CHAPTER 2

RESIDENTIAL CONCERNS FOR SEISMIC SAFETY

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Introduction

The purpose hereinis to evaluate the seismic concerns in different neighborhoods of Berkeley. The aspects to be considered are the structural soundness of the houses, location with respect to geological hazards, and the residents themselves.

Various building designs and features affect a structure's seismic safety. Examination of the architecture of Berkeley provides a good indicator of when and how structures were built, aspects which relate directly to how they will fare in an earthquake. The impact of an earthquake will vary in different parts of Berkeley, depending on the nature of the substrate, landslide potential, and proximity to the fault. The renter/homeowner composition of a neighborhood will also affect the nature of seismic concern, since many residences will sustain severe damage without necessarily harming the inhabitants.

Housing Construction

Generally, architecturally simple, single-story houses can survive earthquakes without heavy damage. Modern, carefully designed and constructed wood frame houses are the safest--when there is damage, it is mostly the result of deficiency in building site, as demonstrated in the San Fernando earthquake of 1971.[10]

Architectural features strongly influence how a building will fare. Usually, split-level structures are less stable than single-story houses. Windows covering an entire wall and non-continuous corner columns are weak features. Residences with small rooms and many walls are stronger. Lateral bracing is probably the most important strengthening factor, the best forms being plywood shear-wall or diagonal sheathing.

The San Fernando earthquake also demonstrated that the "box-like" shape of dwellings lends earthquake resistance. If the roof and floors are offset at different levels, the conformity of the horizontal bracing is interrupted.[5]

Unreinforced brick or masonry does not survive strong shaking. Old buildings made of unreinforced brick are apt to collapse and therefore pose a life hazard. Wooden houses on brick foundations may be extensively damaged, but they probably will remain standing. Brick chemneys are usually the first things to collapse in an earthquake. Modern brick buildings, reinforced with steel reinforcing bars, are safer. Brick or stone veneers may peel off the siding unless they are properly braced. In San Fernando, damage to exterior and interior finish was the first thing to occur along with chimney damage. Rigid finishes, such as plaster, stucco, and gypsum board are vulnerable. Wood finishes showed little or no damage.[5]

A very common weakness is lack of connections between the frame and the foundation. Such anchoring is seldom present in pre-1940 structures. Large unanchored structures have been known to shift off their foundations.

