OES CALIFORNIA
Governor's Office of Emergency Services

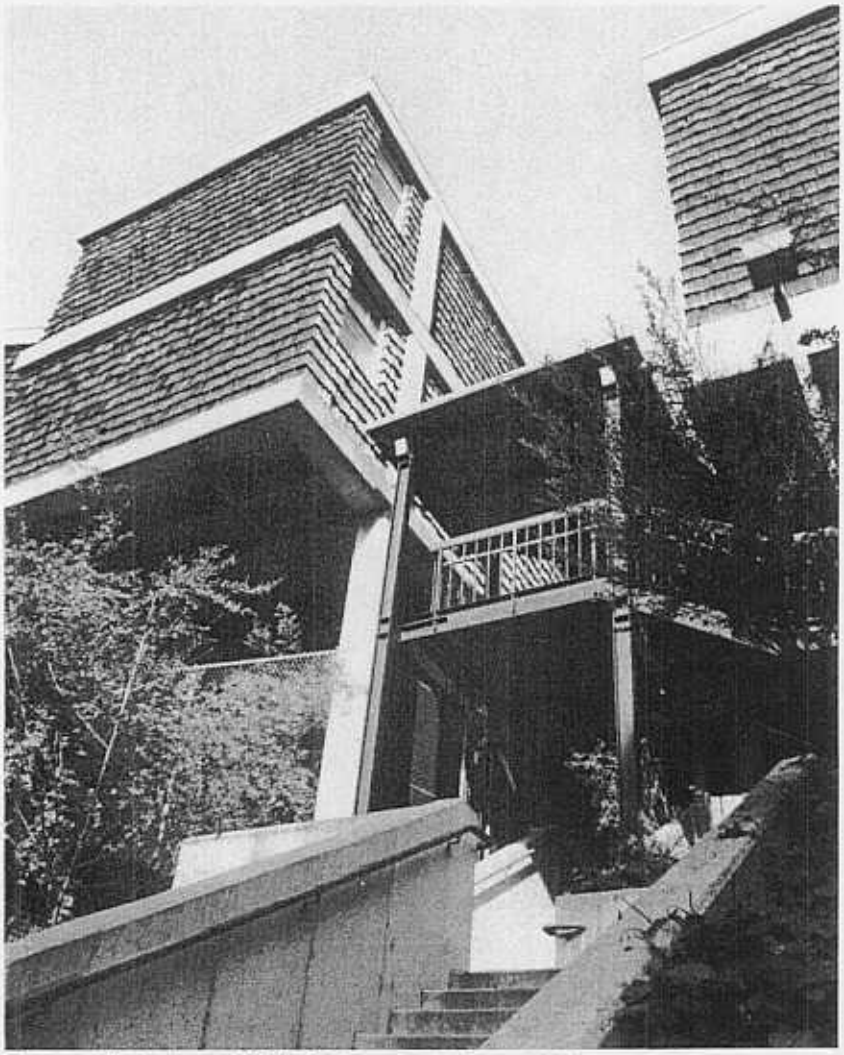
*Earthquake Program*

HAZARD MITIGATION
Case Study

# UNACCEPTABLE RISK:

## EARTHQUAKE HAZARD MITIGATION IN ONE CALIFORNIA SCHOOL DISTRICT

School earthquake preparedness and hazard mitigation are frequently eclipsed by pressing daily problems in California schools. Most school administrators and teachers have numerous other issues on their "TO DO" lists. Many also hold the popular but incorrect idea that Field Act schools are safe by definition; some hope and believe that a quake won't happen on their watches. When an administrator *does* want to work on preparedness or mitigation, he or she must do so with resources and time that can usually be spent on what others see as bigger problems. One challenge is to develop and adopt preparedness and hazard mitigation plans, but additional challenges arise as they are implemented at individual schools within a district.



*Cragmont School was built in 1967 near the Hayward fault.*

Many school officials and parents think that preparedness consists of having some water bottles and granola bars stored at school sites. Similarly, they point to some book cases and file cabinets bolted to walls as evidence of a hazard mitigation program. Few understand that a comprehensive earthquake preparedness and mitigation program involves *everyone* in the school district, takes a long time to put in place, requires investments of time and energy, and raises socioeconomic and

political issues that provoke community-wide discussion.

