17th World Conference on Earthquake Engineering, 17WCEE
Sendai, Japan - September 13th to 18th 2020

THE EVOLUTION OF MANAGING SEISMIC RISK IN AMERICAN URBAN CENTERS AFTER THE LOMA PRIETA EARTHQUAKE: CHANGES IN CALIFORNIA AUTHORITIES AND FEDERAL STATUTES AFTER 1989

M. N. White[(1)], P. Yanev[(2)]

[(1)] *Principal, Law Offices of Mark N. White, mark.white@mnwhitelaw.com*
[(2)] *Principal, EQE Consulting, peter@yanev.com*

Abstract

In the urban centers of the Western United States, after the Loma Prieta earthquake of 1989, three realities have emerged that induce owners to improve the seismic performance of high-rises and other complex facilities. First, the applicable performance target for these complex facilities has expanded from preventing loss of life to reduction of property damage. An integral part of building codes in the Western United States is the reference standard *Minimum Design Loads for Buildings and Other Structures* (ASCE/SEI 7-10; see also 7-16, an updated version entitled *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* which will likely be adopted in the future). Since 1989, ASCE 7 has been modified to require greater protection of property, above and beyond traditional life-safety standards. This shift is reflected in local Western urban ordinances, as well as Federal NEHRP legislation which finances research and "an effective earthquake hazards reduction program" in order to achieve "the purpose of the Congress . . . to reduce the risks of life and property from future earthquakes and increase the resilience of communities" (28 United States Code section 7702, signed into law on December 11, 2018).

Another emerging reality that induces owners to improve seismic performance is the strengthening of the owner's duty to protect the personal and property interests of third parties, particularly when the field performance of complex facilities falls short of design predictions. This is demonstrated in complex litigation currently pending in California arising from the unexpected performance of the Millennium tower and the Transbay Transit Center, both located in San Francisco. These lawsuits are the natural extension of officially reported legal decisions in California, principally the ***Myrick*** and ***Beacon*** cases. Among the lessons learned from these legal authorities are: that owners are not automatically immune even if their facility meets minimum code requirements during an earthquake; and that design professionals can owe duties to avoid foreseeable harm to third parties with whom they have no contract.

A third evolutionary incentive in the Western United States is the strengthening of the owner's duty to assess whether planned or existing facilities suffer from vulnerabilities that would yield substandard performance during a foreseeable earthquake, even if they met or will meet minimum code requirements. This is reflected in ordinances (particularly in urban centers like Los Angeles and San Francisco) requiring assessment and retrofit of facilities suffering from vulnerabilities such as soft stories or non-ductile concrete assemblies.

One best practice that helps owners to minimize their performance gap exposure is to choose seismic performance targets that address potential harm inherent in the project's structural design, and to know, ahead of time, what the sworn testimony will be of their structural consultants concerning the chosen performance targets.

Keywords: performance gap, property damage, urban centers, California authorities, Federal statutes

1. Introduction

In the Western United States, the relationship between a facility owner and its design professionals does not remain static, but changes over time, certainly from generation to generation. The way structural consultants advise their institutional clients improves when the engineering profession learns hard lessons from unacceptable performance of facilities during foreseeable earthquakes, such as Northridge (1994) and Loma Prieta (1989). Among other things, during future earthquakes, design professionals do not want their facilities to experience the same shortcomings that manifested themselves in earlier earthquakes. Best engineering practices evolve to help both the design team and owners to better manage their seismic risk in the legal arena. In California, for instance, structural consultants changed the way they developed structural designs for certain complex facilities after many of the following seismic events in that state:

SIGNIFICANT AND HISTORIC EARTHQUAKES IN CALIFORNIA SINCE 1865
SOURCE: NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION [1]

YEAR	EARTHQUAKE	ESTIMATED MAGNITUDE	ESTIMATED DEATHS	ESTIMATED DAMAGES ($1,000,000)	EST/W CPI INFL ADJ (2019 $)
2019	RIDGECREST	7.1	0	NA	NA
2014	NAPA	6.1	1	$700	$760
2003	PASO ROBLES	6.6	2	$300	$420
1994	NORTHRIDGE	6.7	60	$40,000	$70,300
1992	LANDERS	7.6	3	$92	$170
1992	HUMBOLT COUNTY	7.1	0	$75	$140
1989	LOMA PRIETA	6.9	62	$5,600	$11,900
1987	WHITTIER NARROWS	5.7	8	$358	$825
1971	SAN FERNANDO	6.5	65	$505	$3,250
1952	KERN COUNTY	7.7	12	$60	$580
1933	LONG BEACH	6.3	120	$40	$800
1906	SAN FRANCISCO	7.9	700	$400	$10,000
1868	HAYWARD	6.8	30	$.35	NA
1865	SANTA CRUZ	6.3	NA	$.50	NA

Data accessed on January29, 2020. EST/W CPI INFL ADJ (2019 $) means estimated damages in millions of dollars, updated to December 2019 dollars using the NGDC inflation adjustment tool, based on the Consumer Price Index.

