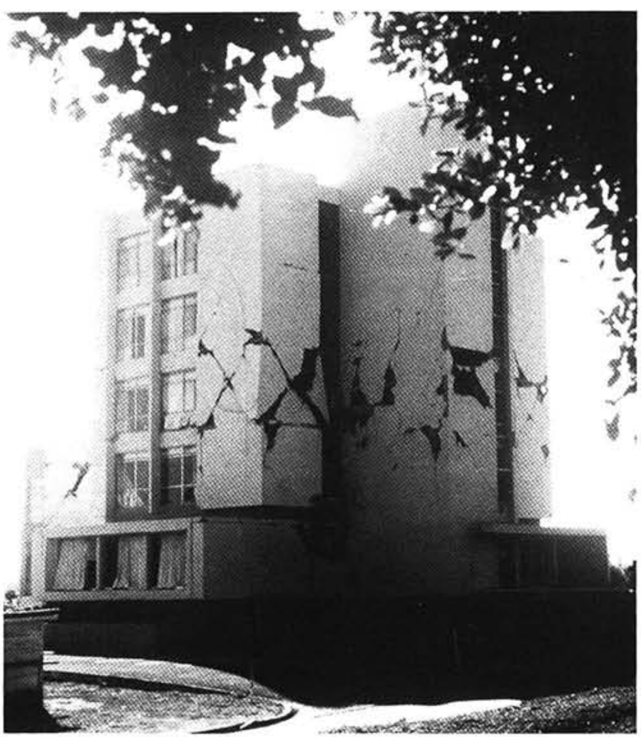
In 1976, AIA/RC proposed to the National Science Foundation a project of research aimed at documenting the specific design requirements that will help ensure that police and fire stations be able to function adequately during and after an earthquake. NSF—which fathers research programs linking architects and earthquakes as the U.S. Geological Survey fathers geophysical research—accepted the proposal.

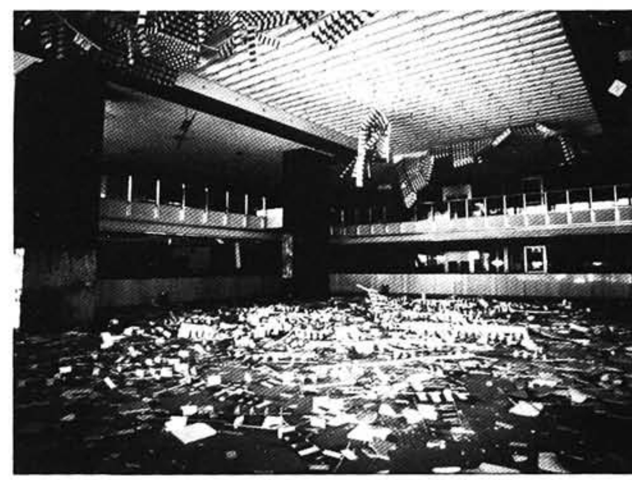
The project was aimed at identifying past and potential seismic damage to police and fire stations, assessing present and future facility requirements for both normal and emergency operation, and developing specific design considerations and alternatives to mitigate damage. Influencing the direction of the research were three other factors: Both NSF and AIA/RC, stressing the nationwide risk of earthquakes, agreed that the project should relate to stations in many communities across the country. Design considerations for both renovation and new design were included because seismic design considerations have been ignored on many recently-completed stations. And AIA/RC's commitment to using federal funding to get practitioners actively involved in research required that several A/E firms be subcontracted to develop specific conceptual seismic solutions for police and fire stations.

The year-long project developed some fascinating background material on high-priority facilities. The researchers discovered that during the 1971 San Fernando earthquake—the strongest to strike California in recent history, though moderate in magnitude and confined to a relatively small area—police and fire facilities suffered significant damage, enough to result in major crises and delays. Power was lost throughout the San Fernando Valley and in parts of downtown Los Angeles, cutting alarm systems off. Several fire stations were seriously damaged, with equipment rendered inoperable and some emergency personnel injured before they could leave stations. Police facilities suffered similar problems; at one



Architectural decisions are crucial to building performance during an earthquake. When the structural system of a building isn't uniform, different reactions to motion can result in first floor damage (Olive View Hospital) or the "pancaking" that killed 42 people in the Caracas building at right (1967). Nonstructural components insufficiently anchored can fall, as happened in the lobby of Managua's Banco Central in 1974 (below). Shear-cracking (below left) is common when a design fails to consider weaknesses in building shape. Flexible utility systems (left) can break at their weakest points—connections—when anchored disparately and subjected to different stresses.





juvenile detention facility 80 inmates escaped when part of a wall collapsed.

Of greater impact were survey results commissioned by the Federal Disaster Assistance Administration, the Federal Office of Emergency Preparedness, and the U.S. Geological Survey. Forecasting the potential effects of future earthquakes, the surveys indicate that in a strong (magnitude 8.3) earthquake along the San Andreas fault in Los Angeles, 23 per cent of the area's fire stations and 16 per cent of its police stations could be rendered completely nonfunctional. In San Francisco, a magnitude 8.3 earthquake along the San Andreas fault could stop one of every four fire stations from functioning. And in Salt Lake City, a magnitude 7.5 earthquake along the Wasatch fault could render fully half of the region's fire stations and more than half of its police stations totally nonfunctional.

These pessimistic statistics darken further with the realization that police and fire stations in all the surveyed jurisdictions were designed with seismic building codes in mind; losses could be higher where no seismic codes exist.

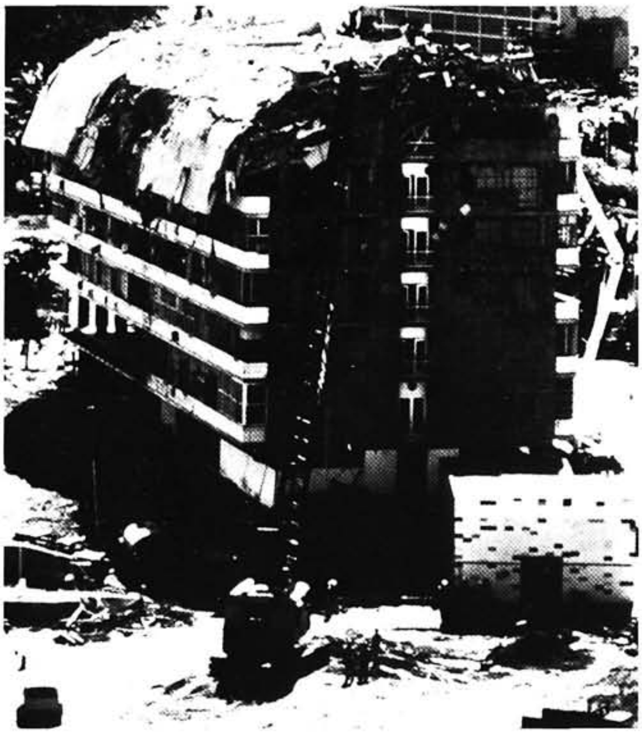
From this frame of reference, the researchers developed case studies and design criteria to help ensure that police stations, fire stations, and emergency operating centers be able to function under all but the most dire circumstances. They also developed subsidiary design considerations for building systems, equipment, and seismic renovation, and extrapolated the data to facilities for coping with other natural disasters. In short, they plowed a lot of ground and developed a lot of new information, all of it immediately applicable in architectural practice.

Earthquakes and education

Information—the kind turned up in architectural research and the kind developed by geophysicists and others—is mounting up in the field of earthquake study. And it's beginning to become a problem, because the profession isn't equipped to disseminate everything it's learning. For architectural educators the problem is particularly difficult.

Seismic considerations have never been a major part of architectural training, with the possible exception of that received in schools located in traditionally earthquake-prone areas where seismic building codes also exist. Yet AIA/RC's research has yielded estimates putting a full third of the nation's practicing architects in areas where the threat of an earthquake is very real. That, compounded with the mobility of the profession and the fact that 70 million Americans live in seismic hazard zones, brings home the notion that the profession's seismic training has been less than adequate to date.

Last summer, AIA/RC sponsored a new kind of educational experience for architectural faculty, designed to help educators overcome existing barriers to seismic train-



ing. With funding from NSF, a week-long Summer Seismic Institute was held at Stanford University. Fifty educators, offered an all-expenses-paid week at one of the nation's leading seismic research centers, faced a curriculum laden with presentations on seismic geophysics, land use and urban planning concepts, the socio-economic implications of seismic risk and public policy, structural and nonstructural design considerations, and seismic renovation and rehabilitation. They also spent time at Stanford's NSF-supported shake-table facility, where building models receive simulated earthquake stresses. For AIA/RC, it was a busy first experiment in raising faculty interest in seismic design; whether the experiment will succeed in significantly increasing seismic awareness in professional schools of architecture remains to be seen. But the indications—including reaction from educators and NSF—are positive, and funding expected from NSF this month will support two institutes this summer, at Stanford and the University of Illinois at Urbana-Champaign (see inset).

Implications for the future

The notion that seismic design should be a basic part of professional training is an important one. In school, architects receive their most intense training; and they form fundamental principles of design that they will hold throughout subsequent years of actual practice. How long will seismic design—already making demands on practitioners, already the focus of a particularly popular nationwide continuing education program at AIA—continue to be relegated to the back shelves of the design library?