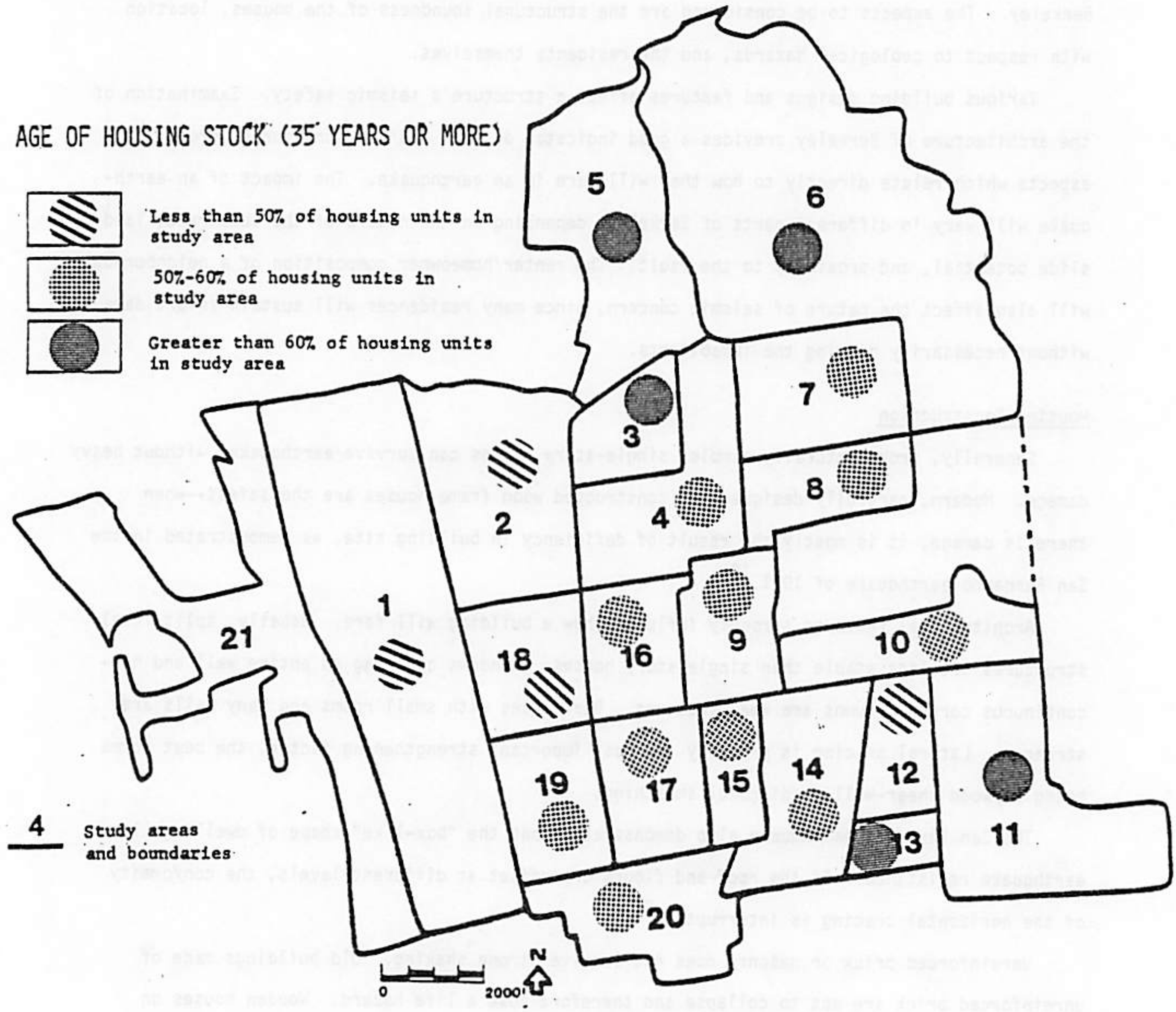


FIGURE 1. Age of Berkeley Housing
SOURCE: Berkeley Planning Department, Master Plan

Lateral force provisions in building codes have come into play only with more recently constructed buildings. Requirements regarding lateral bracing systems and foundation strength first appeared in 1927. The 1933 Riley Act required that buildings be able to withstand certain minimal lateral forces. In 1953 these specifications were modified for taller structures.[7]

In the Santa Rosa earthquake in 1969, the greatest proportion of badly damaged homes were built before 1920. Pre-1940 residences were commonly damaged. Houses built after 1940 have shown little damage in previous earthquakes.[9]

The great majority of the houses in Berkeley were built before 1940. The Berkeley hills, in the eastern part of the city, have a higher proportion of very old homes than West Berkeley (FIGURE 1).

Berkeley Houses

Much of the richness of Berkeley spawns from the city's architectural display. The age of housing, an important factor in seismic safety, can usually be determined by the architectural style. There are also coinciding structural features which relate to earthquake safety. There is, however, a broad variation in the way houses are constructed, and generalizations often do not apply to an individual structure.

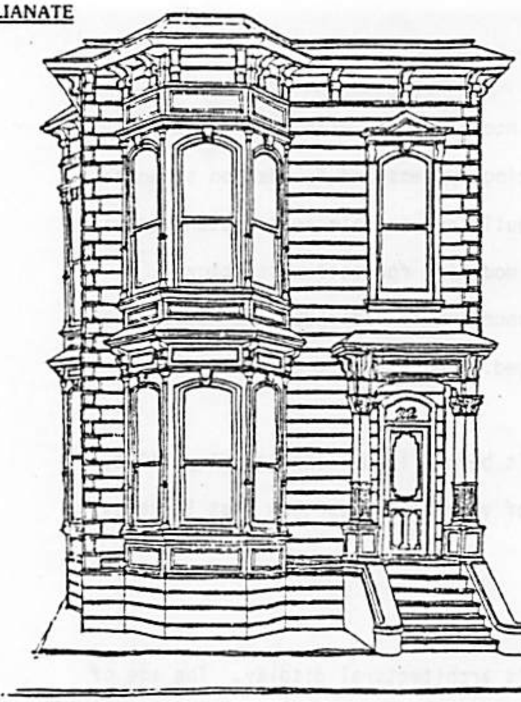
There are several styles of Victorian house, built between 1850 and 1900 (FIGURE 2). The early Pioneer houses (1850-1885) were small and plain, assembled quickly and cheaply from 2x4's nailed to a light frame. The Italianate style (1860-1885), distinguished by tall narrow door and window openings with rounded arches, features ornate brackets and trim. The Stick style (1870-1895) is squared and angular, decorated with narrow strips of wood and carved patterns. The well-adorned Queen Anne houses (1870-1895) are rich with gables, bays, and occasionally rounded towers.[4]