That hazard mitigation gets done within a context much larger than the schools themselves has been demonstrated in the Berkeley, California, school district in recent years. Developments in the Berkeley Unified School District (BUSD) after the 1989 Loma Prieta earthquake were fairly typical of the steps involved in earthquake preparedness planning and hazard mitigation in any school. However, it is significant that in Berkeley all the typical obstacles have been overcome. Berkeley's preparedness and mitigation plans were adopted and implemented for a number of reasons: concerned and informed people, natural events, resource organizations, technical reports, state mandates, available money, circumstances, and committed personalities (not necessarily in that order). Those influences, in different mixes and combinations, are present in all school districts; this study highlights how they worked together in the Berkeley district.

"Who Would Have Thought All This Stuff Would Get Stirred Up?"

-Arrietta Chakos

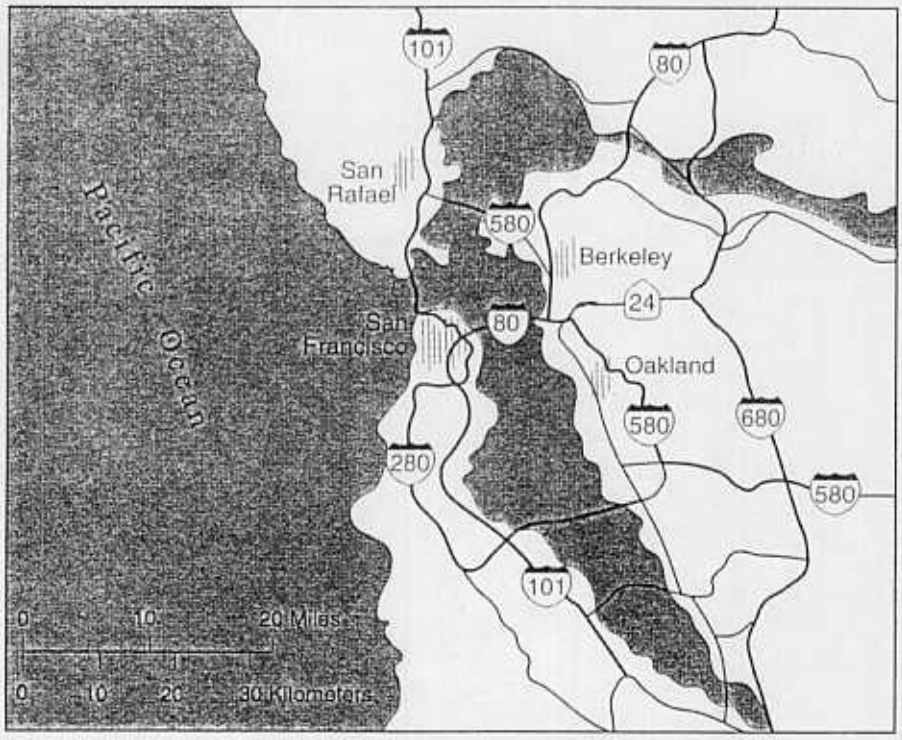
## In the Beginning was the Earthquake

The October 18, 1989 earthquake caused little damage in Berkeley, but it did alert a number of parents to how poorly prepared the school district was for a major quake. In late October, a couple of inquisitive PTA mothers queried the principal of their children's school about its earthquake preparedness plans and emergency supplies. Dissatisfied with the situation at that school, they took their concerns to the district. In talks with a high-ranking district administrator they determined that the district's emergency plans were out-of-date, teachers and staff weren't trained in disaster response, alternate communications equipment was scarce and outmoded, and few first aid, water, or food supplies were stored in any facility.

The mothers took this information back to their PTA group and, in November, the individual PTA involved the larger PTA Council in intense lobbying of the school board. During December and January, the PTA Council members gathered information on the earthquake hazard and the risk from various Bay Area seismic safety information sources: the Governor's Office of Emergency Services Earthquake Program, the California Division of Mines and Geology, and the U.S. Geological Survey, to name a few. A wealth of the collected information was presented to the school board every time it met in those months.

Among the salient points consistently mentioned were 1) the high probability of a damaging earthquake on the Hayward fault, 2) the location of a few of Berkeley's 17 schools on or near that fault, and 3) the potential for strong ground shaking all over Berkeley during an earthquake centered on that fault. The PTA Council also reminded board members of the Katz Bill, the California law requiring that schools plan for earthquakes and mitigate their nonstructural hazards (see the box on page 4).