Seismic design's implications for the future of the profession loom large and inevitable, and for a long list of reasons. Of tremendous importance is the nation's geophysical research, making advances almost daily. The research budget of the U.S. Geological Survey doubled this year, firm evidence that our earthquake intelligence

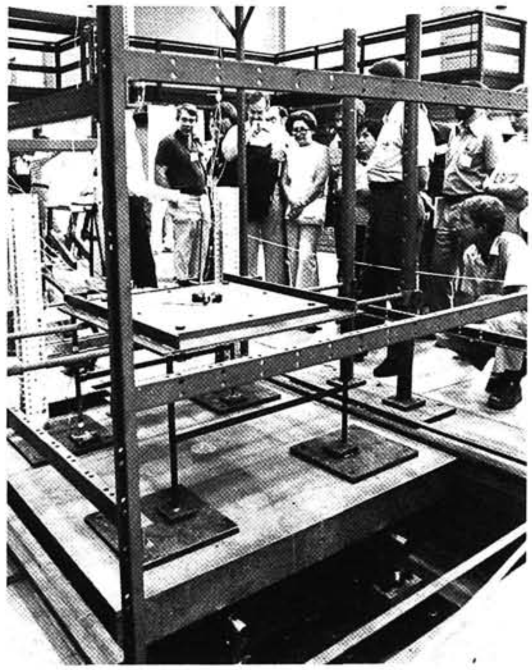
Seismic schooling: AIA/RC's Summer Institutes

AIA/RC will sponsor two special Summer Institutes for architectural faculty interested in seismic building design this summer, at Stanford University and the University of Illinois at Urbana-Champaign.

Designed to raise seismic awareness in the nation's architectural schools, each of the week-long institutes will be open to 50 faculty members from schools of architecture in the U.S. With National Science Foundation funding expected this month, AIA/RC will pay travel, meals, and lodging expenses for each institute participant. The Urbana-Champaign institute will be held the week of June 18-23; the Stanford institute will be held the week of Aug. 20-25.

Each of the institutes will offer a curriculum touching on a broad range of seismic design and safety considerations, including geologic hazards, public policy, land use planning, building codes, building systems, structural concepts, seismic renovation, socio-economic implications, and educational strategies. Though similar, each institute will focus on specific regional considerations in seismic design, Stanford for the western part of the country, Illinois for the eastern and midwestern.

Faculty may apply for either institute, in either of two categories specifying interest in design curricula or technical curricula. Application forms have been sent to all schools of architecture in the U.S., and must be returned by April 17. Interested faculty lacking access to application forms should contact Earle Kennett at AIA/RC in Washington, D.C. (tel. 202/785-7833) as soon as possible.



will increase at an exponential rate in the near future. We learn more and more about our susceptibility to earthquakes every year. New faults, passive and active, are constantly being identified. Research into the advance symptoms of seismic upheaval is rapidly bringing us closer to accurate earthquake forecasting. And researchers are devoting more effort to understanding the earthquakes that occur within plates—the earthquakes that threaten the East Coast and much of the rest of the nation.

As scientific research and knowledge in the field increase, public interest will increase as well, and that too will become important to the profession. Thomas Henry Huxley once remarked that a little knowledge is a dangerous thing. Architects often bewail the overreactive nature of society, and overreaction is fueled by marginal knowledge. It doesn't require much imagination to contemplate the levels righteous indignation may reach in the wake of a destructive earthquake; the liability implications alone send tremors up one's skeletal frame.

Overreaction is equally as serious in the context of codes and regulations. As one architect recently put it, all it will take to generate noisome controversy over the inadequacy of existing seismic building codes is one destructive earthquake. Unfortunately, codes and standards stem too often from such intemperate circumstances. And as designers have learned recently with the debate over ASHRAE Standard 90-75, such crisis-sparked regulation is rarely supportive of optimum design. As a general rule, architects should play a more active and precognitive role in the regulatory process. But the peril inherent in seismic design and construction impels us even more strongly to heed foresight and take action in the field.

There are other, more affirmative reasons to raise our seismic consciousness. With one in every three architects in the nation practicing in an area of seismic risk, getting involved in seismic design isn't just a matter of protecting the profession's ground; it's a matter of expanding architectural expertise, responsibility, and the market for professional services. The marketplace isn't free from monopoly; real seismic expertise is now clustered in a few design firms based in California and other traditionally hazard-prone districts. As South Carolinian investors become more aware of the seismic hazards along their coast—where foreign and domestically-owned industry is thriving and expanding—design firms from Nag's Head to Savannah may face the prospect of losing clients to their more experienced San Francisco-based competitors.

A designer with a firm grasp of the realities of seismic hazards and the skills to design against them also has something special to offer in a client relationship. For a hard-nosed, cost-conscious, productivity-oriented client, an intelligent assessment of the seismic risk that may be inherent in a building site should be regarded as a godsend. When an architect can articulate that risk and offer a cost-benefit analysis of the price of protecting against it, then the professionalism of the relationship is heightened significantly, and the likelihood of a post-earthquake liability suit proportionately reduced.

Resources and good reading

Each of the AIA Research Corporation's projects in seismic design research has focused primarily on developing information of specific and tangible use to practitioners and educators. As a result, the final project reports have been compendiums of design-oriented seismic data well-suited to the architect in need of resources in the field.

Architects and Earthquakes is a product of AIA/RC's first NSF-funded seismic research. Called a seismic primer, it's a broad and basic introductory text on seismic design, touching on everything from plate tectonics to design requirements for mitigating seismic damage. Briefly written, well illustrated, the 90-page primer is an excellent resource for architects beginning to approach seismic considerations in design. It's available for $2.20 from the Superintendent of Documents, U.S. Government Printing Office (GPO), Washington, D.C. 20402, tel. 202/783-3238. The order number is GPO-038-000-00331-3.

Architects and Earthquakes: Research Needs explores more deeply the topics introduced in the primer. A 247-page compilation of proceedings and papers presented at AIA/RC's 1976 Seismic Safety Research Workshop, it includes ten in-depth background papers on seismic fundamentals. It also offers the workshop's recommendations for future research keyed to architectural needs. Among the presentation topics: Earthquake hazards and risk, land use planning, site/structure interaction, structural and nonstructural considerations, critical use facilities, building codes, and seismic urban planning. The report is available from the National Technical Information Service (NTIS), 5285 Port Royal Rd., Springfield, Va. 22161, tel. 703/557-4650.

Summer Seismic Institute for Architectural Faculty is the report on AIA/RC's first seismic institute for architectural educators, held last August at Stanford University. Together with a formidable set of 15 papers presented at the institute by some of the nation's leading seismic design researchers and practitioners, the report details strategies for incorporating seismic design into architectural education, and includes a valuable listing of books, reports, abstracts, a/v materials, and other resources in the field. It may be the most comprehensive assemblage of seismic design information yet produced for architects. The 321-page volume is available free from AIA/RC.

Seismic Design for Police and Fire Stations is an exploration of seismic design considerations necessary to help ensure that police stations, fire stations, and other critical use facili-

Wanted: Seismic designer

The AIA Research Corporation is seeking a designer interested in seismic design to join its Earthquake Program in Washington, D.C. this spring. The position may be permanent or on the basis of a 12-18 month sabbatical from a firm or organization interested in developing a seismic research capability. Interested designers may contact Earle Kennett at AIA/RC, 1735 New York Avenue, N.W., Washington, D.C. 20006, tel. 202/785-7833. All inquiries will remain confidential, and a salary request should be included.

It is the architect—not the planner, the soils engineer, or the structural engineer—who should articulate that seismic risk. We are not so distant from the age of the master builder that we can neglect the profession's final responsibility and fail to design a safe environment. But we are sufficiently far from that Jeffersonian epoch to know that an architect does not—and cannot—possess and apply all of the knowledge that architecture now circumscribes. The reality of our limitations in a field as complex and multidisciplinary as seismic design stands in high relief. In few other areas of design is the weakness of individual effort so obvious and the need for plural intelligence so strong.

"Proper seismic design requires an integrated team," Elmer Botsai told educators at last summer's Seismic Institute. "To do that," he said, "the architect must be able to communicate with the engineering profession; the architect must be able to hear the engineering profession; the architect must *want* to hear the engineering profession." With the ability to translate what we know about earthquakes into criteria for building design, and with the open intelligence to apply the particular expertise of each member of the building team, architects can reduce the seismic risk present throughout most of the United States to the smallest possible fraction.

Seismic engineer Lloyd S. Cluff put it another way last summer, describing neatly the object of the profession's work through the AIA Research Corporation and the National Science Foundation's purpose in funding that work. "With an interdisciplinary approach," Cluff said, "requiring a geologist, seismologist, structural engineer, architect, and planner, and with the support of the public and elected officials, it is possible, theoretically, to have from a large earthquake, rather than a spectacular disaster, nothing more than an exciting experience."

–Kevin W. Green

ties remain in operation during and after natural disasters. In addition to an overall assessment of the problems in this crucial design area, the book also offers specific design concepts developed by seven design firms who subcontracted on the year-long project. The report makes fascinating reading for any designer interested in seismic information, or just interested in critical facility design. The report should be available from AIA/RC for free by midsummer.

