Coastal Management's Role in Seismic Safety

Political Lessons from California's 1989 Loma Prieta Earthquake

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Abstract

The San Francisco Bay Conservation and Development Commission *(BCDC)* — the first coastal management agency in the United States — has been involved in seismic safety since the Commission was established in 1965. As part of a comprehensive planning program, BCDC studied the physical characteristics of the bay and the major planning issues confronting the bay by preparing a series of technical reports. Four of these reports dealt directly with the issue of the safety of fills during an earthquake. The reports noted that structures built on bay fill are particularly vulnerable during earthquakes, but that sound engineering of both the placement of the fill and the design of the structures could significantly reduce these hazards.

Based on the recommendations in these reports and the advice BCDC received from a board of structural and geotechnical engineering consultants that the Commission had appointed, BCDC included findings and policies on safety of fills in its *San Francisco Bay Plan* in 1968. In 1969, the California Legislature authorized BCDC to carry out the Bay Plan through the Commission's regulatory program and specifically required BCDC to assure that any fill project which the Commission approves must be "constructed with sound safety standards which will afford reasonable protection to persons and property against the hazards of unstable geologic or soil conditions or of flood or storm waters."

To assist the Commission in meeting this legal mandate, BCDC relies on the advice of an Engineering Criteria Review Board *(ECRB)* consisting of eminent geologists, structural engineers, architects, and geotechnical engineers. Over the years, as a result of the ECRB's review, the design criteria for many new bay fill projects have been refined to incorporate state-of-the-art concepts into the project designs. The effectiveness of the ECRB's review was demonstrated on October 17, 1989 when the Loma Prieta earthquake rocked the San Francisco Bay region. Other than minor cosmetic cracks, none of the ECRB-reviewed structures suffered any damage.

Despite the effectiveness of BCDC's program in improving seismic safety, a legal restriction limits the applicability of BCDC's seismic safety policies and the use of the ECRB to new bay fill projects. However, much of the area within the Commission's regulatory jurisdiction along the shoreline of the bay is actually old bay fill that was placed before BCDC was established. As a result, construction on old bay fill poses the same as or greater danger than construction on new bay fill. To remedy this

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problem, the Commission proposed that California law be amended so that projects built on land along the bay shoreline would have to meet the same standards that apply to projects built on new bay fill. This change would allow BCDC to take advantage of the proven effectiveness of its ECRB and authorize BCDC to require reasonable seismic safety measures in projects built along the shoreline.

In spite of the seeming logic of this proposal, the legislation faced some opposition from a few local governments, some development interests, and an organization opposed to any expansion of government authority. This paper discusses the underlying analytical and technical bases for BCDC having jurisdiction over seismic safety, summarizes the political debate over the proposed legislation, and chronicles the legislative battle to have state law amended to carry out BCDC's proposal.

Early BCDC Involvement in Seismic Safety

Although many state coastal management agencies have taken a leadership role in dealing with hazard issues such as erosion and hurricanes, seismic safety is not typically thought of as an issue that is of primary concern to coastal managers. However, the San Francisco Bay Conservation and Development Commission — the first coastal management agency in the United States — has been involved in seismic safety since BCDC was created (BCDC, 11/89).

On September 17, 1965, the California Legislature established BCDC as a temporary agency and charged it with stopping the indiscriminate filling of San Francisco Bay. Between 1849 and 1965, landfills and diking had reduced the size of the open bay by almost one-third. About 2,300 acres of bay surface were being lost each year to landfills for housing, ports, industry, airports, real estate speculation, and solid waste dumps. The Commission was given regulatory authority over new fill projects and was directed to prepare a long-range plan for protecting San Francisco Bay for developing appropriate uses along the bay shoreline (Odell, 72).

BCDC began its comprehensive planning effort by preparing a series of separate, but related, technical background reports on the physical characteristics of the bay and on the major planning issues confronting the bay. The Commission then individually considered and adopted the reports' conclusions and recommendations, and subsequently merged these conclusions and recommendations to form the findings and policies of the *San Francisco Bay Plan* (Odell, 72).