The turn of the century brought on a less embellished styling. The different styles of Colonial Revival house (1890-1915) (FIGURE 2) is distinguished by a high-peaked gable roof. Other examples are the Classic Box and the Neoclassic Rowhouse (1895-1915) (FIGURE 2).[4]

These early wood frame houses contain certain structural strengths as well as weaknesses. Studs, set at arbitrary intervals, extend all the way from the foundation sill to the roof. Clapboard siding or diagonal sheathing provide a good deal of rigidity to the frame. Unfortunately, the foundations are usually brick or stone and mortar, which could crumble in an earthquake. Concrete foundations came into use starting around 1900, phasing out brick foundation construction by 1920.

The First Bay Tradition class of architecture includes the distinctive works of many Bay Area architects, such as Bernard Maybeck and Julia Morgan. Widely used were untreated wood and

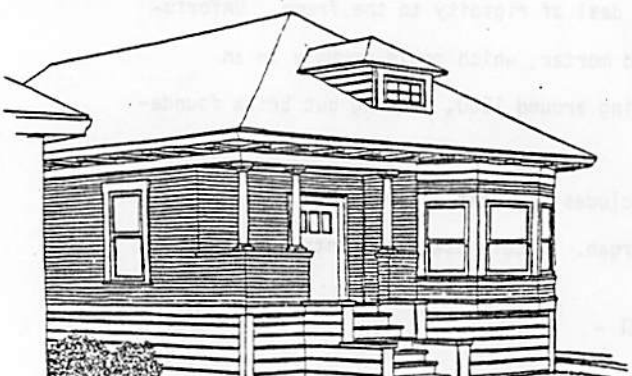
ITALIANATE



SAN FRANCISCO STICK

QUEEN ANNE

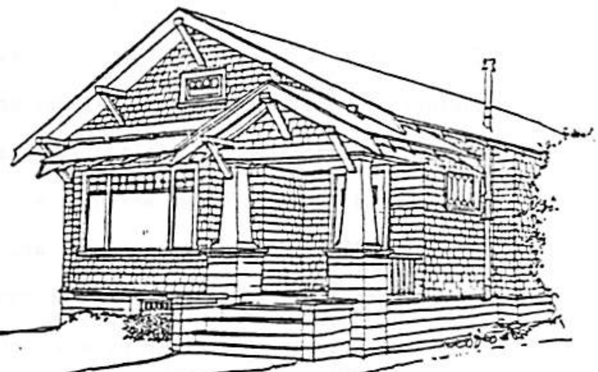
NEOCLASSIC ROWHOUSE



EASTERN SHINGLE COTTAGE

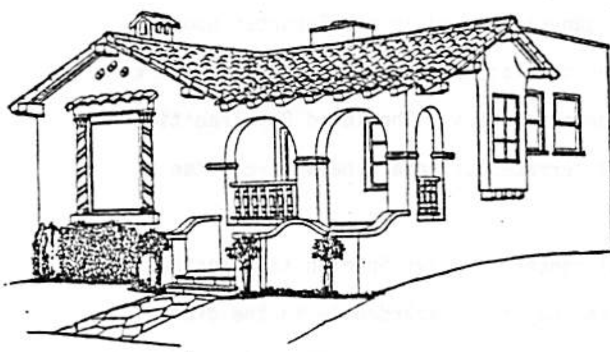
CALIFORNIA BUNGALOW

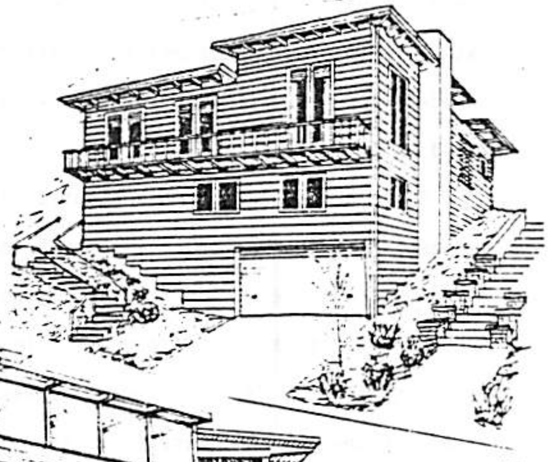
CRAFTSMAN BUNGALOW

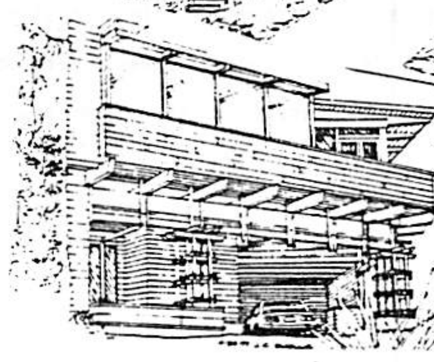


BROWN SHINGLE

MEDITERRANEAN STYLE







MODERN

FIGURE 2: Berkeley Architecture

SOURCES: City of Oakland Planning Department,[4] Berkeley Architectural Heritage Association[1] industrial materials such as concrete or asbestos. Decorative detailing is no longer seen (FIGURE 2). The Brown Shingle (1890-1915) has a plain design and a natural looking siding. Characteristic of the Craftsman (1905-1925) are wide overhanging beams and eaves, and combinations of natural untreated materials. The plain, square, stucco Prairie School design (1910-1925) is inspired by Frank Lloyd Wright. Very common throughout the flatlands are the California Bungalows (1910-1925), small, box-shaped, and usually stucco.[4]