For architects interested in exploring earthquake risk and seismic design, there is a host of other good reading on the subject.

Earthquakes is a 319-page report on seismic damage and destruction of buildings in four major earthquakes: Morocco (1960), Yugoslavia (1963), Alaska (1964), and Venezuela (1967). Extensively illustrated, the softbound book is available from the American Iron and Steel Institute, 1000 16th St., N.W., Washington, D.C. 20036.

D. J. Dowrick's **Earthquake Resistant Design: A Manual for Architects and Engineers** follows a logical design office sequence as it explores the major design considerations of minimizing seismic damage. It's available for $27.50 from John Wiley & Sons, 605 Third Ave., New York, N.Y. 10016.

Learning from Earthquakes is a planning and field guide aimed at maximizing what we can learn in the wake of future earthquakes. It's available for $5 from the Earthquake Engineering Research Institute, 424 40th St., Oakland, Calif. 94609.

Gerald McCue and Garrison Kost authored **The Interaction of Building Components During Earthquakes.** Their 207-page report documents component interaction with particular focus on the enclosure and finish systems; the goal is to develop a conceptual basis for solving the interaction problem. It's available from NTIS for $7.75 (order number NTIS PB258326).

Seismic Resistant Design of Mechanical and Electrical Systems tackles the same task McCue and Kost did, except that its emphasis is on mechanical and electrical service systems. Authored by engineers G. M. and T. R. Simonson, the 215-page report is also available from NTIS.

San Francisco designers Stone Marraccini Patterson authored **Study to Establish Seismic Protection for Furniture, Equipment, and Supplies for VA Hospitals** for the Veterans Administration. The design considerations discussed here were recently manifested in SMP's Pettis Memorial Veterans Hospital in Loma Linda, Calif. The 205-page report is available from the VA, Washington, D.C. 20420.

And **Building Practices for Disaster Mitigation,** a compilation of papers and proceedings from an NBS-sponsored national workshop on the subject, focuses on current building practices, potential improvements there, and recommendations for future research. The lengthy (nearly 500 pages) document is available for $5.30 from GPO (order GPO C13-29/2:46).

ABSTRACTS

Current research results

The following abstracts of recent architectural research are drawn from the AIA Research Corporation's Research Information Retrieval System (RIRS), a computerized architectural data bank containing information on research projects and reports touching on every aspect of architectural practice.

The RIRS system exists to be used by practitioners in need of current and often specialized information. Only recently developed by AIA/RC, the system is accessed through a keyword list, and its resources are available for quick retrieval upon request. References are being added—and the keyword list expanded—almost daily.

In addition to drawing abstracts, reports, and publications from RIRS, practitioners are also encouraged to contribute to the system. If you or your firm have recently completed work that may advance the expertise of the profession as the work detailed here and elsewhere in this issue of *Research & Design* has, you are invited to summarize and submit it for inclusion in the RIRS system.

All submissions, requests, and other inquiries should be addressed to Ella Hall, AIA Research Corporation, 1735 New York Avenue, N.W., Washington, D.C. 20006. Tel. 202/785-7843.

Visitor Center Design Evaluation

This study represents a step toward developing a feedback mechanism for the planning/design process. It is a comparative evaluation of 12 National Park Service visitor centers, and it addresses an array of design and design-related issues, including function, maintenance, visitor use patterns, safety, security, and aesthetics. The primary objective of the report is to develop information which can contribute to more enlightened and informed design decisions in the future and, in so doing, identify components or attributes which contribute to or detract from the quality of the centers. These components and attributes can be physical (site, size, or building material), perceptual (attractiveness and suitability), and procedural (design process). The survey and field observation procedures used in the study are fully documented.

RIRS #780061.

This abstract refers to: Visitor Center Design Evaluation, by Zube, Crystal, and Palmer, April, 1976.

This publication can be ordered from: Denver Service Center, National Park Service, 755 Parfet Street, Denver, Colo. 80225.

Levels of Illumination and Legibility

This report on recent experimental work related to illumination level requirements in the working environment makes some important assertions for architects. The report raises serious questions about the current basis for recommending illumination levels as minimums. The general philosophy of "more light, better sight" is specifically criticized because research has shown that, at certain levels, the "goodness of seeing" decreases. The research makes a distinction between levels of visual performance called "detection," "recognition," and "identification."

A further distinction is made between biological responses to light and psychological responses. The report is written in clear prose and includes charts of research results.

RIRS #780054

This abstract refers to: Levels of Illumination and Legibility, by Yonemura, Benson, and Tibbott, November 1977.

This publication can be ordered from: National Technical Information Service, Springfield, Va. 22151, for $4.50. Ask for report PB274652 by the National Bureau of Standards.

Method for Predicting the Stiffness of Wood-Joist Floor Systems with Partial Composite Action

Residential wood floor systems have long been designed by considering the joists to be simple beams which act independently in supporting imposed loads. Interaction between the joists and sheathing material, however, increases the stiffness above that of the joists alone. The interaction is not complete, though, due to the non-rigid behavior of the mechanical or adhesive fasteners which attach the sheathing to the joists. Gaps in the sheathing disrupt its continuity and further complicate the analysis.

By using methods for computing the stiffness of composite beams and predicting the load-slip characteristics of individual mechanical fasteners, complex computational procedures were reworked and combined into an easy-to-use format. The problem of open gaps in the sheathing was handled with a simple modification of the basic method. This procedure gave excellent correlation between computed and experimental values obtained at the Forest Products Laboratory and elsewhere.

With known material properties and the procedures presented, it is possible for designers to easily and accurately predict floor stiffness properties.

RIRS #780059

This abstract refers to: Method for Predicting the Stiffness of Wood-Joist Floor Systems with Partial Composite Action, by William J. McCutcheon.

This publication can be ordered from: Forest Products Laboratory, U.S. Dept. of Agriculture, Madison, Wisc. 53705.

Stone Preservatives

Although numerous materials have been proposed as preservatives for the stone in historic buildings and monuments, their efficacy is difficult to establish. In the work described here, a laboratory research program of accelerated simulated stone decay was used to obtain data on stone preservatives and to suggest criteria for their selection. Over 50 materials usable as stone preservatives were tested.

Tests to simulate stone decay were of two types: (1) exposure to combined weathering factors using a special test chamber for accelerated decay (CAD), in which chemical attack, salt and water action, and thermal effects were simulated in one operation; (2) exposure to single causes of stone decay using sulfurous acid fog, sodium chloride fog, water condensation/evaporation cycling, sodium sulfate penetration and crystallization, and ultraviolet radiation.

Methods for measuring the effects of the exposures are given together with the test data; these have been used to set limits of acceptable performance in preliminary performance criteria for the selection of stone preservatives. The behavior of each stone preservative tested in meeting these criteria is given. No one stone preservative met all criteria.

RIRS #780053

This abstract refers to: Stone Preservatives: Methods of Laboratory Testing and Preliminary Performance Criteria, by Gerald A. Sleater for the National Bureau of Standards, May, 1977.

This publication can be ordered from: Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price is $2.30. Stock #003-003-01727-2.

Smoke Hazards in Covered Multi-level Shopping Malls

Covered, multi-level shopping malls in the United Kingdom are becoming both larger and more widespread, and they can present several new potential fire hazards. One such hazard is caused by the need for the actual central mall to serve as the major escape route for users. It should be possible in principle to provide a smoke-free region on all the levels of a multi-level mall. This paper describes an experiment to investigate geometric design variants frequently used in practice, which would restrict smoke spread. The author attempts to draw some more generally applicable principles from the results.

RIRS #780052

This abstract refers to: Smoke Hazards in Covered Multilevel Shopping Malls: Some Studies Using a Model Two-story Mall, by Morgan, Marshall, and Goldstone, June, 1976.

This publication can be ordered from: Distribution Unit, Application Services Division, Building Research Establishment, Garston, Watford, WD2 7JR, England. Copies are available and a charge may be made for supplies in quantity.

Fire Behavior of Foamed Plastics Ceilings Used In Dwellings

The upper floor ceilings in multistory domestic buildings and the ceilings of single-story dwellings are not required to resist fire penetration for any minimum period because there is no habitable accommodation above them. They may however be subject to the flame spread requirement applicable to the exposed surfaces of rooms.

The choice of materials for the construction of ceilings in domestic buildings is dictated by considerations such as sound and thermal insulation, appearance, durability, etc. One type of material used has been foamed plastic, such as polyurethane, generally sandwiched between two layers of paper. These boards may be treated on the soffit to improve their performance in the surface spread of flame. This paper examines tests made in England comparing the behavior of fire in rooms having polyurethane and plasterboard ceilings. The tests were carried out in separate, identical buildings.

The London Fire Brigade concluded that the use of polyurethane ceilings could lead to increased fire hazard because of easier penetration of the fire into the roof space leading to more rapid fire spread and structural damage.

Following these tests it was agreed that a more comprehensive series of tests should be carried out under carefully controlled conditions. It was decided that the new tests would look at the ease with which a fire could penetrate a ceiling to the space above, the possibility of downward penetration from that space into an adjoining room, and also at the smoke build-up on an escape route separated from the fire by a normally fitted closed door. This paper presents a summary of all test results.