Finally, in part because the geologic observations and risk information were persuasive, and in part because of the PTA lobbying efforts, the school board decided in February of 1990 to spend $193,000 for comprehensive earthquake planning and preparedness. The monies came from the district's Reserve for Economic Uncertainties, an emergency fund required by the state of all school districts.




The San Francisco Bay Area and Berkeley's location in it.




*Maps: California Division of Mines and Geology*

**The Katz Bill**

Adopted in 1984, the Katz Bill (California ***Education Code*** Sections 35295, 35296, 35297) requires that public and private elementary and high schools with an enrollment of more than 50 students establish an "earthquake emergency system." Specifically, schools are enjoined to plan and prepare for earthquakes, conduct periodic duck and cover drills, train staff and students for earthquake safety and response, and mitigate hazards in school buildings. However, since monies have never been appropriated by the State Legislature either to support school compliance or to penalize noncompliance, the law can be characterized as small carrot and ephemeral stick. A very few school districts in the state are in full compliance; many have attended selectively to the law's requirements; and some are only dimly aware that there is such a law. A school district's compliance with the law will become an issue only when there is a damaging earthquake during school time, some children are injured or killed in school facilities, and liability suits are brought by grieving parents. Failure to have taken steps to follow the "standard of care" set forth in the Katz Bill will most likely constitute district negligence in such cases.

Following both the specifications of the Katz Bill and the recommendations in the 1989 ***Report of the Earthquake Preparedness Task Force***, by the California State Department of Education, BUSD undertook the following tasks:

✦ Developing a comprehensive, district-wide disaster preparedness plan and site-specific plans for all 17 schools and all departments.

✦ Providing training for all staff in the elements of the plans, as well as an instruction program in first aid and CPR staffed by district personnel.

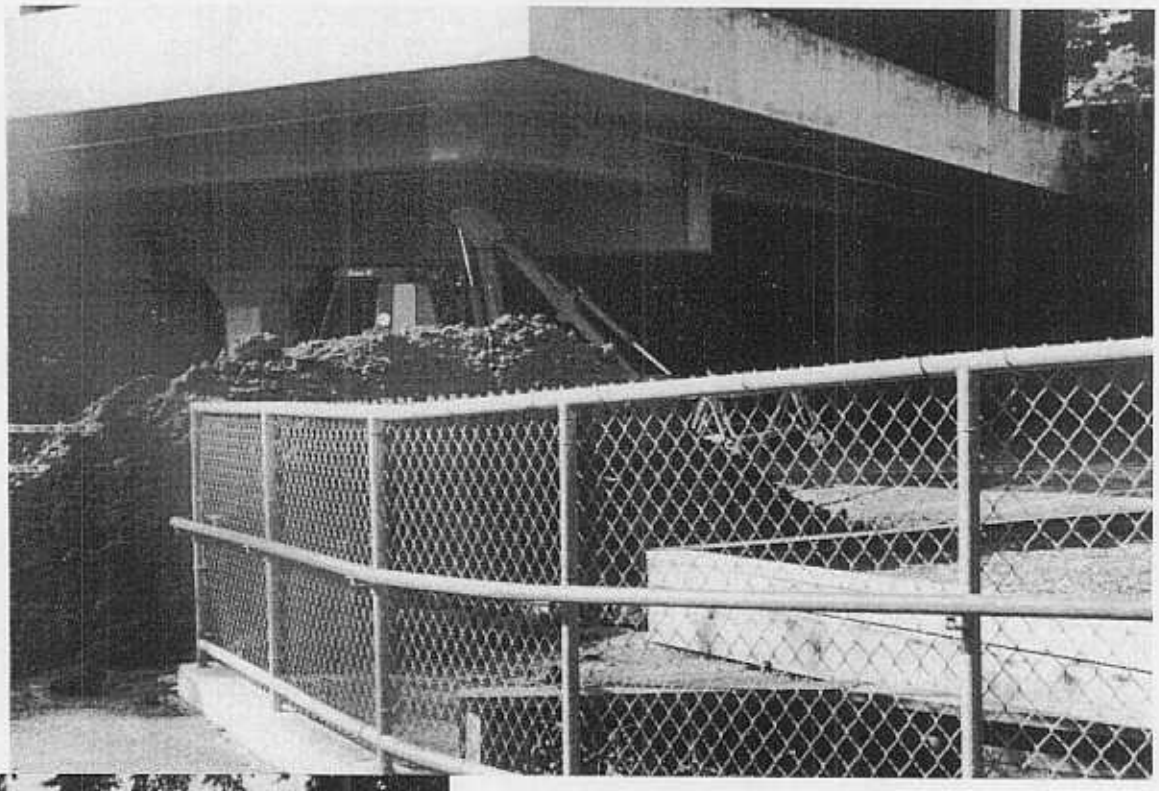
✦ Acquiring and stockpiling emergency and medical supplies for all district schools, back-up communications equipment using a variety of power sources, and two day's worth of food and water at each school.