The uniqueness of many First Bay Traditions make it impossible to generalize as to the quality of their construction. Shingle siding is usually, but not always placed over clapboard. When the clapping is arranged diagonally, the structure is very strong. Normal horizontal clapboard is good.[11] The California Bungalow is generally safer than the older and larger Victorian homes. Studs are set at a standard 16", with a solid concrete foundation beneath.[4] Stucco, covering clapboard walls, can be very strong. However, seasonal expansion and contraction of the foundation causes small cracks in the stucco. This weakening leaves the structure more vulnerable to earthquake shaking. The wood shingle styles are generally preferable to stucco.[11]

The Period Revival buildings (1900-1955) are imitations of various past styles. Among them are the English-Tudor, French Provincial, American Colonial, and Swiss Chalet. The English Cottage is common in North Berkeley. The Mediterranean style (1915-1935) (FIGURE 2), with stucco walls and Spanish tile roof, was often used for apartment buildings.

There is a wide variety of Modern houses in Berkeley (FIGURE 2). Second Bay Tradition buildings (1930-present) are generally low and horizontal, with flat, tightly-joined redwood or plywood siding. They are distinguished from Suburban houses (1945-present) by their sophisticated handling of materials. Wood or aluminum siding is generally used in the Suburban houses. The Multi-Unit buildings (1945-present) generally use stucco, flagstone, brick or masonry block exteriors, and outside steel frame stairways with cast-concrete steps. The Third Bay Tradition (1960-present), vertical boxes with wood siding and broad terraces or square bays, are often found in the hills.[1]

Certain features of Modern buildings warrant special concern. Heavy Spanish tile roofs, as seen in Mediterranean styling, are not well anchored and may fall hazardously to the ground. Multi-unit apartments in Berkeley commonly have ground-level garages, leaving very little lateral support for the large structures. This sort of building has suffered a disproportionate amount of damage in past California earthquakes. Many modern hill houses are built on stilts on unstable ground. This is unsafe unless there is a solid concrete foundation and shear-wall bracing.