RIRS #780051

This abstract refers to: Fire Behavior of Foamed Plastics Ceilings Used in Dwellings, by Morris and Hopkinson, November , 1976.

This publication can be ordered from: Distribution Unit, Application Services Division, Building Research Establishment, Garston, Watford, WD2 7JR, England. Copies are available and a charge may be made for supplies in quantity.

Sound Isolation Requirements In Multi-Occupancy Residential Buildings

Building codes are usually a compromise between what is desirable and what is practical. What is desired by residents of multiple occupancy dwellings is adequate acoustic privacy from neighbors and other noise sources, such as traffic. What is specified is essentially the airborne sound insulation of the common wall between dwellings, measured under idealized conditions.

Acoustic privacy would require the accurate specification of field noise reduction, background noise levels, and sound levels of sources. Apart from the difficulties of specifying an appropriate background noise level and the correct noise reduction, there are problems of changing requirements and conditions and noise sources which can be classified as "impact sources" (e.g. footsteps, door slamming, and plumbing) which cannot be dealt with so easily.

To try to resolve this impasse, a survey of residents in the eastern suburbs of Sydney, Australia was undertaken. The survey was similar to other surveys carried out in Britain and the Netherlands, in that it established the noise sources of importance. It is suggested that people living in apartments cannot expect a better acoustic environment than occupants of detached dwellings.

Thus, if the perceived level of acoustic privacy can be found in each case, for each source, a more realistic and usable building code should result which may overcome the problems inherent in trying to apply definitive acoustic criteria.

RIRS #780060

This abstract refers to: Sound Isolation Requirements in Multi-occupancy Residential Buildings, by Fergus Fricke.

This publication can be ordered from: Prof. H. G. Cowan, Dept. of Architectural Science, University of Sydney, Sydney, N.S.W. 2006, Australia. Price is $1.50.

ELEMR Technical Report Series

The "Effects of the Living Environment on the Mentally Retarded" (E.L.E.M.R.) Project is a longitudinal (3 years) and multidisciplinary research project to assess the built environment's impact on mentally retarded people. Using a multiple-baseline, quasi-experimental design, state school residents and attendants are being observed before, during, and after their present living quarters (large sleeping wards and dayhalls) are converted into smaller, more home-like spaces.

The conceptual approach used by the ELEMR project focuses on examining transactions within the immediate community of residents, staff, and built environment. This conceptualization identifies three key elements in the normalization process—the level of normalization (or opportunity) created in the built environment, the response of residents to the current renovations, and the interactive role of the staff in this process.

The technical report series for this project is now available. The series includes: (1) "The Living Environment and its Effect on the Behavior Patterns of the Institutionalized Mentally Retarded: Preliminary Proposal of Goals and Methods," which summarizes the background literature and methods of observation proposed at the outset of the ELEMR research project; (2) "Observation Manual: Residents and Attendants," which includes descriptions of observational procedures and behavioral categories used for collecting quantitative data on residents and attendants in their living and working environments; (3) "Normalization as a Social-Physical System," the first major conceptual statement based on the ELEMR research program, a preliminary theoretical framework within which empirical findings may be meaningfully understood, and (4) "Research Strategies for the Social Sciences: An Integrative Approach," which reviews issues in methodology and proposes an integrated framework for multi-method approaches to maximize validity in empirical research.

RIRS #780056

This abstract refers to: ELEMR Technical Reports #1-4, by the Environment and Behavior Research Center, University of Massachusetts.

This series can be ordered from: Environment and Behavior Research Center, Institute for Man and Environment, U/Mass., Amherst, Mass. 01002.

Reliability-Based Design Procedures for Wood Structures

Probabilistic methods provide a rational and consistent way to balance the competing demands of safety and economy. They are universal in that they apply to all materials and all facets of design. This paper is an introduction to the concepts of probabilistic design for wood users and producers. Second moment safety analysis is illustrated in detail by an example application to the design of wood floor joists. Necessary background information is provided. The distinction between second moment analysis and limit states design is noted.

RIRS #780058

This abstract refers to: Reliability-Based Design Procedures For Wood Structures, by John J. Zahn.

This publication can be ordered from: Forest Products Laboratory, U.S. Dept. of Agriculture, Madison, Wisc. 53705. Single copies are available free of charge.

Facility Influence On Productivity

This report describes a Herman Miller Research Corp. (HMRC) research project cosponsored by Michigan State University, Herman Miller Inc., and HMRC, which examined the direct influence of the physical environment on the satisfaction and proficiency of students and faculty at MSU.

An applied facility experiment was developed in which two older, conventional laboratory classrooms were converted to an experimental environment designed to support innovative programs. It was proposed that a more responsive environment with strong facility management could pay off, in both improved educational proficiency and more intense usage of expensive building space.

A year-long evaluation was conducted which compared the performance of the experimental setting with that of the same facility before renovation. A multiple measurement technique was utilized, composed of the following five indices: Facility response, negotiation, possession, utilization density, and economic index.

The results of the experiment exceeded the performance objectives of the research program. Indications of improvement were consistent and collectively significant. An old facility, rejuvenated at moderate cost, delivered high utilization and effectiveness. Moreover, this performance was judged to be better than the uni-

One of the Michigan State University classrooms redesigned during the Herman Miller Research Corp. study of facility influence on productivity.

versity average for class/lab spaces in conventional new facilities. The implications of the experiment are that facility influence on process is much more forceful than generally assumed, and that there is potential for facilities to enhance and improve productivity.

RIRS #780057.

This abstract refers to: Facility Influence on Productivity, by R. Propst, Adams, and C. Propst.

This publication can be ordered from: Herman Miller Research Corp., 3970 Varsity Drive, Ann Arbor, Mich. 48104. Price: $5.50.

Assessment of the Technical Literature on Emergency Egress from Buildings

The Center for Building Technology of the National Bureau of Standards has investigated the technical research underlying OSHA's emergency egress standards. A recently-released report on this project identifies and reviews the technical literature on which current egress regulations are based, and identifies those areas for which there are either insufficient or contradictory research findings. The investigation included the literature on egress requirements (from which came the 22-inch "module" on which current stair and exitway design is based); signage, lighting and visibility through smoke, and "after-the-fact" studies of occupant behavior in fires.

RIRS #780062

This abstract refers to: An Assessment of the Technical Literature on Emergency Egress from Buildings, by Fred Stahl and John Archea.

This publication can be ordered from: National Technical Information Service, Springfield, VA 22151, for $5.25. Ask for report no. NBSIR 77-1313.

Flexural Fatigue of Glass Fibre Reinforced Cement

In recent years considerable interest has been shown in the reinforcement of gypsum plaster and Portland cement with small amounts of glass fibre for use in partitions, cladding panels, ducting, etc. Considerable work has been done on the static behavior of this material, both in tension and bending, and some cyclic tensile tests have been reported. This paper, however, is concerned mainly with the effect of fluctuating stress on these type composites made in the form of large sheets by a spray-suction technique. The behavior of the material varies to a greater or lesser extent, with time and the conditions under which the material is cured and stored. Results are therefore presented for a range of materials which had been stored under different conditions for various lengths of time.

RIRS #780050

This abstract refers to: Flexural Fatigue of Glass Fibre Reinforced Cement, by A. P. Hibbert and F. J. Grimer, January, 1976.

This publication can be ordered from: Distribution Unit, Application Services Division, Building Research Establishment, Garston, Watford, WD27JR, England. Copies are available and a charge may be made for supplies in quantity.

Solar Energy Update

This publication provides abstracting and indexing coverage of current scientific and technical reports, journal articles, conference papers and proceedings, books, patents, theses, and monographs for all sources on solar energy. All information announced in SEU, plus additional backup information, is included in the energy information data base of the Department of Energy's Technical Information Center. The subject matter covered by SEU includes solar thermal, photovoltaic, biomass conversion, ocean thermal, heating and cooling, wind power, and wave energy.

RIRS #780055

This abstract refers to: Solar Energy Update, by the U.S. Department of Energy, December 1977.

This publication can be ordered from: National Technical Information Service, Springfield, Va. 22161. Cost for an annual subscription is $27.50. Ask for publication #NTISUB/C/145.

THE MARKETPLACE

Architectural opportunity in research

Profile:

National Science Foundation

Although difficult to destroy, charm is not completely indestructible. Over very long times it is possible for charm to disappear owing to the effect of weak interactions, weak because they take so long to act."

That isn't a phrase from a debutante's handbook or an earnest treatise on dinner-party etiquette. Its real source is the National Science Foundation; the context is NSF's 1976 Annual Report, and charm is a "behavioral characteristic" of subatomic particles called quarks. When not in pursuit of the charmed quark, NSF, an independent Federal agency, expends the remainder of its considerable budget (for Fiscal Year 1978, $865 million; for FY 79, $934 million is being requested) on a stunning variety of scientific projects—some of them of deep interest to architects.