✦ Completion of structural and nonstructural hazards assessments at each school.

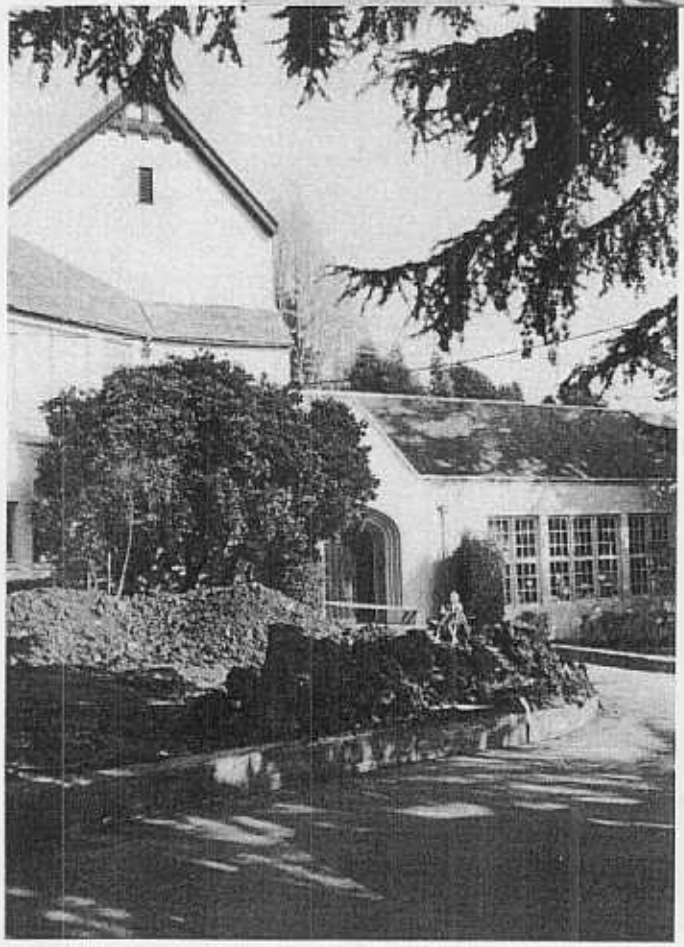
## The Step from Zero to One

Work began immediately and continued throughout the spring and summer to develop a plan, survey schools for nonstructural hazards, purchase and store supplies, and train personnel. A well-known Bay Area earthquake engineering firm was engaged to conduct a structural safety survey of the six or seven school buildings in the district considered most potentially hazardous--either because of their proximity to the fault, their advanced age, or their structural peculiarities. The engineers used the framework provided in a recent publication of the Applied Technology Council: ***A Handbook for the Seismic Evaluation of Existing Buildings***.

The results of the engineering study were delivered to the school district on September 1, 1990, the very day a new (surprised) superintendent assumed her position. The report indicated that two of the elementary schools--Whittier/Arts Magnet and Cragmont School, both nonductile concrete frame buildings--were potential collapse hazards in a serious Hayward fault earthquake. Cragmont, built in 1967, is the youngest of Berkeley's schools and was considered the flagship of the Berkeley fleet. However, it is located so near the Hayward fault that trenching was begun in an attempt to determine exactly where the fault lies. (In mid-1993, geotechnical consultants located the fault trace on one side of the school property; it had been difficult to do so, in part, because of landslide debris at the site obscuring the fault.)



*Trenching to locate active traces of the Hayward fault at Hillside and Cragmont Schools.*



## Will the Walls Come Tumbling Down?

Many people were surprised and shocked by the engineering report, perhaps because they believed in the inherent safety of Field Act schools (see the box on p. 8). However, with the report in print, the school board was advised that it had a legal imperative to act to protect the children in the hazardous schools. The board held a series of special meetings to debate whether to close all or parts of the questionable schools until repair work could be done. They also considered the possibility of putting some of the students in portable classrooms, and the practicality of relocating others to safer schools (the district had a couple of buildings it had closed for demographic reasons that were seismically safer than some occupied ones).