It may be an overstatement to say that seismic engineering was still in its infancy in the mid-1960s, but clearly the profession had not reached the maturity it has today. But even in the '60s, memories of the San Francisco Earthquake of 1906 resulted in more awareness of seismic problems in the San Francisco Bay Area than in other parts of the United States. The Bay Area was also the home of a number of consulting firms that specialized in seismic issues, and the University of California at Berkeley devoted considerable attention to earthquake science and seismic engineering. The combination of this knowledge base and the rampant filling of San Francisco Bay made policy-makers aware of the danger of building on bay fill. As a result, four of BCDC's background technical reports dealt directly with the issue of the safety of bay fill during an earthquake: (1) *Geology of San Francisco Bay* by Harold B. Goldman, a senior geologist with the California Division of Mines and Geology; (2) *Seismic Problems in the Use of Fills in San Francisco Bay* by H. Bolton Seed, a professor of engineering at the University of California, Berkeley; (3) *Seismic Risk to Buildings and Structures on Filled Lands in San Francisco Bay* by Karl V. Steinbrugge, a structural engineer; and (4) *Bay Mud Developments and Related Structural Foundations* by the consulting firm of Lee and Praszker. The last three reports were combined into a background report entitled *Fill: Three Reports on Aspects of Fill in San Francisco Bay* (BCDC, 11/89).

Seismic Conditions Underlying San Francisco Bay

According to BCDC's report *Geology of San Francisco Bay*, layers of ancient bay mud were deposited over bedrock. The older bottom muds are more consolidated by the pressure from the mud above and contain less moisture. The younger bay mud is more troublesome from an engineering perspective because it is weak and highly compressible. When younger mud is covered with fill material, it becomes increasingly unstable as the thickness of the fill increases.

The report further noted that there are active major earthquake faults on both sides of San Francisco Bay — the San Andreas Fault running up the peninsula on the west side of the bay, and the Hayward and Calaveras Faults which run along the East Bay hills. The ground motion from earthquakes changes in magnitude and frequency depending on the material through which the motion passes. Soft materials, such as bay muds, amplify ground motion. As a result, poor ground conditions create a greater potential hazard than do proximity to faults or earthquake epicenters (BCDC, 11/89).

The report *Fill: Three Reports on Aspects of Fill in San Francisco Bay* described some of the problems that have to be addressed to safely use bay landfills. For example, the report found that soft muds and clays transmit fewer shock waves per minute than do other natural soils and bedrock — a condition that is particularly damaging to tall buildings. In addition, the report described how earthquake shaking can cause loose silts, sands and gravels to shift and settle in relationship to each other. If the soil is saturated with water, the entire mass can become fluid and loose all strength, a condition known as "liquefaction." Damage from liquefaction can be particularly destructive to buildings and utilities as occurred in San Francisco's Marina District during the Loma Prieta earthquake (Mitchell, 90).

The report concluded that in order to meet earthquake and normal settlement requirements, a thorough analysis of the specific site conditions must be undertaken. Then, engineers using the latest technological information must craft a design solution to deal with the site conditions and building criteria. Finally, construction must be carried out under close professional supervision.

The report also observed that in 1968 there were no minimum codes regulating construction on fill placed on top of bay mud simply because there was insufficient data upon which to base code requirements. Therefore, the report recommended that in order to protect public safety, an independent review board should be established to: (1) set and refine standards as rapidly as new information became available; (2) review all fill proposals on the basis of available knowledge; and (3) prescribe an inspection system to ensure that fill would be placed according to an approved design.

In response to the recommendations in these reports, on February 16, 1968, BCDC established a Board of Consultants to Review Safety of Proposed Fills. The new board, which was composed of eminent seismic design experts from Bay Area consulting firms, public agencies and universities, began preparing engineering design criteria that would ensure a satisfactory level of safety for buildings constructed on bay fill. The Board incorporated the results of its work into a report entitled *Carrying out the Bay Plan: The Safety of Fills,* which included qualitative criteria that addressed geological and seismological conditions, soil and foundation engineering considerations, and engineering safety requirements. The Board recommended that in order for these safety criteria to be enforceable, they should be included in the Commission's plan for the bay. The report also recommended that BCDC should establish a permanent consultant board to continue working on seismic safety considerations (BCDC, 11/89).

Engineering Criteria Review Board

Based on the technical background reports and the recommendations of its Board of Consultants, BCDC included findings and policies on the safety of fills in the *San Francisco Bay Plan*. To implement the safety of fills policies, the Commission created a permanent Engineering Criteria Review Board *(ECRB)*, consisting of geologists, structural engineers, architects and civil engineers specializing in soils engineering. The Commission relies on the advice of the ECRB to assure that Commission-approved fills, structures and other developments are designed to withstand seismic events. The Bay Plan safety of fills policies prohibit BCDC from approving a fill project, even if it is consistent with all other Bay Plan policies, if hazards cannot be overcome adequately for the intended use in accordance with criteria prescribed by the ECRB.

The ECRB reviews BCDC permit applications for major bay fill projects to ensure that appropriate safety criteria are used in their design and construction. This process guarantees that state-of-the art concepts and the latest professional and technical information are used in designing structures on bay fill. A number of subjective and quantitative factors are balanced to establish the appropriate safety criteria, including the professional judgment and technical skill of the designer, the degree of geological hazard, the importance, use and configuration of the structure, the sophistication of analysis, and the choice of construction materials and techniques.