To understand NSF's architectural interest we need some historical background. NSF is practically synonymous with two Washington catchphrases—spectacular growth and continuing controversy. After several false starts, NSF was born in 1950 when President Truman, impressed with the success of World War II's Manhattan Project and science's defense role, signed into existence an agency dedicated to basic scientific research. NSF started with a budget 1/300 of its present size—$3.5 million. Basic research is what we used to call "pure science," and most of it is as far removed from the practicing architect as the charmed quark is from a debutante's dreams. NSF is governed by a director, well-known Stanford University psychologist Dr. Richard C. Atkinson, and the National Science Board. The Board's 24 members (plus the director) are "representative of the scientific leadership of the nation" and include at present 16 university professors and eight industry professionals. Supported by a national scientific constituency, a reliable (though often critical) Congressional leadership, and a public which values scientific and technological success, NSF has established itself as the voice of basic research in Washington.

NSF blossomed through the '50s and '60s, the era of Sputnik, the missile gap, and the space program. In the early 1970s, however, it ran into difficulty. With the end of the space program, the nation faced an over-supply of PhDs in science and a disenchantment with the notion that raw scientific effort could conquer the pressing national problems of the environment, race relations, and poverty. NSF responded by creating a new program called RANN: Research Applied to National Needs, a program oriented more toward applied research than the basic research and educational programs traditionally supported by NSF.

RANN

The very name, Research Applied to National Needs, speaks volumes about RANN's relations with the rest of NSF and the rest of government. Historian Milton Lomark remarks that in 1971 then-NSF Director William D. McElroy regarded the acronym as a "semantic triumph in that the phrase 'research applied' as distinct from 'applied research' clearly indicated that RANN would support whatever kind of science—basic or applied—the problem with which it dealt appeared to require." Semantics aside, RANN's research—applied or not—has seemed frequently at odds with NSF's orientation. The resulting symptoms of organizational schizophrenia have included some hostility from both the basic research community and pure science's Congressional representatives. Then too, there has been uncertainty about RANN's duties. RANN has appeared to compete with other larger and more powerful Federal departments who, after all, perform their own research applied to national needs. And there has been some uncertainty about just how scientific some of RANN's activities are, especially in the social sciences.

RANN's response has been to conceive of itself as a kind of stalking horse: It identifies a problem with substantial scientific content and supports work on the problem until its scientific aspects achieve a degree of maturity. Then RANN turns its program over to the other, more mission-oriented federal agencies.

The paradigm of this process has been RANN's energy program. Alfred Eggers Jr., former director of RANN, spoke in 1976 of how "RANN went over the energy mountain during the past five years . . . If you looked at the energy budget in RANN in 1971, it was on the order of $1 million. In 1973 . . . it was on the order of $14 million. In 1975, it peaked at about $93 million. Today [1976], it is back to the order of $1 million." By 1975, Eggers said, NSF had transferred more than half its energy program out to ERDA (the Energy Research and Development Administration, now amalgamated into Dr. Schlesinger's Department of Energy). "Today," he said, "the transfer is essentially complete." We all know how events intervened to hasten that transfer.

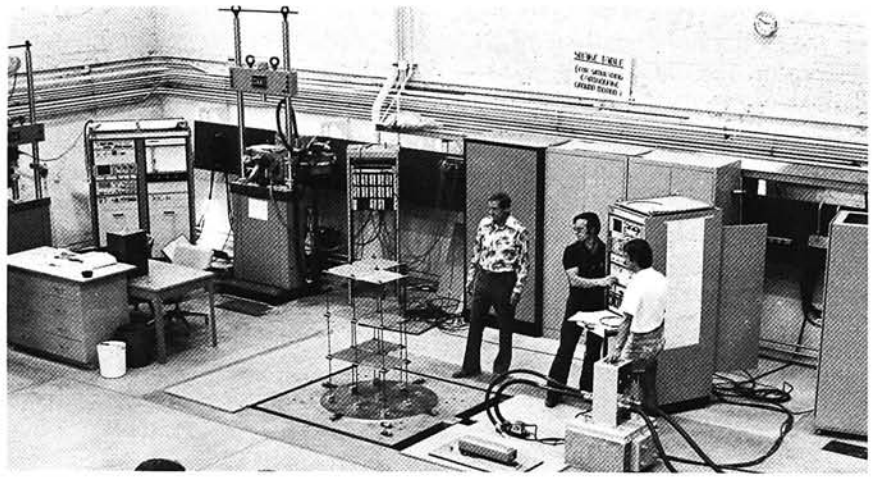
RANN has been the NSF directorate most closely concerned with architectural research. As you read this, however, RANN is metamorphizing into ASRA—Applied Science and Research Applications—and it is ASRA architects will have to deal with from last Feb. 6 on. ASRA's program has not fully crystallized, but its general charge is twofold: To concentrate its resources on a few important problems which applied scientific work can solve, and to integrate RANN's applied research work with the considerable basic research resources the remainder of NSF can call on.

Earthquakes and Architects

Right now, there is architecturally relevant work going on at NSF in the Earthquake Hazards Mitigation program (EHM), which will be continued under ASRA's Directorate of Problem-Focused Research Applications. The head of this directorate and the driving force behind EHM is Dr. Charles C. Thiel (NSF, 1800 G Street, N.W., Washington, D.C. 20550). While other federal agencies, including the Department of Housing and Urban Development, the Veterans Administration, and the General Services Administration have participated in studies relevant to earthquake design, the major federal work is centered at the U.S. Geological Survey and the National Science Foundation. USGS is concerned primarily with the geophysics of earthquakes and the esoterica of plate tectonics. NSF has concerns of a more directly practical nature.

At NSF, EHM germinated in the middle 1960s, so it antedates the programs—RANN and ASRA—which have administered it. EHM's ultimate goal is "to reduce casualties, damage, and social and economic disruption from earthquakes." NSF hopes that EHM can generate solid information about how the built environment and social institutions can be adjusted to mitigate, rather than aggravate, earthquake danger to life and limb.

NSF's total FY 78 budget is $865 million, of which EHM has been allocated $18 million. That gives EHM by far the lion's share of the Problem-Focused Directorate's budget. And to encourage widespread participation in research, 12.5 per cent of ASRA's budget has been earmarked for grants or contracts to small businesses. NSF hopes that architectural firms will become more deeply involved in earthquake hazard mitigation research, an area traditionally dominated by structural and geotechnical engineers.



NSF supports the shake-table facility at Stanford University's Blume Center, one of the leading seismic research centers.

The EHM program campaigns along three specific fronts—design, siting, and policy research. Dr. Mike Gaus (tel. 202/632-5700) has been there from the creation of NSF's earthquake program. Instrumental in its development during the '60s and its introduction into RANN, he is now senior scientist on the program, advising the three specific area directors. Gaus is particularly knowledgeable about aspects of earthquake hazards shared with such other natural hazards as floods, hurricanes, tornadoes, and landslides. He also has a firm grasp of the many special and technical facets of earthquake hazard mitigation. Among the special projects Gaus manages are studies of the problems high winds pose for exposed structures, and the special difficulties of incorporating hazard-mitigating design features into tall buildings.

Design

Managing EHM's efforts on the design front are Dr. John Scalzi (tel. 202/632-0648), a structural engineer, and Dr. Fred Krimgold (tel. 202/632-5700), an architect. Scalzi divides his projects into testing and analytical components. He smiles when he mentions the most dramatic example of his testing work—the subjection of a high-rise building in St. Louis's ill-fated Pruitt-Igoe public housing project to earthquake-simulating shocks. Perhaps it is some consolation to its designers that the uninhabited high-rise held up very well. A 400-s.f. shake-table supported by NSF and run by the University of California at Berkeley tests models and other building components by using giant hydraulic jacks salvaged from abandoned missile silos to transmit computer-simulated, quake-like shocks. Other important design-related work includes exploring the effects of aftershocks on already weakened structures, and the effects of both vertical and horizontal seismic forces.

Dr. Krimgold's relatively recent arrival at EHM signals NSF's growing interest in the architectural aspects of earthquake resistant design. He hopes to see a general rise in the level of interest architects and planners show in EHM's design program. He hopes, too, that their input into the EHM program will rise.

Among the published results of EHM's design research effort are *Architects and Earthquakes*, proceedings of a 1977 *Summer Seismic Institute for Architectural Faculty, Seismic Design for Police and Fire Stations* (these three by the AIA Research Corporation), *Earthquakes and Planners* (an American Institute of Planners project), *Building Configuration and Seismic Design* (by Building Systems Development Inc. of San Francisco), *Basis for Seismic Resistant Design of Mechanical and Electrical Service Systems* (by T. R. Simonson Inc. and Engineering Decision Analysis Co. of San Francisco), and *The Interaction of Building Components During Earthquakes* (by MBT Inc. and Engineering Decision Analysis Co.).

Siting

Dr. Chi Liu (tel. 202/632-0648) heads a trio of highly-organized siting programs. One features the development of analytical models for the dynamic forces affecting any structure, regardless of type. This includes characterizing the dynamic loads imposed by earthquakes, winds, tsunamis, and other disastrous phenomena. Soil liquefaction—virtual melting of the soil under the repeated jarring of an earthquake—poses its own unique problems for building foundations. Liu notes that quake-related soil-subsidence also needs further research. Published data here include proceedings of a 1977 Austin, Texas workshop on geotechnical engineering, which will be available soon. The third part of the siting program concentrates on the security of utility and other network systems. Power, water, and communications lines can become life-lines in times of disaster—or they can themselves become sources of hazard and contamination.