After discussing some of the lessons learned from the last significant earthquake in Northern California, this paper will focus on three realities that have emerged after the 1989 Loma Prieta earthquake in the San Francisco Bay Region. Each of these realities induces owners of complex facilities (including high-rises) to improve their seismic performance in foreseeable earthquakes.

First, the applicable performance target for complex facilities in urban centers has expanded from preventing loss of life to reduction of property damage.

Second, the owner's duty to protect the personal and property interests of third parties has increased, particularly when serious injuries could be sustained if and when the field performance of complex facilities falls short of design predictions.

Third, the owner's duty to assess whether planned or existing facilities suffer from vulnerabilities that would yield substandard performance during a foreseeable earthquake has increased, even if they met or will meet minimum code requirements.

2. A Model to Address Performance Gap Challenges in the Legal Arena

The cumulative effect of these emerging realities is that structural consultants are induced to advise owners earlier, and with more precision, what performance targets are prudent under the circumstances peculiar to the facility in question. In particular, one best practice that helps owners to minimize their **performance gap** exposure [2] is to select seismic performance targets that address potential harm inherent in the project's structural design, and to know, ahead of time, what the sworn testimony will be of their structural consultants concerning the chosen performance targets.

The latter conclusion is derived from awareness of not just patterns of professional engineering practice, but also the dynamics of the American legal system, which inevitably come into play when a complex facility experiences substandard performance during a foreseeable earthquake. Some of those legal dynamics are the offspring of the ever-evolving system that comprises the American "common law." Just as design professionals must ultimately predict the performance of their facilities, lawyers must ultimately predict the performance of judges and juries in relation to the merits of their client's case.

As used in this paper, "common law" refers to the process by which judges and juries spell out the details of legal obligations that may have limited corresponding statutory provenance; indeed, some legal obligations are untied to any specific statutory language. Because elements of American "common law" that are related to an owner's potential seismic liability are fluid and rarely fixed, design professionals are often mystified and frustrated by their inability to pin down legal liability in a manner that mimics their ability to comply with certain building code prescriptive requirements. Some of this confusion is reduced when we analyze what questions a judge will allow at trial, and how the corresponding expert testimony will address those seminal questions. Put another way, managing seismic risk in the legal arena requires an assessment of what the sworn testimony of design professionals will be long before the foreseeable earthquake occurs. Because this assessment takes place at the predictive intersection of the legal and design professions, here it will be called the **Performance Prediction Binary Model**. [3] A real-world example will help illuminate our model.

On October 17, 1989 (5:04 p.m. PDT), a magnitude 6.9 earthquake struck the San Francisco Bay Region. Poor performance of manmade structures caused the death of more than 60 people, along with several billions of dollars of direct damages. More than 40 of these victims died as a result of the collapse of the state-owned Cypress Viaduct, a two level, cast-in-place reinforced concrete, box girder bridge built in Oakland in 1957 and partially retrofit in 1977. [4] The viaduct was designed in 1949 and was located roughly 60 miles from the epicenter. Conventional wisdom appears to be that peak ground acceleration during the event was less than 0.30 gravity—most probably 0.25 to 0.29g on the high end. The viaduct was supported by soft Bay mud; bedrock was more than 500 feet below grade. During the earthquake, a large portion of the upper deck collapsed, causing the more than 40 deaths described above and injuries to more than 150 other victims. The prevailing explanation for the poor performance included the following: "The structure had nonductile detailing of the reinforced concrete and inadequate confinement in joints as measured by today's standards of practice." [5]

Recognizing the need to "aid the victims of the collapse of . . . the Cypress structure caused by the October 17, 1989 earthquake," the California Legislature added sections 997 through 997.6 to the California Government Code, which became effective on November 7, 1989, three weeks after the event. The gist of these provisions is that a fund was created by the state for distribution of monies to victims who submitted meritorious claims for compensation, without the usual necessity of filing a lawsuit and establishing fault on the part of the state. In the end, the vast majority of claims were resolved through the special claims process and only a handful of lawsuits made it to the courthouse steps on the eve of trial, when they were also settled. No reported cases were tried to a jury or appealed. The state appropriated more than $110 million for distribution, of which more than $70 million was paid to victims. [6]