The problem and the possible solutions provoked much public discussion on various topics: whether engineers can accurately assess

future building performance; the psychological effects of windowless portables on teachers and students; whether the portables were assembled with toxic materials and in violation of California's environmental quality laws; why, in general, women were more disturbed than men by the words "collapse hazard"; and which Berkeley students, from what neighborhoods, should get bused where. Parents, teachers, students, city officials, state officials, private community activists, private engineers and geologists, and local psychics all participated, and the local press covered it.

While the debate was raging, and quite coincidentally, the U.S. Geological Survey published, and disseminated in millions of Sunday newspapers, a tabloid booklet called ***The Next Big Earthquake in the Bay Area May Come Sooner Than You Think.*** The Sunday supplement, as it has come to be called, reported the new results of geological studies on Bay Area earthquake probabilities: they were even higher than previously estimated--67% chance for a damaging earthquake on a major Bay Area fault in the next 30 years. This scientific judgment was thrown into the boiling pot at the school board meetings and what followed was energetic, if inconclusive, discussion of statistical probabilities and earthquake risk assessment--what does a percent probability really mean (for example, if a 67% probability over 30 years translates into a 20% chance in ten years, is that more compelling?); is assigning probabilities science or just informed guessing; how much weight should public decision makers give to earthquake probabilities; what weight should citizens assign; and, of course, did women have a sound rationale for being more worried about the probabilities than the men were?

Further impetus to close the hazardous schools came from two additional players. The Office of the State Architect (OSA--now the *Division* of the State Architect), the California state agency responsible for the structural safety of California schools, reviewed the engineering report and concurred with its conclusions. It happened, also, that the parent of a child in one of the suspect schools was a prominent structural engineer, and not only did he agree with the findings, but he wrote a long letter to the district and met with the Assistant Superintendent. His ability to speak as both a technical specialist and a concerned parent had an immediate effect. The school board voted, with the support of the superintendent's office, to close Cragmont,

**Nonductile Concrete Construction**

Between the early 1900s and 1973, thousands of nonductile concrete frame buildings were constructed in California. This particular kind of structure was favored for high-occupancy office buildings, hospitals, and schools. However, studies of the damage patterns in the 1971 San Fernando earthquake showed building professionals that nonductile concrete structures are prone to damage in strong earthquakes. Hundreds of California schools, or parts thereof, are made of nonductile concrete, and are thought to be potentially dangerous.

To appreciate nonductile concrete's vulnerability to shaking, one must understand a bit about concrete frame structures. In them, columns and beams distributed throughout the building carry vertical loads and withstand lateral (side-to-side) forces. The frames are made of steel-reinforced concrete, a composite material composed of steel bars (rebars) placed lengthwise in concrete. The placement and the detailing of the rebars is essential to the strength of the concrete column or beam. For example, if there are not enough rebars, a column or beam can fail abruptly.

Nonductile design makes a structure too brittle to flex; a nonductile frame is not designed to withstand the repeated bending and swaying it can get in earthquakes. Such a structure tends to catastrophic collapse. On the other hand, ductile design allows a structure to flex; it dissipates energy but does not lose strength.

partially close Whittier/Arts Magnet, use portables where possible, relocate a number of students to other schools, and begin the process of finding money to pay for structural retrofit. It also decided to have the engineers evaluate all the other schools in the district.