Liu stresses that "we still do not have the capability of predicting the kind of ground motion" California or New Hampshire can expect. "We need to work on analytical models, soil-testing techniques, dams, and off-shore structures," he says. Working with Liu on the siting research is Dr. William Hakala (tel. 202/632-0648), a recent EHM arrival who came from RANN's Advanced Productivity and Technology Directorate. Hakala is an expert in excavation technology.

Policy

Thiel emphasizes that the policy research program is the "bottom line" of EHM's efforts: What good, after all, is the accumulation of design information, criteria, and analytical models if architects, engineers, and city fathers design quake-vulnerable buildings with failure-prone walls on ill-suited soils.

Sociologist Dr. William A. Anderson (tel. 202/632-7396), head of EHM's policy component, directs several interesting studies. In one, University of Denver sociologists are studying the reactions of community organizations and ordinary citizens to disasters, hoping to identify their most difficult problems in coping with a quake. Another problem looming on the horizon as earthquake prediction comes close to becoming reality is our reaction to warnings. What would you do if an earthquake were predicted for your area 24 hours or 24 days in advance, with the accuracy, say, of today's TV weather forecasts? The soil under Palmdale, Calif. is slowing rising, often a precursor of a quake. UCLA is checking on Palmdale's anxiety quotient—changes in insurance rates and property values, reaction from local officials and "earthquake watchers." In Santa Barbara, studies are progressing on land-use planning codes favorable and unfavorable to the promotion of seismic safety. Another group at the University of Delaware is assessing popular knowledge of natural hazards and its impact on civil preparedness.

In contrast to the mission-oriented federal agencies, NSF was created specifically to lend an attentive ear to unsolicited proposals from the scientific community. This attitude seems to have carried over into ASRA and EHM. Approximately 20-25 per

Drawing by D. Fradon; © 1958 The New Yorker Magazine Inc.

cent of EHM's $18 million budget is expected to be laid out for architectural and planning work; but this proportion depends partly on the interest and initiative architects and planners themselves exhibit. The Problem-Focused Research Applications Directorate will be publishing Requests for Proposals (RFPs) for earthquake resistant design projects this spring, but preproposals and unsolicited proposals are also welcome. Contact Krimgold for guidelines on writing proposals and preproposals, as well as for general EHM design information.

The earthquake program at NSF is healthy and is expected to grow over the next several years. But future prospects for architectural work in the EHM area may be even brighter than at present. Sen. Alan Cranston (D-Calif.) was one of the backers of Public Law 95-124, the Earthquake Hazards Reduction Act of 1977, signed into law by President Carter last year. It directed that an EHM implementation plan, the so-called Steinbrugge Report to the President, be prepared. That report is now in draft and is likely to recommend that substantial efforts be made to use NSF's seismic research results in a more directly practical way—good news for architects. NSF seems strategically placed among the galaxy of federal agencies to carry out this implementation phase, especially if it secures the explicit Congressional direction it has received in its past earthquake efforts.

One of only a few in the U.S., Stanford's shake-table delivers both vertical and horizontal shocks to structural models, simulating earthquake stresses.

In the Wings: Environmental Design

On Dec. 1, 1976, architect Henry J. Lagorio, then an NSF program manager, submitted a report to NSF entitled *Environmental Design Research: NSF Program Options,* which he authored with the assistance of consultants Dr. D. Michael Murtha and Dr. Irme R. Kohn. The report has become an important document as NSF has leaned more and more toward funding research on environmental design. ASRA head Dr. Jack Sanderson has said that environmental design is under "very active consideration" as one of ASRA's problem-focused research efforts. It is in competition with such other research options as urban technology, urban engineering, appropriate technology research, and research and technology for the handicapped (these topics, too, will soon be represented at NSF by their own option papers). But Sanderson has indicated that "civil and mechanical engineers have expressed interest in addressing the same [environmental design] problems" already. Whether or not environmental design research is chosen to become one of ASRA's five or six problem-focused research areas, he says, it seems certain that at least parts of it will be funded, very likely in ASRA's Division of Applied Research. Architects could profitably contact EHM's Krimgold about the environmental design options likely to be implemented by NSF.

The report on environmental design research options done by Lagorio (who now serves as an AIA/RC director) was originally prodded into existence by a specific amendment to NSF's FY 76 appropriations legislation—evidence that the field has at least some Congressional interest. The report entertains a very broad notion of environmental design, with eight chapters describing proposed "Program Elements." Among them are physical and psychological elements, environmental use patterns, urban design considerations, and design information and methods. Lagorio's report envisions a far-reaching cross-disciplinary effort in ASRA's new Problem-Focused Research Applications Directorate.

NSF is known for pursuing the charmed quark and other exotic species; now, with support for Lagorio's concept evident, NSF seems ready to tackle another family of problems—the quality of life.

Grantsmanship

When people think of research and development, they think most often of massive federal R&D programs. And with good reason; the mammoth space and defense programs of past decades and the giant energy programs currently underway have served to reinforce the association of big research with big government.

Some researchers, however—especially those concerned with the built environment—are looking less intently toward Washington than they used to for R&D support. Instead, they are looking toward state and local governments for work in architectural research and planning.

One key reason for the switch: Federal revenue-sharing with state and local governments, a policy started in the Nixon Administration and continued under President Ford. President Carter, too, has endorsed the concept as much for the sake of re-establishing local autonomy as for the sake of efficiency in governmental decision-making. He has indicated to Congress his intent "to build a more effective partnership between the federal government, state and local governments [and] the private sector."

Another reason for the increasing presence of aspiring researchers in state capitol offices is the enormity of the federal budget deficit. President Carter's half-trillion-dollar budget proposal to Congress for Fiscal Year 1979 projects a deficit of $60.6 billion. Washington observers, however, noting that this is an election year, forecast tax cuts larger than those proposed by Mr. Carter, a move that would drive the deficit to even higher levels. Yet this shortage of funds on the federal level, reflected in the relatively slight (11 per cent over FY 1978) budget increase for federal research and development in FY 79, isn't shared on the state level. Grants to state and local authorities from the federal government, in the form of revenue-sharing, will stay roughly the same in FY 79 as in FY 78—17 per cent of the total federal budget. This means that state treasuries are now and will generally remain in much better shape than that of the federal government. Some states and municipalities are actually reporting substantial surpluses and planning tax cuts. California, with a $2.9 billion surplus, leads a list including New York, Michigan, Illinois, Florida, Massachusetts, Georgia, and Maryland. Texas, too, will dissipate some of its surplus revenues by increasing spending 25 per cent over last year.

In his State of the Union message to Congress, a more detailed version of the televised State of the Union address, Mr. Carter singled out the need to "improve urban physical environments and strengthen urban

communities." In practical terms, this broad goal means federal funding of local projects in line with the recent trend to move funds to communities and municipalities. Architects looking for research work should be warned that in most cases, federal funds are allocated to states, local development councils, or municipalities rather than directly to local contractors. The potential contractor, therefore, must learn to work both the federal and local sides of the street.

The single largest example of this trickle-down movement of federal funds is the $3.5 billion Community Development Block Grants Program. These grants are administered by the Department of Housing and Urban Development under the 1977 Housing and Community Development Act. The recipients are, as usual, urban public agencies; but changes in the 1977 bill seek to make funded renovation efforts more effective by permitting these agencies to contract with private profit-making groups for the acquisition and renovation of private properties.

Title I of the 1977 Act provides authorization for community development block grants for FY 78 of $3.5 billion, for FY 79 of $3.5 billion, and $3.8 billion for FY 1980. The funds are allocated on a complex formula which ranks age-of-housing, per-capita income, and total population; the anticipated net result is that the greatest proportion of funds will

flow to the cities of the Midwest.

Compared with previous bills of the same kind, this law heavily emphasizes age-of-housing as a factor in determining eligibility. It also emphasizes retention and attraction of higher-income residents as a redevelopment strategy. This tactic is expected to increase an area's tax base and stabilize property values. The bill's provisions are designed to allow more flexibility and executive discretion for HUD in its treatment of smaller communities. The minimum population for block grant eligibility, however, remains at 50,000.

Another example of federal aid to state and local authorities is HUD's $75 million Comprehensive Planning Assistance program (more details in the Prospects section of this issue) which is administered through HUD's regional offices after extensive negotiations with local authorities. Mr. Carter singled the program out for explicit mention in his message to Congress.

The Federal Aviation Administration's Planning Grants are a more typical example of the helping hand Washington lends to local administrations. FAA's Planning Grants Branch contracts with public agencies through its Airport Terminal Development Program for terminal expansions, renovations, and improvements on the 3200 airports in the National Airport System Plan. Impetus for the program has come largely from a significant increase in corporate flying and reductions in scheduled airline service to some regional airports since the 1974 oil embargo.

FAA guidelines for the program require that an airport terminal assessment report be written before the FAA considers the grant application. Written at the reimbursable expense of the local government, the reports may be executed by design firms.

To help local governments and firms formulate these airport needs reports, Arnold Thompson Associates Inc. has been awarded a $74,135 FAA contract to prepare an advisory circular (available at midyear) suggesting criteria for spaces in airport terminals. Local planners, architectural firms, and airport operators might profit by obtaining a copy of the circular and other related information from Lowell H. Johnson, chief of the Planning Grants Branch, FAA, Washington, D.C. 20591, tel. 202/426-8434. Acting Assistant Administrator for Airport Programs William V. Vitale, at the same address, may also be of help.