Over the past two decades, this review has resulted in significant improvements in the seismic engineering of fills and structures built on them. In many cases, the ECRB advised applicants that additional soil and geological information was necessary to properly define the hazards inherent in a development. This additional information has, in turn, lead to design changes which have reduced hazard potential. For example, as a result of the ECRB's suggestions, the design of the Pier 39 amusement arcade on the San Francisco waterfront was refined to deal with the expected lateral pressure on the piles and a liquefaction potential; shutoff valves were placed in an oil pipeline where it crossed a fault line; bay mud was removed from beneath a dike at a Port of Oakland terminal; additional testing was conducted to assure that the roof of San Francisco ferry terminal could withstand distortion without breaking; the amount of shear walls was doubled in an East Bay waterfront restaurant; and a bridge in Oakland, which had been designed in the early 1970s, was redesigned in light of the findings from the 1971 San Fernando earthquake which disclosed that bridge design standards were inadequate. In addition to these specific accomplishments, it appears that the mere existence of the ECRB, with its reputation for thorough review, encourages developers and their consultants to use higher seismic safety standards and more sophisticated analytical methods than are required by existing codes (BCDC, 4/13/90).

Loma Prieta Earthquake

At 5:04 p.m. on October 17, 1989, the San Francisco Bay Area was rocked by its most severe earthquake since 1906. The quake's intensity measured 7.1 on the Richter Scale. Its epicenter was located in the Santa Cruz Mountains about 60 miles southeast of San Francisco near Mount Loma Prieta. The earthquake resulted in 62 deaths, more than 3,750 injuries, and left over 12,000 people homeless. The temblor was felt over a 400,000 square mile area, and damage was reported over an area 120 miles long. The quake resulted in over $6 billion in damage, including $1 billion in damage to highways and bridges. Liquefaction problems extended from Bolinas, on the Marin County coast, to Gorda on the Big Sur coast. Although there was considerable liquefaction around Monterey Bay, there was virtually none in San Francisco Bay south of the San Mateo–Hayward Bridge (State/Federal Team, 90).

Shortly after the Loma Prieta earthquake, BCDC's staff conducted a survey of the structures whose designs had been evaluated by the ECRB. Other than minor superficial damage, none of the structures had been affected. Of particular note was the Dumbarton Bridge which had been built in the late 1970s by the California Department of Transportation. In its initial analysis of the original design in 1972, the ECRB noted numerous seismic design shortcomings. Over the next five years, the design was refined and the ECRB reviewed these changes on ten occasions. As a result of these design improvements, the Dumbarton Bridge survived the Loma Prieta Earthquake without any structural damage. In fact, even though the Dumbarton Bridge was closer to the quake's epicenter than any of the other major bridges that span the bay, it was the only bay bridge that did not have to be closed for at least a short time after the quake (BCDC, 11/89).

Problems of Building on Old Bay Fill

The effectiveness of the ECRB in assuring the safety of *new* bay fill projects was even more dramatic when contrasted with the damage that occurred in structures built on *old* bay fill. Much of San Francisco's Marina District was built over an old bay cove that was filled with rubble from the 1906 earthquake. Structures that were built on land along the shoreline of the former cove survived the October 17, 1989 earthquake, while those built on fill were severely damaged. The extent of damage in San Francisco's "South of Market" area correlated with the location of the fill in the former Mission Bay and along the course of the original Mission Creek. In Oakland, the portion of the Interstate 880 Cypress Viaduct that collapsed was built on fill. The fill under the Bay Bridge toll plaza and along the Interstate 80 Eastshore Freeway liquefied in some places and failed in others (BCDC, 5/13/90).

On November 6, 1989, California Governor George Deukmejian created The Governor's Board of Inquiry on the 1989 Loma Prieta Earthquake. This eleven member board of experts in civil, structural and seismic engineering and design, and earthquake science held nine days of public hearing, heard 70 presentations, toured damaged structures, and reviewed hundreds of pages of written material. On May 31, 1990, the Board released its report entitled *Competing Against Time* which included the following assessment of the dangers inherent in building on filled land:

> *Damage observed in many areas was concentrated at soft ground sites. A soft soil...site...is defined as a site underlain by several feet to several tens of feet of young bay mud. Damage in the Marina district, the most heavily damaged area of the City of San Francisco, the South of Market area, the Oakland Airport and waterfront, and the Cypress Viaduct were all located on sites with soft soils. Generally these were sites with landfill over bay muds, many completed some time ago without specific engineering consideration.*

According to a report entitled, *On Shaky Ground*, prepared by the Association of Bay Area Governments *(ABAG)*, the council of local governments in the San Francisco Bay region:

> *...the earthquake epicenter is NOT the point at which most damage occurs...Thick, loose soils tend to amplify and prolong the shaking. The worst such soils in the Bay Area are the loose clays bordering the Bay — the Bay mud.* (Emphasis in original.)