What lessons can be learned from the Cypress Viaduct collapse and the ensuing compensation to innocent victims? Some relate to future management of seismic risk in the legal arena, under the auspices of expected testimony from expert witnesses. First, a public highway (such as the Cypress Viaduct) should not be expected to collapse when exposed to peak ground acceleration (PGA) of 0.30g or less. Second, when the public owner is unlikely to establish an exonerating defense, it will likely take tangible steps to compensate innocent victims of the substandard performance. Third, in the process of assessing whether the substandard performance could reasonably have been avoided, the public owner will consider whether the seismic vulnerability that proximately caused the poor performance was known or discoverable before the earthquake.

In the case of the Cypress Viaduct collapse, the state commissioned a report from technical experts (denominated a Board of Inquiry) to evaluate the state's familiarity with the seismic vulnerability before the collapse. [4] The gist of the Board's conclusions includes the following:

- The Cypress Viaduct design conformed to state agency standards when it was built in the 1950s. It had inadequate rebar confinement and thus was "non-ductile" in design and construction. Ductile design techniques were not employed by the state agency until the 1960s. [7]
- After the 1971 San Fernando earthquake, the state agency changed its general design practices to require ductile detailing in order "to achieve adequate seismic performance of reinforced concrete bridges." [8]
- After the 1987 Whittier Narrows earthquake, the state agency "embarked on a program to retrofit weak columns and evaluate the seismic performance of [its] structures" because of "the near collapse of the retrofitted I-605/I-5 overcrossing." But, despite this general awareness of the seismic vulnerability of its non-ductile highway components, the "short time since the 1987 Whittier Narrows earthquake was not enough for [it] to identify the vulnerability of the Cypress Viaduct." Thus, the "general observation did not translate into a specific understanding of the true seismic hazard posed by the Cypress Viaduct and did not cause it to be singled out as a high risk structure." [9]
- If a "modern engineering seismic assessment of the Cypress Viaduct [had been] conducted before the earthquake," it probably would have determined that "Collapse would have been anticipated for the intensity of ground motion that did occur at the Cypress Viaduct site in the Loma Prieta earthquake, however, the extent of the collapse would probably not have been anticipated." [10]

Applying the Performance Prediction Binary Model to the known facts about the Cypress Viaduct collapse yields the following after-the-fact analysis. The relationship in play is that between the state agency and citizens using a state highway. The state has waived its sovereign immunity and has a duty under California law to provide reasonable protection to the citizens using its highways. During the Loma Prieta earthquake, the seismic capacity of the Cypress Viaduct was exceeded by the moderate spectral acceleration and shaking that it experienced in response to the local peak ground acceleration at grade (most likely less than 0.30g and more than 0.25g). As to the temporal element of the model, before the earthquake, the state agency had general knowledge of the vulnerability inherent in non-ductile detailing, but less than two years to assess the extent to which the Cypress Viaduct was specifically vulnerable. After the earthquake, the state moved promptly to limit the dislocations created by litigation and paid out $71 million in less than three years to settle all claims. After the earthquake and before commencement of the claims system, most defense counsel would have advised the state that the likelihood was high that a jury would conclude that the agency had failed to act reasonably when it kept an unsafe highway component open for use, thereby putting unsuspecting drivers at extraordinary risk.

Applying the Performance Prediction Binary Model to contemporary situations can help owners better manage their legal exposure profile, particularly if (a) emerging realities are considered and (b) corrective action is taken before a foreseeable earthquake demonstrates in real time that a gap exists between what was promised beforehand, and actual problematic performance in the field.

3. First Emerging Reality: Applicable Performance Targets for Complex Facilities Have Expanded from Preventing Loss of Life to Reduction of Property Damage

When an owner discusses with its structural consultant which seismic performance targets should be pursued, it is better practice to consider which outcomes must be avoided and which interests of third parties must be protected. It is axiomatic that for decades the primary performance objective for complex facilities in urban settings was the avoidance of catastrophic collapse, which corresponded to loss of human life and serious personal injury. [11] Most owners will want their structural consultants to predict that such a facility will carry its gravity load and facilitate safe exit by occupants during all foreseeable earthquakes.

However, after the Loma Prieta earthquake, another performance target is increasingly being required of complex facilities in urban settings: minimization of property damage and improved resiliency. As these expectations become more widely known, the common law system changes and what a juror will conclude is “reasonable” becomes more demanding for the owner. Since 1989, expectations have increased at the grass-roots level that not only should occupants be able to walk away from the facility after a severe earthquake, but the property interests in the facility should remain largely intact as well, with manageable levels of repair in the offing.