A last example of how federal funds find their way through state and local agencies to support work carried out by private firms: The Colorado State Office of Energy Conservation, using federal funds allocated by the Energy Conservation Act of 1976, contracted last year with Interplan, a subsidiary of the Denver design firm RNL Inc., to develop and manage an Energy Conservation/Alternatives Center. The Center, a clearinghouse for information and demonstration of energy conservation techniques, is geared to the needs of commerce and industry. Interplan estimates that use of the Center's resources by some of the state's biggest energy consumers should result in a minimum energy saving of 30 trillion btu's by 1980—3 per cent of Colorado's total projected energy consumption. The three-and-a-half-year contract totals nearly $500,000. Interplan partner John B. Rogers landed the contract just a year after attending an August, 1976, AIA/RC-sponsored Grantsmanship Workshop; he considers himself a "successful student."

Prospects

President Carter's landmark budget for Fiscal Year 1979, the half-trillion-dollar proposal sent to Congress with his State of the Union message last January, smiles slightly on the nation's research and development community. If the budget's R&D portions pass relatively unscathed through Congress, as it appears they will, then architects interested in research may be able to hope for somewhat better prospects in the coming year.

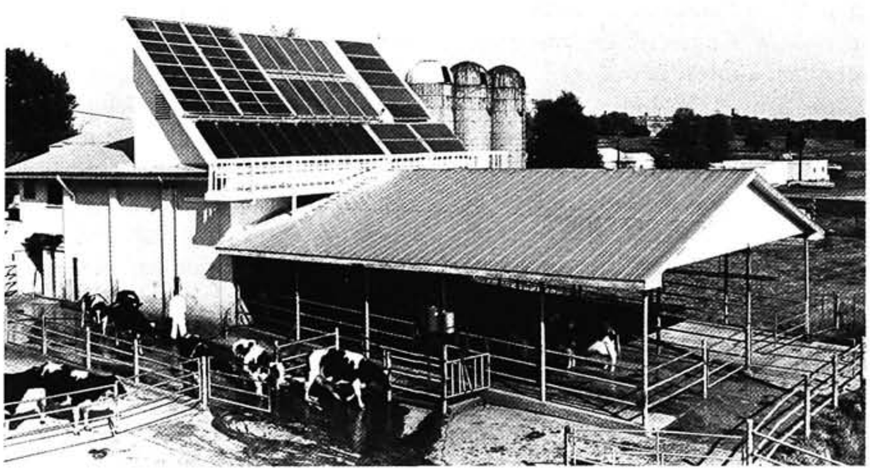
The increase for basic research in Mr. Carter's FY 79 budget is 11 per cent over FY 78—about 7 per cent after accounting for inflation. Hardly dramatic, it's nonetheless in line with the Ford Administration's reversal of the Nixon R&D drought. Presidential science advisor Dr. Frank Press is described, appropriately enough, as being "sympathetic to the needs of the science community," and the President has himself publicly indicated his concern for the state of the nation's research and our capital investment in R&D. Such support should bolster the chances of success for budget funding earmarked for federal research.

While most of the FY 79 growth is expected to be in the basic science sector, where architects have barely a toehold, more funds will be channeled into other research areas as well. Designers should look for a reported 30 per cent increase in climate research, where interest has been spurred by the memory of two devastating winters and the tentative prognostication of possible changes in global climate. Research here may presage long term prospects for architects who can make their designs more climate-specific. Look for climate research funding to be apportioned among NSF, NASA, DOE, and the National Oceanic and Atmospheric Administration (NOAA).

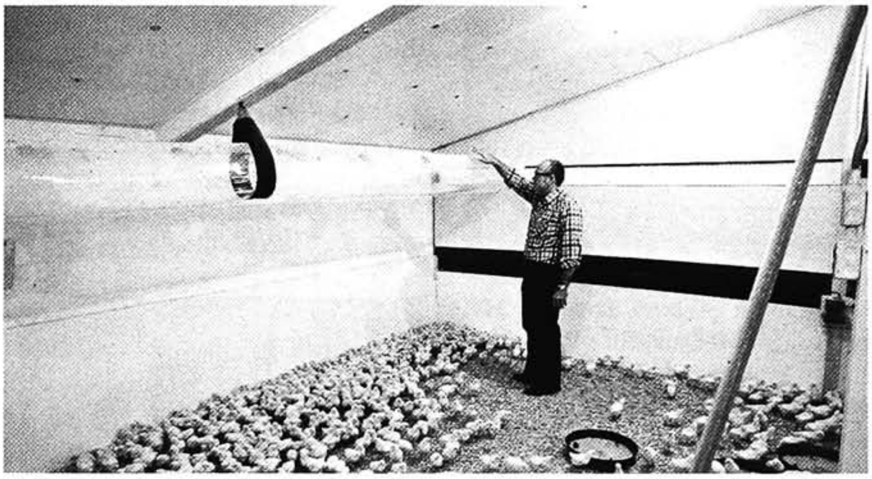
In the overall research picture for FY 79, the National Institutes of Health (NIH) and the Defense Department are expected to see growth of 10 and 13 per cent in their respective research efforts, while NSF, the usual standard bearer in basic research, will share—but not disproportionately—in the increase.

Department of Agriculture

While the Carter strategy seems to emphasize basic research over demonstration projects, Congress maintains a strong interest in solar demonstration work. So it should be interesting to watch the fate of numerous solar demonstration projects being conducted at the Department of Agriculture. USDA's **Agricultural Research Service,** with its own laboratory facilities at Clemson University and contracts spread throughout the country, is currently completing work on several design-oriented projects, including an 1,000-s.f. solar-heated house (USDA Plan #7220) capable of satisfying up to 75 per cent of its own heating needs. The house uses a passive collector attic and a ducted crushed-rock heat storage system. USDA also envisions a bovine application of solar principles: Milking parlors on dairy farms, requiring large amounts of hot water and relatively minimal space heating, could adapt well to solar systems. Solar crop-drying, tobacco-curing, and greenhouse heating are also being studied.



At left, cows head for the Beltsville, Md. milking parlor where USDA researchers are testing four collector types for solar space and water heating. Below, research assistant Bobby J. Bates checks the solar air duct in the poultry house at USDA's South Central Poultry Research Laboratory in Mississippi.



Another potentially active field is rural housing research. According to both HUD and USDA sources, funds have been appropriated for such research since 1974, but haven't been disbursed yet. This year, however, the official summary of the Housing and Community Development Act of 1977 specifically states that "the Secretary of Agriculture is directed to establish a research authority within the **Farmers Home Administration** to undertake, or to contract with any public or private body to undertake research authorized by existing law. Previously, the Secretary was only authorized to contract with public or private bodies if needed research could not be feasibly performed through USDA personnel or by land-grant colleges." If USDA Secretary Robert Bergland acts on his directions from Congress, architects could find new research opportunities at FHA before the end of the year.

Out of USDA's total FY 78 research and development budget authority of $87.4 million, $43 million is allocated to the Agricultural Research Service. For FY 79, the Carter Administration is asking that the Research Service's basic research grant funding authority be doubled. Whether Congress accepts the White House proposal, and whether the additional funding and Congressional demands for rural housing research will actually stimulate substantial research contracting both remain to be seen. Still, it's certain that stimulation from the architectural community can't help but quicken USDA interest in rural housing research and other design-oriented activities. Suggested contact: Gordon Cavanaugh, director of the Farmers Home Administration, USDA, 14th and Independence Ave., N.W., Washington, D.C. 20250, tel. 202/447-7967. It might also be helpful to contact Dr. Ronald Bird, deputy director for community resources in USDA's Economic Development Division, tel. 202/447-8781.

Department of Housing and Urban Development

Funding to assist in comprehensive planning—including definition of needs and long term goals for land use, housing, and community facilities—is available under HUD's **Comprehensive Planning Assistance Program,** part of the Housing Act of 1954 and updated last year. In FY 78, the program budget reached $75 million. The funds are made available as negotiated grants ranging from $1,000 to several million dollars. States, metropolitan clearing-houses, other metropolitan areawide planning organizations, and smaller local governments (including tribal councils) are eligible. There are two types of grant recipients—direct and indirect. Direct recipients include state government and metropolitan authorities, tribal councils, and Eskimo villages. Indirect grants go to metropolitan public groups via state agencies. Basic eligibility requirements for each recipient category are spelled out under Section 610-D of the Housing and Community Development Act of 1974.

Negotiations for total grant money in each HUD region occur between December and May; application deadlines are usually at the end of May. The notice of award is sent out by the end of July. Agencies not yet having established programs with HUD are advised to plan projects well in advance.

The administering office is that of the Assistant Secretary for Community Planning and Development, HUD, Washington, D.C. 20410, tel. 202/755-6270. James Selvaggio, director of the Office of Community Development and Program Coordination (tel. 202/755-6240) might also be profitably contacted.

Because these grants go to public agencies, architects and planners may do better to contact local planning agencies first, to ascertain areas of interest and contracting and subcontracting possibilities. Each grant is administered locally by the HUD regional office—a good source for more specific information.