Between 1949 and 1965, the size of San Francisco Bay was reduced from 787 square miles to 548 square miles through bay filling. Thus, there is 239 square miles of new "land" around the shoreline of the bay that overlies bay mud. According to the Bay Plan safety of fills findings, "Safety of a fill...depends on the manner in which the filling is done, and the materials used for the fill" (BCDC, 12/89). Most of the fill

around the bay shoreline was placed before modern engineering practices were developed to deal with the difficulties of erecting a safe structure on unstable ground. Therefore, this old bay fill is often referred as "unengineered fill" (BCDC, 4/13/90).

The Bay Plan warns of the difficulties of building on fill, but also acknowledges that if special engineering precautions are taken, the hazards of earthquakes in shoreline structures can be significantly reduced :

> *Construction of a fill or building that will be safe enough for the intended uses requires: (1) recognition and investigation of all potential hazards — including (a) settling of a fill or building over a long period of time, and (b) ground failure caused by the manner of constructing the fill or by shaking during a major earthquake — and (2) construction of the filling or building in a manner specifically designed to minimize these hazards. While the construction of buildings on fills overlying Bay deposits involves a greater number of potential hazards than construction on rock or on dense hard soil deposits, adequate design measures can be taken to reduce the hazards to acceptable levels.*
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> *...Therefore, the highest order of skilled judgment, utilizing the available knowledge of all affected disciplines, is required to: (1) recognize and investigate all potential hazards of constructing a fill; and (2) design the fill and any construction thereon to minimize these hazards.*

BCDC's Legal Authority

The McAteer-Petris Act (the state law under which BCDC operates) prescribes that BCDC has different types of regulatory authority over different geographic areas. BCDC has broad authority to control uses and filling within the Commission's "Bay jurisdiction." For example, section 66605(e) of the McAteer-Petris Act states that:

> *The public health, safety and welfare require that fill [in the Bay] be constructed with sound safety standards which will afford reasonable protection to persons and property against the hazards of unstable geologic or soil conditions or of flood or storm waters.*

In contrast, the Commission has considerably less authority within its "shoreline band jurisdiction" which extends 100 feet inland from the bay shoreline. Specifically, section 66632.4 of the McAteer-Petris Act restricts BCDC's actions on applications for proposed projects within the shoreline band by stating:

> *Within any portion or portions of the shoreline band which shall be located outside the boundaries of water-oriented priority land uses, as fixed and established pursuant to Section 66611, the commission may deny an application for a permit for a proposed project only on the grounds that the project fails to provide maximum feasible public access, consistent with the proposed project, to the bay and its shoreline.*

To ensure that sound safety standards are incorporated into new fill projects, section 66632(f) of the McAteer-Petris Act authorizes the Commission to impose reasonable conditions, including specifying construction methods and methods for placing fill, when BCDC issues a permit. But the restrictive language of section 66632.4 creates considerable legal doubt as to whether the Commission can apply these policies and rely on its ECRB when it reviews permit applications for structures within BCDC's shoreline band jurisdiction. This is particularly unfortunate because shoreline structures are more susceptible to damage during earthquakes than are those on new bay fill. As noted in the Bay Plan, the safety of a fill depends on the manner in which the filling is done and the materials used for the fill. In a new bay fill project, the manner and materials of the fill can be carefully designed to reflect the latest information in

seismic engineering. But because so much of the land within the Commission's shoreline band jurisdiction is actually bay fill that was placed before BCDC was established, this old fill does not meet current engineering and probably was not engineered at all.

To deal with this legal problem, in January 1990 the Commission decided to request a legislative amendment to section 66632.4 of the McAteer-Petris Act so that BCDC could have the projects within its shoreline band jurisdiction evaluated by the ECRB and could impose conditions in the permits for those projects to ensure that the projects would be designed and built to the highest safety standards. Based on an analysis provided to the Commission by its staff, BCDC decided to request that precisely the same legislative mandate that applied to new fill projects be applied to shoreline projects. With this change the Commission could also more effectively address another problem that had become apparent over the past few years — shoreline flooding from sea level rise (BCDC, 12/22/89).