## The Bottom Line

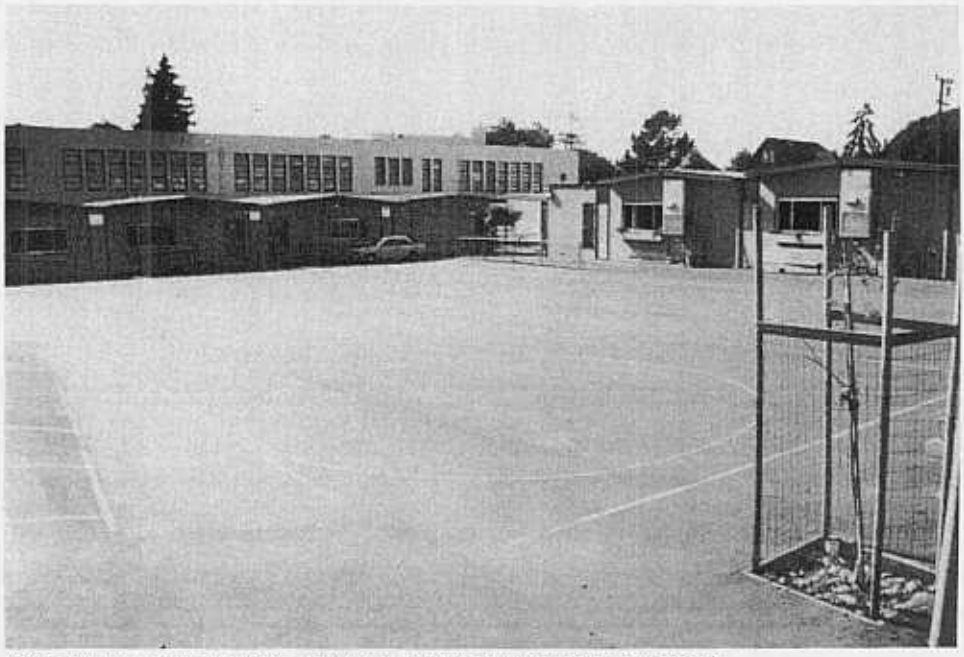
In recognition of the fact that additional school buildings could be found unsafe, and knowing full well that the district would need ambitious projects to apply for and/or raise money for what could be a multi-million dollar retrofit program, the superintendent hired the forceful leader of the PTA group to develop and monitor the district's projects. In so doing, she secured for the district a person who had an unshakeable commitment to seismic safety and, by that time, a comprehensive understanding of all the issues.

BUSD's first move to obtain financial help, in October, 1990, was an application to the State Allocation Board (SAB) for grants to "modernize" the seismically unsafe portions of the two schools already found to be hazardous. The State Allocation Board is a state agency that oversees school facilities funding in California.

The chief concerns of the SAB with respect to Berkeley's request were that funding Berkeley would set a precedent that would open the door for other urban school districts in California to expect retrofit money. Berkeley is like many urban districts in California (and the rest of the country): it consists of typically older school buildings whose safety is questionable because 1) the buildings were built before the 1971 San Fernando earthquake brought about a dramatic change in seismic building codes, and 2) they were sometimes sited in fault zones before the 1972 Alquist-Priolo Act prohibited that for schools. It was thought by those in charge at the SAB to be a most inopportune time for the State of California to be setting such a precedent since it was becoming clear that the state budget deficit was approaching $13 billion.

The school district also applied to the Federal Emergency Management Agency for hazard mitigation grants to support the Cragmont and Whittier/Arts Magnet retrofit projects. In the counties affected by the Loma Prieta earthquake, FEMA offered matching funds to jurisdictions and to public and private sector organizations proposing hazard reduction projects. Ultimately, BUSD received approval of $1.7 million in matching funds from FEMA.

Over time, and despite repeated requests, the SAB was consistently reluctant to fund the Cragmont project: on one occasion it refused approval on the grounds that the building is under 30 years old, and therefore not eligible under SAB policy guidelines for modernization. Matching funds for the Whittier/Arts Magnet school building were also not approved because usually projects are not allowed to use more than



*Portables occupy part of the playground at Whittier/Arts Magnet School.*

5% of total monies for *structural* rehabilitation. The total expenditure on modernizing a school building is not to exceed 75% of the building's total replacement value, and the potential costs for Whittier/Arts Magnet could approach that cap.

Nonetheless, the district has continued initiatives to get money from the state. In so doing, it has raised serious questions about the equity of school facilities funding in California in the recent past. Nearly all of the State Allocation Board funds to school districts go to build new schools in suburban areas, yet it is the voters in urban areas that give the school bonds their winning margins. Before 1992, $4.9 billion in state school bonds had been approved by California voters, but less than 10% of those funds were given to older urban districts. For example, prior to 1992, Alameda County received one-quarter of 1% of the total, and San Francisco County received 1%.

In response to this perceived inequity, legislators from the East Bay succeeded in adding to a pending state schools bond on the June, 1992, two propositions (152 and 155) to increase monies available to older urban districts. Proposition 152, for example, allowed for $570 million of its total $1.9 billion to be used for financing the seismic upgrade of old school structures.