The Site

How well buildings will perform during an earthquake depends also on the geology of the site (See page 5). The type of substrate is important. Bedrock is usually the safest material to build on, whereas alluvium may amplify earthquake vibrabions. Locations right on fault traces are very risky, though structures built on solid rock alongside the fault may be safer than those built on loose rock farther away. Interfaces between alluvium and rock can reflect and amplify shock waves.[2] Structural damage often depends on the vibrational period of the building compared to that of the ground.[3]

In the San Fernando earthquake, there were concentrations of severely damaged houses in the areas near the base of hills where there was a transition between alluvium and firmer soils. There was also a correlation between increased dwelling damage and greater slope.[5]

Landslides triggered by shaking pose a widespread threat to homes in the Berkeley hills. Unbraced houses may be severely damaged. Houses on poor foundations or on stilts are especially vulnerable. Liquefaction of artificial bay fill makes those soils extremely unsafe to build on.

The People

Many structures can sustain severe structural damage without necessarily harming the inhabitants. In the Alaska earthquake of 1964, major multi-story buildings suffered damage ranging up to 40% of their replacement values without accompanying life loss.[6] In the early Colonial Revival or Victorian houses, weak foundations are a problem, but the wood frame above should hold together. Though it is hard to predict, probably few injuries would result directly.[11] In the City of Berkeley as a whole, a few hundred residential deaths could easily result from a strong earthquake.[11]

The seismic concerns of homeowners are different from the seismic concerns of renters. Homeowners have a sizeable financial interest in strengthening or insuring their houses against structural damage. Renters have no financial incentive to protect their residence beyond the point of safety from injury. Almost 40% of the housing units in Berkeley are rented.[8] Neighborhoods vary from predominantly rented to mostly non-rented.

This difference in concerns should influence city-wide efforts to mitigate earthquake damage. For instance, government expenditures to aid in strengthening structures would only be in the interest of property owners.

The Combined Elements

One city block in each of three diverse neighborhoods in Berkeley was surveyed to evaluate seismic interests and concerns at different locations. Each area shows characteristic building styles, variations in geological hazards, and differing socio-economic composition (TABLE 1).

In the less expensive Flatlands location with mostly small single-story bungalows, one would expect the least earthquake damage. Here, most of the houses are rented. The hills location with many expensive, old, split-level homes, is on the least stable substrate. Earthquake losses would be very costly. Since most of the dwellings are owned by the residents themselves in this area, there is a strong economic incentive for them to strengthen their houses. The high density South Campus location has the oldest houses of the three neighborhoods. Though there is potential for great damage in this location, there is little impetus for the renters who live there to take preventative action. Clearly, the residential earthquake concerns are different in various parts of Berkeley.

BLOCK LOCATION/ BOUNDARY STREETS	GEOLOGICAL FEATURES	BUILDING CHARACTERISTICS	NEIGHBORHOOD: % RENTERS/ MEDIAN RENT
1. HILLS Spruce Oxford, Eunice Los Angeles	In part on fault trace, landslide area	Generally 1st Bay Tradition - many brown shingle, 2-3 story	14% $162
2. SOUTH CAMPUS Parker Carlton Dana Ellsworth	Alluvium substrate	Victorian & Colonial Revival, plus Multi-Units. 1-2 story, some 3-story apartments	84% $163
3. FLATLANDS Sacramento Spaulding Addison Allston	Alluvium substrate	California Bungalow, some Multi-Units. 1 story, except Multi-Units	90% $141

TABLE 1. Neighborhood Survey in Three Berkeley Neighborhoods. Architectural characteristics from each home were tabulated from Berkeley Architectural Heritage records. Renter information was derived from census tract data.[8]

Conclusion

Since most of Berkeley's houses are very old and major geological hazards are present, it may be concluded that costly structural damage will be common. Foundation failures will be common in a strong earthquake. The greatest economic losses will be felt by homeowners in the hills and East Berkeley where the older and larger houses are.

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