Flooding from Sea Level Rise

Flooding of shoreline areas had long been recognized as a serious problem by BCDC. In 1968, the Commission added a finding to its Bay Plan to acknowledge that "Flood damage to fills and shoreline areas can result from a combination of heavy rainfall, high tides, and winds blowing onshore." To address this finding, the Commission adopted a Bay Plan policy which states, "To prevent damage from flooding, buildings on fill or near the shoreline should have adequate flood protection as determined by competent engineers."

In the late 1980s, the Commission noted that the long-standing problem of designing shoreline structures to withstand occasional flooding was becoming more difficult because studies by the U.S. Environmental Protection Agency and scientists worldwide were concluding that global warming would lead to an accelerated rise in sea level over the next century. This could result in permanent inundation of low-lying coastal areas, increased coastal flooding, more shoreline erosion, and salt water intrusion into fresh water areas.

Because an accelerated rise in sea level would jeopardize development along the bay shoreline, in 1985 BCDC retained Dr. Philip Williams, a consultant on tidal hydraulics, to study the implications of sea level rise in San Francisco Bay. Dr. Williams concluded that mean sea level could rise approximately four feet in San Francisco Bay over the next century. To develop specific measures for dealing with this possibility, in 1987 the Commission retained the coastal engineering firm of Moffatt & Nichol to prepare practical and specific flood control engineering criteria and procedures. In 1989, the Commission amended its Bay Plan findings and policies to acknowledge the predicted accelerated rise in sea level in the bay and to incorporate tidal flood protection engineering design review procedures and criteria into BCDC's permit application review process. These procedures and criteria allow specific flood control measures to be crafted for a shoreline project by taking into account the relative change in sea level at the project location (the sum of the change in sea level and the change in land elevation at that point), the intended use of the project, and other factors (BCDC, 4/13/90).

Unfortunately, the same legal provision that makes it questionable whether BCDC can address seismic safety concerns when it reviews projects within its shoreline band jurisdiction also casts legal doubt on whether BCDC can take sea level rise into account when it evaluates a project that would be built on existing dry land along the shoreline. This is particularly ironic because by its very nature, a rise in relative sea level will impact areas of the shoreline that are not now subject to flooding. Thus, the

Commission found it was doubtful that it could apply its sea level rise policies and procedures in the area where they would be most effective.

To deal with this problem, the Commission recommended that local governments should incorporate the Bay Plan tidal flood protection engineering design review procedures and criteria into their land use planning and regulatory processes. BCDC also co-sponsored a conference on sea level rise with ABAG in 1989 to assist local governments in this effort. Despite these efforts, local governments are moving slowly to incorporate sea level rise provisions into their plans and ordinances.

BCDC's Legislative Proposal

To deal with the shortcomings in its legal authority, in March 1990, the Commission approved a staff recommendation that BCDC should seek *explicit* legal authority so that the Commission could have impose conditions to reduce the risks to persons and property from earthquakes, floods and other natural hazards in all projects which the Commission authorizes. In its Nollan v. California Coastal Commission decision, the United States Supreme Court concluded that a government regulatory agency cannot impose a permit condition to resolve some flaw in a development project unless the agency also has the underlying legal authority to deny a permit for the project because of the flaw. Therefore, in order to impose conditions that require ECRB review or design modifications to deal with seismic safety or sea level rise, BCDC has to have the underlying authority to deny a permit for a project that fails to provide reasonable protection against earthquake hazards or flooding (BCDC, 4/13/90). To achieve its objective and comply with the Supreme Court's guidance, the Commission requested that the California Legislature amend section 66632.4 of the McAteer-Petris Act to make the following changes:

> *Within ~~any portion or portions of~~ the shoreline band ~~which shall be located outside the boundaries of water-oriented priority land uses, as fixed and established pursuant Section 66611,~~ the commission may deny an application for a permit for a proposed project only on one or more of the following grounds ~~that~~:*
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> *(a) The proposed use is not consistent with a designated priority use as fixed and established pursuant to Section 66611;*
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> *(b) The project fails to provide maximum feasible public access, consistent with the proposed project, to the bay and its shoreline; or*
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> *(c) The project fails to provide reasonable protection to persons and property against the hazards of unstable geologic or soil conditions or of flood or storm waters.*

Opposition to the Legislation

Opposition to the legislative proposal surfaced quickly. Led by the mayor of Foster City — one of the last major projects built by diking low-lying areas and filling bay tidelands before BCDC was established in 1965 — the opponents focused on two substantive issues and a number of peripheral ones. First, the opponents argued that the Commission should rely entirely on local governments to ensure that shoreline structures are adequately designed to withstand earthquakes. It was suggested that any shortcomings in the local review process should be resolved by amending the Uniform Building Code. Second, the opponents expressed concern that through the ECRB review process, appointed (as opposed to elected) individuals would express their subjective opinions about the seismic design of structures resulting in arbitrary criteria being set on a case-by-case basis. Finally, some opponents had less defined worries including a belief that the legislation would expand BCDC's authority, fear

that BCDC would preempt local government, a belief that new policies would have to be established, and concern that BCDC's review would delay project approval and result in many permits being denied (Chinn, 90, Johnck, 90). Each of these issues is discussed below.