**Field Act Schools**

Though public schools in California have been built to rigorous design standards since the passage of the Field Act in 1933, older school buildings are not expected to perform as well as newer ones in damaging earthquakes because they were built before our understanding of earthquake and building dynamics was as sophisticated as it now is. A school which met 1955 Field Act design and construction regulations might not meet the 1991 regulations. Additionally, in the oldest school buildings, the construction materials are aging, and **not** very gracefully. The Division of the State Architect (DSA) has two categories of buildings about which it is especially concerned: 1) Early Field Act schools--those built between 1933 and 1941; and 2) Older Field Act schools--those built between 1941 and 1976. Early Field Act schools are thought to pose a particular threat to their occupants' lives and safety for a couple of reasons: a) many are inadequately reinforced masonry buildings, and b) some are badly reinforced masonry or nonductile concrete buildings. Between 1,000 and 4,000 schools are estimated to be Early Field Act Schools. Over 50% of the 53,000 public school buildings in California are known to be more than 30 years old. Doing the math on that yields the staggering conclusion that around 25,000 California schools may be in need of retrofit or reconstruction in order to assure the safety of their occupants.

## More Bad News

In February, 1991, the school district received the structural engineering reports for the rest of its school sites--and the news was not good. The engineers had identified significant structural deficiencies in six additional buildings. Three more elementary schools were found to be potentially hazardous, two of which are non-ductile concrete frame buildings, and one is a wood frame stucco built in the 1910s. The nonductile concrete cafeteria at Berkeley High School was also ranked as a serious collapse hazard. In response to the reports, the district changed the use in the additional structures. At this writing, four BUSD schools buildings are closed, or partially closed: 1) Cragmont has kindergartners in portables on site and all other students at Franklin; 2) Whittier/Arts Magnet has students in portables on site; 3) Thousand Oaks has students in portables on site; and 4) Columbus has transferred all kids to Franklin. The Berkeley High cafeteria is closed and will be demolished. Before demolition, however, asbestos must be removed.

## A Cloud of Smoke With a Silver Lining

*Columbus School sits vacant in the autumn sunshine.*

The school district determined that it was necessary to float a local bond issue to finance a ten-year phased school reconstruction plan. The plan included both seismic retrofit for the vulnerable structures and needed modernization for all the schools in the district. The modernization would involve, by law, bringing all the schools up to speed with fire codes, other pertinent structural codes, child welfare regulations, and disabled accessibility standards. School board members and school administrators began to think strategically about the best time to put the measure on the local ballot, especially in light of the growing budget crisis and recession in California. They were further worried about their prospects for getting the necessary 67% approval to pass the measure, since similar school bond referenda had recently fallen a little short of that figure in neighboring communities.

As they were considering all the possibilities, the Oakland-Berkeley hills caught on fire in October of 1991. Though no schools were damaged, some came frightfully close to being destroyed. That the fire burned the area underlain by the Hayward fault did much to remind people that earthquakes cause fires too and to raise the hazard awareness of the citizens in the community. The fire in their own back yards reminded people, as the distant Loma Prieta earthquake had not, of how vulnerable the schools were to catastrophe. Shortly after the smoke cleared, the school board decided to put Measure A for Schools on the June, 1992 ballot. The measure proposed to raise $158 million for school reconstruction, $90 million of which would be earmarked for seismic retrofit.

The fire, and a well-organized campaign, led the voters of Berkeley to pass Measure A by 70.7%, one of the largest victory margins for *any* bond measure in the state of California. On the same day, the State School Facilities Bond Measures, Propositions 152 and 155, also passed by a significant margin. For the first time since the use of state bond measures, older urban districts gained access to SAB-distributed funds for substantial renovation projects.

## The Plot Thickens

The school district's celebration was cut short by the first implementation planning meeting the following week. When the administrators sat down with the facilities managers to decide what needed to be done and which schools to work on first, it became apparent that other large issues had to be settled before "simple" decisions could be made on remodeling and repairing buildings. Most specifically, it was pointed out that the demographics in the district had changed in the last 20 or so years, the student population was

therefore not balanced numerically or racially among the schools, and Berkeley Unified was in fact out of compliance with its own desegregation policy. Before facilities people could remodel and modernize buildings, school administrators, parents, and community groups had to reach consensus on district reorganization and necessary policy changes.