Applicable code-based performance targets for high-rises and other complex facilities have expanded from preventing loss of life to reduction of property damage. An integral part of building codes in the Western United States is the reference standard *Minimum Design Loads for Buildings and Other Structures* (ASCE/SEI 7-10; see also ASCE 7-16, an updated version entitled *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*; the two will be referred to interchangeably as ASCE 7 here). [12] California regularly incorporates certain ASCE 7 chapters covering earthquake loading and structural design requirements into its building code. *See, e.g.,* section 1613.A.1 of the 2013 California Building Code and its successor, section 1613.1 of the 2019 California Building Code. Since 1989, ASCE 7 has increasingly required greater protection of property, above and beyond traditional life-safety standards. For instance, the ASCE Commentary for ASCE section11.5.1 explains that one purpose of the Importance Factor is to “reduce damage for important structures in addition to preventing collapse in larger ground motions.” [12] Section 11.5 covers “Importance Factor and Risk Category” and its “fundamental purpose” is “to improve the ability of a community to recover from a damaging earthquake by tailoring the seismic protection requirements to the relative importance of a structure.” [12] This objective is achieved by “requiring improved performance of structures that . . . Present the potential for catastrophic loss in the event of an earthquake”, among other things. Both ASCE 7 and the California Building Code have, for several years, required high-rises to be classified as Risk Category III structures when they “represent a substantial hazard to human life in the event of a failure.” *See, e.g.,* 2013 and 2019 California Building Code, Table 1604.5.

Most residential high-rises built in San Francisco after Loma Prieta were designed and built to meet the performance targets of Risk Category II, while most mixed-use high-rises arguably were designed to meet the requirements of Risk Category III. [13] Many expert witnesses will testify that virtually all of these residential high-rises should have been designed and built to Risk Category III, which mandates a substantially lower collapse rate in MCE earthquake scenarios. Many of those experts will also testify that San Francisco's General Plan (particularly its Community Safety Element) [14] requires all new high rises to minimize property damage and to allow residents to promptly return to their residential condominiums after a significant earthquake. Because ASCE 7 contemplates that up to ten percent of all Risk Category II high-rises will collapse in an MCE, it is foreseeable that two or more residential high-rises will be expected to collapse during the next MCE in San Francisco, with substantial loss of life, personal injury and devastating economic loss. Legal counsel and experts for the injured parties will almost certainly argue that any such collapsed tower should have adhered to the stricter requirements of Risk Category III.

As recently as December 2018, the United States House of Representatives, Senate and executive branch endorsed the adoption of community resiliency and damage reduction as national performance objectives by enacting and executing NEHRP legislation which finances research and "an effective earthquake hazards reduction program" in order to achieve "the purpose of the Congress . . . to reduce the risks of life and property from future earthquakes and increase the resilience of communities" (28 United States Code section 7702, signed into law on December 11, 2018).

4. Second Emerging Reality: Increasingly, the Common Law Requires Owners to Protect the Personal and Property Interests of Third Parties from Catastrophic Injury or Loss

Another emerging reality that induces owners to improve seismic performance is the strengthening of the owner's duty to protect the personal and property interests of third parties, particularly when the field performance of complex facilities falls short of design predictions. This is currently demonstrated in complex litigation currently pending in California arising from the unexpected performance of the Millennium Tower and the Transbay Transit Center, both located in San Francisco. [15] These lawsuits are the natural extension of officially reported legal decisions in California, principally the ***Myrick*** and ***Beacon*** cases. Among the lessons learned from these legal authorities are: that owners are not automatically immune from legal exposure even if their facility meets minimum code requirements during an earthquake; and that design professionals can owe duties to avoid foreseeable harm to third parties with whom they have no contract.

Most judges rely on statutes and published legal precedent when assembling jury instructions. In California, the basic rule of tort liability for property owners (including an owner of a high-rise) is that the **owner** must use ordinary care in the management of his or her property to prevent injury to another. California Civil Code, section 1714. California's leading precedent concerning legal liability for poor seismic performance suggests that the owner of a high-rise will be expected to act to prevent unsatisfactory seismic performance that may result from foreseeable earthquakes, even if it was designed, built and operated in accordance with minimum code standards.