Shortcomings of the Uniform Building Code. Although local government programs that deal with seismic safety should be the cornerstone of an overall earthquake preparedness and response system, it would not be effective to rely solely on local building codes to assure that structures are designed and built to provide reasonable protection to lives and property from earthquakes. This conclusion is based in part on the following analysis contained in the 1987 ABAG publication *On Shaky Ground:*

> *The building departments of Bay Area cities and counties use the Uniform Building Code (which is revised every three years) as a minimum standard for earthquake-resistent structural design. Problems can develop, however, when the UBC becomes a "cookbook" and replaces design judgment. The Code has been developed to ensure a* ***minimum standard of life safety, NOT*** *to create "earthquake-proof" structures. Structural damage, damage to contents, and disruption of function in major earthquakes are expected in buildings designed "to Code."*
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> *Other problems in buildings can develop because of the lag between when Code language is written, adopted as part of the Code, and finally adopted by the local jurisdiction. For example, the most current code in 1987 is the 1985 UBC, yet many cities are still using the 1982 — or even the 1979 — version. At the same time, significant changes are being written to become part of the 1988 UBC.*
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> *The Code is designed for standard rectangular buildings. Thus, little recognition has been given to problems that can arise when more complex configurations (both in plan view and elevation) are used. Such configurations are a trademark of contemporary architecture*
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> *...The Code contains a "soil factor" to deal with variations in ground shaking experienced on rock and firm soil, as opposed to moderately soft, and finally soft, soil. The seismic-resistant design requirements on soft soil are currently 1½ times those for rock. Because of the types of problems expected on thick Bay mud, the addition of a fourth category of soil for such mud more than 40 feet thick is being discussed for inclusion in the 1988 Code. The requirements will be 2 times those on firm soil and rock.*
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> *Finally, small structures, including many single-family houses, are not required to have professional design. Thus, these small structures are more likely to incorporate "cookbook" design and use less than state-of-the-art design judgment.* (Emphasis in original.)

Although some of the shortcomings of the UBC discussed in the ABAG report were addressed by the 1988 amendments to the code, the California Seismic Safety Commission has found that the UBC needs further improvement in its standards for construction on soft, saturated clay soils (i.e., the precise conditions found along the shoreline of much of San Francisco Bay). Specifically, the 1989 edition of the Seismic Safety Commission's *California At Risk* report states:

> *Studies of earthquake damage in Mexico City reveal a weakness in the way the current building code establishes design forces for midrise buildings (10 to 15 stories) located on soft, saturated clay soils of 30-foot or greater depth.*

This weakness could lead to structural deficiencies in new buildings unless the design engineer and building official compensate for this deficiency.

Furthermore, in order to be most effective, the UBC requires that everyone who is involved in the design and construction process must be able to understand and correctly apply the principles of the UBC. Unfortunately, in its *California At Risk* report, the Seismic Safety Commission found:

The standards of practice of all the professionals and workers who participate in the processes of designing and constructing structures need to be improved, and special attention given to ensuring that all such future physical development built in California is adequately resistant to earthquake shaking.

Courses and information materials on seismic safety and earthquake resistant construction should be prepared for use by architects, engineers, building officials, plan checkers, inspectors, contractors, and construction supervisors and workers.

Course materials on the importance of earthquake safety and geologic hazards in local decision making are also needed for all the principal professions that serve in municipal and county governments, and especially for urban planners, and city and county administrators, as well as the members of the locally elected councils and boards of supervisors.

Despite these generalizations, some local governments are doing an admirable job of ensuring that development is designed and constructed to the highest seismic safety standards. For example, ABAG's *On Shaky Ground* report notes that Redwood City has developed innovative code requirements. As valuable as these individual local government efforts are, officials at the California Seismic Safety Commission believe that the fundamental problems in relying on code alone remain — the lag time between the availability of new information, the incorporation of that information into the code, and the adoption of the latest version of the code by a local government; the reliance on the code as a "cookbook" by designers who are not fully acquainted with sophisticated seismic design solution; and the need for state-of-the-art design and engineering knowledge to deal with complex building shapes or unusual soil conditions. Most importantly, as the ABAG report emphasized, the Uniform Building Code contains minimum standards, not standards for "earthquake-proof" structures. And even if the UBC were fully adequate although BCDC has jurisdiction over state and federal projects, whereas local governments do not. Therefore, the Uniform Building Code cannot be applied by local governments to state or federal projects (BCDC, 4/13/90).