Thus began a debate on how best to redistribute the student population and also follow federal and local laws on school integration. The population of Berkeley is somewhat topographically distributed between "The Hills" (to the east) and "The Flats" (towards the Bay on the west). In general, more affluent families live in the Hills, and less affluent families live in the Flats. Previously, children from the Flats had been bused to the Hills schools, and children from the Hills had been bused to Flats schools to achieve numerical and programmatic balance. However, because of declining enrollment in the public schools, some of Berkeley's schools are bursting at the seams while others are only half-full. Some have integrated populations and programs, while others do not.

Various suggestions have been made to correct these imbalances: 1) continue two-way busing, but change the ratios to even out the student population; 2) change to a new system of neighborhood schools (which is potentially problematic because it would tend to reinforce segregation); or 3) develop a new system, called "controlled choice," in which every school becomes a magnet of some sort and both options and choosers are organized in such a way to guarantee balance. In the midst of all these large questions, of course, concerns about seismic safety--the initial issue that drove the bond measure--nearly disappeared from the debate.

After a number of heated, but inconclusive, open community meetings at many of the schools, the school district hired a community organizing/policy setting consultant group to conduct more hearings, study laws, identify policy options, and make some informed

*The High School cafeteria, a potential collapse hazard, is closed to students.*

recommendations on the optimum organization of the schools. The consultants presented their report to the school board in June of 1993. Subsequently, the Superintendent suggested that additional community-wide and school board discussions take place in the fall, with final decisions being made late in 1993 about changes in school organization.

*Modernizing and earthquake retrofitting are underway in the fall of 1993.*

## Slowly But Surely

Two other projects, independent of the community-wide debate, were approved and will get underway first. At the end of June, 1992, the State Allocation Board finally authorized a state contribution to the FEMA and BUSD monies already earmarked for the Whittier/Arts Magnet modernization project, a project first proposed in October of 1990. More recently, near the end of June, 1993, the SAB approved the repair of two Berkeley High School buildings--the first school seismic retrofit project ever to be funded with California school bond money.

Earthquake planning and hazard mitigation in the school district hasn't happened quickly, but it is under way. The school personnel, students, and their parents are better prepared and trained now than they have ever been. When students go back to school in the fall, their buildings will have significantly fewer nonstructural hazards, and work will have begun on the structural problems in some of the buildings. All the structures in the district won't be retrofit for a few more years, but they will be


by the tenth anniversary of the Loma Prieta earthquake. Social, economic, and political change--which is what earthquake hazard mitigation consists of--takes time. But ten years is *nothing* in geological time.

## Doing Something about School Buildings

To determine the structural make-up of their school buildings, districts have two immediate options--1) hiring a private structural engineer to evaluate individual buildings; or 2) requesting the Division of the State Architect to review individual buildings. If Option 1 is chosen, select private engineers experienced with seismic safety considerations. To exercise Option 2, contact the Division of the State Architect, **Office of Regulation Services, in Sacramento at (916) 445-0783.**

To obtain state funds for renovation, California school districts must work with the Office of Local Assistance, the staff arm of the SAB, to determine their eligibility for the Leroy Greene Lease-Purchase Program (a.k.a. the State School Building Program). Applications must be processed through OLA; once eligibility has been established, the SAB must approve the project. The state has developed very stringent guidelines for funding; districts must be persistent in their efforts to obtain the monies. For additional information, contact the following State of California offices:

**Office of Facilities Planning, Department of Education: (916) 445-2114**

**Office of Local Assistance, State Allocation Board: (916) 445-3160.**

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For their assistance and support in the development of this case study, special thanks are due to Arrietta Chakos, Legislative Liaison, and to the Superintendent and School Board, all of the Berkeley Unified School District.

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For more information on hazard mitigation and preparedness planning in schools, please contact the OES Earthquake Program at one of its offices:

- Coastal Region Earthquake Program, 101 8th Street, Suite 152, Oakland, CA 94607, (510) 540-2713
- Southern Region Earthquake Program, 1110 E. Green Street, Suite 300, Pasadena, CA 91106, (818) 304-8383
- Southern Region Earthquake Program, 1350 Front Street, Suite 4015, San Diego, CA 92101, (619) 525-4287
- Southern Region Earthquake Program, 117 W. Micheltorena, Suite D, Santa Barbara, CA 93101, (805) 568-1207

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