Information from HUD's Washington offices can also be obtained about the new **Urban Development Action Grants** (UDAG) established in 1977. UDAG's objective is the reversal of physical and economic disintegration in stagnating or deteriorating low- and moderate-income neighborhoods. The grants are made directly to cities or metropolitan authorities. Research opportunities here are available insofar as eligible proposals include activities in community and neighborhood development, conservation and reclamation, and renewal of underutilized real property. At least 25 percent of the grants must go to cities having populations under 50,000. One of the explicit selection criteria for proposals is "the extent to which the program describes activities representing a special or unique opportunity to meet local priority needs and block grant objectives." $400 million per year for FYs 77-79 is authorized for the UDAG program.

A program billed as "an urban Fulbright" is being offered by HUD's **Office of Policy Development and Research,** including grants and contracts for a wide range of urban research areas. These are usually awarded through competition to an audience which is primarily academic. An exploratory letter describing the area of research you are interested in will be welcome, though, and is probably a good idea before committing substantial intellectual or monetary resources to a potential project. The exploratory letter is preferable to an unsolicited research proposal.

Among the major program areas HUD is interested in analyzing are ways to reduce the component cost of housing, including legal research in building and zoning codes; building and financing methods; energy conservation and environmental reviews; alternative housing finance methods; urban economic revitalization via private-sector investments involving small businesses; coordinating local and federal government housing resources; the best strategies for serving the housing needs of the elderly and handicapped (including access to housing and the pattern of their consumption of housing-related services); neighborhood reinvestment and revitalization, and "imaginative and amenable design to achieve lower-density housing and to integrate housing into the neighborhood environment." The last mentioned includes evaluation of neighborhood standards for HUD-assisted programs.

In conjunction with this program, HUD is gearing up a **visiting scholar program** in which year-long professional visits to HUD are envisioned, as well as year-long internships at the department for graduate students. Universities may ask to receive a list of area HUD contractors who will be seeking graduate students to work for a year in fulfilling a HUD research contract.

For more information (or to submit an exploratory letter) write to Donna E. Shalala, Assistant Secretary for Policy Development, HUD, Rm. 8100, 451 Seventh Street, S.W., Washington, D.C. 20410, tel. 202/755-5600. Deputy Assistant Secretary for Research and Demonstration Raymond J. Struyk, Rm. 8132, tel. 202/755-5561, may also be able to help.

The National Institutes of Health

The needs of aging, retired, and elderly people continue to be concerns for federal research. NIH's **National Institute on Aging** has announced Special Emphasis Research Awards in this area. While aimed primarily at the aetiology (causes) of aging, the research supported covers a broad range of interests, including social and behavioral phenomena; the psychological problems of retirement, widowhood, and isolation; the effect of family patterns on the aged, and the consequences for the elderly of government policies on housing, transportation, etc. It should not be assumed that the elderly alone are the subjects of NIA research; on the contrary, the Institute "has special interest in the middle years of life, the transition from young adulthood to old age"—certainly a broad mandate.

Research proposals must be well-defined and have specific problems as their objects. A proposal must appeal to the scientific instincts of NIH, so the submitting architect must distinguish between the analytical and synthetic aspects of a project, define carefully its research component and the specific object of his research, and collaborate, perhaps with experts in the medical, psychological, social, and behavioral fields. Maximum grant funding is $30,000 per year for a maximum of three years; the annual salary of the principle investigator may not exceed $18,000.

Further information and application forms are available from the associate director for Extramural and Collaborative Research Programs, National Institute on Aging, NIH, Bethesda, Md. 20014. The director of Aging Programs at that address is Dr. Lester Smith, tel. 301/496-5534. It might also be useful to contact Geraldine Leser, Division of Research Grants, tel. 301/496-7324. When your proposal is mature and you need help with budget allocation and grants management procedure, call Barbara Wilson, tel. 301/496-1472.

Department of Health, Education and Welfare

The Department of Health, Education, and Welfare's separate **Administration on Aging** also has programs of architectural and design research interest. Model Project Aging grants are available again this year, and among the areas of research for which proposals will be entertained are housing and living arrangements and ambulatory day care center design. New 1978 guidelines and priorities should be ready and available now from Dr. Marvin Taves. His address is AHDS/AOA/ORDMR, RAD, Model Projects, Rm. 4273, HEW-North, 330 Independence Avenue, S.W., Washington, D.C. 20201, tel. 202/245-2143.

National Center for Appropriate Technology

"Small is Beautiful" seems to be the motto of NCAT, the private National Center for Appropriate Technology, headquartered in Butte, Montana. Small technology may not only be beautiful—sometimes it is the only

The Mission Inn in Riverside, Calif., acquired with the help of a $2,500 Consultant Services Grant from the National Trust.

technology available or affordable for rural communities and low-income urban areas. Funded by the **Community Services Administration,** the successor to the old War-on-Poverty-era Office of Economic Opportunity, NCAT is extensively involved in solar heating technology applications, low-cost housing, mobile home energy and weatherization improvements, housing rehability, and other related activites. According to Executive Coordinator James F. Schmidt, this past year NCAT established that the "demand" for its appropriate technology approach is "out there" with numerous small grants and demonstration projects. This year, Schmidt says, NCAT hopes for a total budget in excess of $1 million, with the bulk to be expended on large scale projects in the $100,000 range (although this is not yet firm). Some smaller grants will also be available for demonstration projects. As of this writing NCAT's budget is still being worked out with CSA.

Appropriate technologies are those which can be put to work by local talent using nearby natural resources, without employing the tremendous capital investments our high-technology society takes for granted. Grants focus on self-help demonstration and economic self-reliance projects. Unsolicited grant applications with this orientation are welcomed. This year, most large grants will be selected from submissions to NCAT's regional offices and organizations, which are sent to Butte for final review. Project proposals may be submitted at any time. One area of specific interest is community and shelter design and improvement, which includes owner-built housing, building with locally produced materials, community centers, grey-water treatment, integration of greenhouses in shelter design, and a string of energy-related design projects. NCAT also acts as a clearinghouse for appropriate technology information; it is in the process of establishing its own "deep retrieval" information system.

If you're interested in learning just how beautiful small can be, write or call Schmidt at NCAT, P.O. Box 3838, Butte, Montana 59801, tel. 406/723-6533/5474. Addresses for 10 regional newsletters are also available from NCAT. Beth Sachs handles requests for information; Bob Corbett and Blair Hamilton review architectural designs.

National Trust for Historic Preservation

The National Trust is continuing its **Consultant Services Grant Program** this year. The object of the program is to help preservation groups hire professionals to aid them in on-going preservation or restoration projects, or to help them to develop such projects. In the past eight years, the Trust has helped 307 organizations. Grants average around $1,000 and do not exceed $5,000. Among the assisted projects have been the Woodward East Preservation Project in Detroit and the redevelopment in Pittsburgh of the Pittsburgh & Lake Erie Railroad Terminal. Each grant must be matched by an equal or greater amount from another organization or the recipient's own funds. A repeat after the second year is not allowed.

Additional information and application forms can be obtained from Suzanne B. Sherwood, financial aid assistant in the Advisory Services Division, National Trust for Historic Preservation, 740-748 Jackson Place, N.W., Washington, D.C. 20006, tel. 202/638-5200.

Department of Justice

Unsolicited research proposals are welcomed by the **National Institute of Corrections,** an agency of the Department of Justice. NIC had an FY 78 budget of $4 million for research and technical assistance programs. NIC's status inside Justice has since been upgraded from a merely advisory role to an active one in independent research, so the dollar amount available for research is expected to increase significantly. Among NIC activity areas of potential interest to architects are its field services and jails programs, general research, and special projects. Telephone calls and exploratory letters are welcomed. Grants made on the basis of unsolicited proposals come from the "special requests" area (FY 77: $150,000). Since the direction of NIC will become clearer this year, you may want to contact Director Sherman Day for updated information at NIC, U.S. Department of Justice, 329 First Street, N.W., Washington, D.C. 20543, tel. 202/724-3106.

A great many practicing professionals have been part of the seismic research this issue of *Research & Design* discusses, and their contributions should be noted. Though a complete list would be too lengthy for inclusion here, participants have included Christopher Arnold; Robert J. Barnecutt; Elmer E. Botsai, FAIA; Stanley W. Crawley; Henry J. Degenkolb; Robert N. Eddy, AIA; John L. Fisher, AIA; Alfred Goldberg; Henry J. Lagorio, AIA; George G. Mader, AIP; Arthur E. Mann, AIA; Gerald M. McCue, FAIA; Daniel Shapiro; Karl V. Steinbrugge; John C. Worsley, FAIA, and Thomas D. Wosser. A number of design firms and other organizations have made significant contributions as well, including Boyd A. Blackner Architect and Associates of Salt Lake City; Building Systems Development International of San Francisco; Fischer-Stein Associates of Carbondale, Ill.; Gruzen & Partners of New York City; Public Technology Inc. of Washington, D.C.; Koehler-Woodfin Partnership of Muncie, Ind.; Rockrise Odermatt Mountjoy Associates of San Francisco, and Marion J. Varner and Associates of Pasadena, Calif.

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