Engineering Criteria Review Board as a Model. The concept of utilizing an independent board of engineering professionals to review the seismic designs of proposed projects caused grave concern to some of the opponents of the legislation. They felt that this process would result in "outsiders" second-guessing project designers and would make it impossible to ever know whether a design would be adequate (San Carlos, 90).

The approach used by the Engineering Criteria Review Board — commonly referred to as "independent peer review" — is assessed by the California Seismic Safety Commission as follows:

Independent peer review of design recognizes outside professional judgment is needed to test project design assumptions and concepts that extend beyond existing required code compliance reviews.

The critical importance of independent peer review has also been recognized by the Governor's Board of Inquiry on the 1989 Loma Prieta Earthquake. Based in part on what the board had learned about the effectiveness of BCDC's Engineering Criteria Review Board, (BCDC, 12/22/89) the board's report states:

> ***Independent, technical review is essential to achieve consistent excellence in engineering design and construction.*** *The American Society of Civil Engineers manual titled Quality in Construction Projects states:*
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> > *Projects that should be peer reviewed are those that are complex, unique, or would have greater consequence should failure occur. A project peer review should be conducted if the owner/client wants extra assurance that a project design of acceptable quality will be received at a fair cost and is prepared to pay for that added assurance by means of peer review.*
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> *The Board of Inquiry endorses this statement. The practice of civil engineering is not yet precise. The process of design of structures is still one that entails the making of many decisions and technical compromises.*
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> *...[California's] experiences clearly demonstrate that design not subject to review often has higher earthquake damageability than does construction that is reviewed, and that the State can effectively provide seismic design review and achieve higher degrees of seismic safety and lower damageability. The civil engineering and design professions accept peer review and readily participate in it, realizing that it is an action that fosters better designs and that is a useful approach to ensuring that problems are identified and resolved before and during construction.*

Using the ECRB to provide this independent peer review overcomes the single cautionary note observed by the American Society of Civil Engineering. Because the professionals who serve on the ECRB volunteer their time, there is no cost to project applicants for this review. The members of the ECRB are among the nation's leading experts in their respective fields. Therefore, the ECRB review process has been described as BCDC providing the services of highly qualified multi-disciplinary consultants at no cost to project designers (Travis, 90).

The Seismic Safety Commission, has also stressed the importance of independent peer review:

> *New private special-occupancy buildings and new state and local public buildings need added seismic safety emphasis during design and construction. Added seismic safety reviews should include...geological and structural reviews of seismic safety aspects of the proposal through independent peer reviews...*

In 1990, the National Oceanic and Atmospheric Administration surveyed the 30 state coastal management programs being administered under the federal Coastal Zone Management Act to identify effective management approaches for dealing with natural hazards. NOAA's report *Coastal Management Solutions to Natural Hazards* includes a detailed assessment of the ECRB as one of only five innovative ideas worthy of national recognition because "the ECRB's review has resulted in a significant improvement in the seismic engineering of fills and structures built on them" (NOAA, 90).

Thus, the American Society of Civil Engineers, the Governor's Board of Inquiry, the California Seismic Safety Commission and the National Oceanic and Atmospheric Administration believe that the independent peer review approach used by the ECRB

is a respected and effective means of ensuring that structures are designed to minimize earthquake hazards. This approach ensures that each structure is designed to reflect both its unique underlying geological conditions as well as the function of the structure. By relying on a multi-disciplined board, the ECRB evaluates all of the factors — such as soils, geology, structural design, and building use — that affect a structure's performance during an earthquake. Finally, because the ECRB is made up of eminent experts in seismic safety, the members have state-of-the-art knowledge which can be applied immediately.

The relevant building code is always used as the starting point by the ECRB. But it can take several years before local codes are revised to reflect the lessons learned from the most recent earthquakes. For example, in the last few years there have been devastating earthquakes in Mexico City, Armenia, and Northern California. The lessons from Mexico City are just now being incorporated into revisions of the Uniform Building Code. It may take some local governments a few more years before they amend their local codes to bring them into conformance with the updated UBC. And it will take another few years before the lessons from Armenia and Northern California are reflected in the UBC. However, through their visits to these earthquakes, their reading of the reports on the earthquake damage, and their discussions with fellow professionals, the members of the ECRB are already applying the knowledge gained from the study of these recent seismic events.

The Proposed Legislation In Practice. In an attempt to counter the charges that the proposed legislation would impose a considerable burden on applicants or would significantly impact local governments' authority to control development within their respective jurisdictions, BCDC's staff released a report on April 13, 1990 which evaluated how the proposed legislation would actually work in practice. The report emphasized five points, each of which has been updated to reflect 1990 BCDC permit data (BCDC, 91).

- ***The Legislation Would Not Expand BCDC's Jurisdiction.*** The proposed legislation would not enlarge the geographic area in which a BCDC permit is required. All of the projects that would be impacted by the legislation would require a permit from BCDC whether or not the legislation is passed. Currently, local government makes the primary decision as to what type of land use and what sort of development should be permitted along the shoreline of the bay. BCDC's review is limited to assuring that any project approved by a local government is consistent with the priority use designations in the Bay Plan and includes maximum feasible public access to the bay shoreline. The proposed legislation would retain this relationship between local government and BCDC, but would allow BCDC to also assure that the development is designed in a manner that will reduce the risks to persons and property from earthquakes, floods and other natural hazards.
- ***The Standards BCDC Would Apply Are In Place.*** Because the proposed legislation would simply allow BCDC to exercise the same authority over shoreline projects that the Commission currently exercises over new bay fill projects, BCDC would use the same policies and procedures to evaluate the safety of shoreline projects that it now uses to evaluate the safety of bay fill projects. The policies are contained in the Bay Plan, and the procedures are in the Commission's regulations. The decision to require the ECRB to review a project design is typically made by the Commission after a public hearing. The Commission normally has the ECRB evaluate the engineering of three types of projects: (1) those that would have high occupancy levels, such as hotels; (2) those in which failure during an earthquake would likely result in significant environmental impacts, such as oil terminals and sewage treatment plants; and (3)

those with unusual designs or difficult geological conditions, such as new types of breakwaters or construction in an area known to be filled with rubble or debris.

- ***The Legislation Would Not Delay the Approval of a Project.*** The proposed legislation would not change the current requirement that BCDC process all permit applications within 90 days. If the Commission determines that the project raises issues that deserve special engineering attention, the Commission includes a condition in the permit requiring ECRB review. The ECRB review takes place after the permit has been issued at the point in the design process before detailed working drawings are prepared. After the ECRB has established that the design criteria for the project are appropriate, detailed plans are prepared by the permittee's consultants for review by BCDC's staff engineer. Local governments also require these detailed plans. The local review and BCDC's review are carried out concurrently. Thus, the overall amount of time needed to process a permit application and approve plans would likely be unchanged if the proposed legislation were enacted.

- ***The Legislation Would Impact Few Projects.*** During the 1980s, BCDC issued 191 major permits, but ECRB review was necessary for only 26 of these projects — less than 14 percent of the projects approved by the Commission. In the three year period from 1988 through 1990, BCDC issued 51 major permits, 24 of which involved some bay fill and 27 of which were where for projects wholly or partially within the shoreline band. Of the 24 bay fill projects, only three were required to be reviewed by the ECRB — the widening of an Interstate highway bridge across the Carquinez Strait, the repair of the San Francisco-Oakland Bay Bridge after the Loma Prieta earthquake, and an aquarium on a pier in which over a million people a year would pass through an acrylic tube on the bottom of a fish-filled tank. If the proposed legislative change had been in place during the past three years, ECRB review would have been appropriate for only three of the 27 shoreline projects approved by the Commission — a high-occupancy hotel in Oakland, a portion of a freeway overpass built on old fill in Richmond, and the main fire station built on fill in Emeryville. Thus, the passage of the proposed legislation would impact only a few projects. But in these few projects, review by the ECRB could result in the same sort of design refinements that have proven so successful in allowing the ECRB-reviewed bay fill projects to survive the Loma Prieta earthquake virtually unscathed.

- ***The Legislation Would Probably Not Result In Any Permits Being Denied.*** The purpose of ECRB review is not to keep a project from being built. Rather, the purpose of the review is to ensure that the project is designed to meet the requirements section 66605(e) of the McAteer-Petris Act which mandates that the project must "afford reasonable protection to persons and property against the hazards of unstable geologic or soils conditions or of flood or storm waters." To date, BCDC has not denied any permits because it found that the proposed project would not meet the requirements of section 66605(e). Instead, where the Commission has had concerns about the safety of a project, the Commission has issued a permit for the project, but has also included a condition requiring ECRB review. The design refinements required as a result of the ECRB review have never been so onerous as to render a project unbuildable. There is no reason to believe that this practice would change if the proposed legislation were enacted.

The Legislative Battle

The Loma Prieta Earthquake came at a bad time in the California Legislature's calendar. The Legislature operates on a two year cycle with 1990 being the second year of the 1989-90 session. Thus, legislation introduced in the aftermath of the earthquake

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