In the published court opinion entitled ***Myrick v. Mastagni*** (2nd District 2010) 185 Cal. App. 4th 1082 (***Myrick***), the trial judge, the jury and the court of appeal all found that a building owner can have legal liability for the poor seismic performance of a structure even if its management and use is in accordance with the minimum standards of local ordinances and building codes. In that case, during the 2003 Paso Robles earthquake, a commercial roof collapsed when exposed to peak ground acceleration on the order of 0.25g, causing the death of two passers-by, leading to an award of $2 million in damages after a lengthy jury trial.

As a matter of law, is a **design professional** who contracts directly with the project developer automatically immune from legal liability when a party with whom it has no contractual relationship claims that it is entitled to damages for the poor seismic performance of the facility? In most American courts, the answer will be in the negative! In a published California Supreme Court opinion filed July 3, 2014 and entitled ***Beacon Residential Community Association v. Skidmore, Owings & Merrill LLP et al.*** (2014) 59 Cal. 4th 568 (**"*Beacon*"**), the California Supreme Court held that the architects who had directly contracted with the developer owed a non-statutory duty of care to follow-on purchasers of project units despite the absence of any contractual relationship with the follow-on purchasers and despite language in the architects' contracts that attempted to limit their liability to future follow-on purchasers. Most American courts would apply similar reasoning and reach the same conclusion if follow-on purchasers pursued claims for poor performance of project units during an earthquake against the structural engineers of record who had contracted directly with the developer.

5. Third Emerging Reality: Increasingly Owners are Required to Assess Whether Planned or Existing Facilities Suffer from Vulnerabilities that Would Yield Substandard Performance During a Foreseeable Earthquake

A third evolutionary incentive in the Western United States is the strengthening of the owner's duty to assess whether planned or existing facilities suffer from vulnerabilities that would yield substandard performance during a foreseeable earthquake, even if they met or will meet minimum code requirements. This is reflected in ordinances (particularly in urban centers like Los Angeles and San Francisco) requiring assessment and retrofit of facilities suffering from vulnerabilities such as soft stories or non-ductile concrete assemblies.

Before Loma Prieta, conventional wisdom among structural consultants was that there was, in the absence of impending collapse, no duty for owners of complex facilities to assess or remediate known seismic vulnerabilities in their structures. As long as the structure had earlier met code minimums, an operational philosophy prevailed of "if it ain't broke, don't fix it." Poor performance of soft-story structures during Loma Prieta changed that. In 2013, San Francisco enacted a mandatory wood-frame soft story program that "requires property owners to seismically strengthen vulnerable buildings that have an increased risk of danger during an earthquake." [17] The gist of the ordinance is that certain structures suspected of having a soft-story vulnerability must be assessed by a design professional for seismic capacity, and a report provided to a city agency; if capacities are below specified thresholds, the facility must either be remediated or demolished. The City of Los Angeles followed suit, enacting its equivalent soft-story ordinance, effective November 2015 and amended February 2016. [18]

With regard to older non-ductile concrete structures, however, Los Angeles enacted its mandatory plan in October 2015. [19] Similarly, The gist of the ordinance is that certain reinforced concrete structures suspected of having a non-ductile detailing vulnerability must be assessed by a design professional for seismic capacity, and a report provided to a city agency; if capacities are below specified thresholds, the facility must either be remediated or demolished. When retrofit plans are submitted for approval, the design professional is required to provide a certification along the following lines: "I am responsible for designing this building's seismic strengthening in compliance with the minimum standards of Chapter 95 of the Los Angeles Building Code using the design criteria of (75% of ASCE 7 or ASCE 41)." [20]

6. Conclusion

How does the developer and the lead structural consultant manage their respective legal risks when they develop, design, build and operate a complex facility in California, such as a high-rise in San Francisco? The starting point for meeting this challenge is to develop a strong evidentiary record long before the facility is subjected to a service level (or more severe) earthquake. This includes knowing ahead of time what evidence concerning development of the structural design will be presented to a judge and jury in the event the facility performs poorly in a foreseeable earthquake. In particular, the developer and the lead structural consultant should establish a clear understanding of the performance target. [16]

In summary, one best practice that helps owners to minimize their performance gap exposure is to choose seismic performance targets that address potential harm inherent in the project's structural design, and to know, ahead of time, what the sworn testimony will be of their structural consultants concerning the chosen performance targets long before construction commences.

7. References

[1] National Centers for Environmental Information. Website:ngdc.noaa.gov. The relevant data was derived from the following search on January 29, 2020: https://www.ngdc.noaa.gov/nndc/struts/results.

[2] The failure of a complex facility to meet the performance targets that have been specified by the design team will be referred to as the "performance gap."

[3] The **Performance Prediction Binary Model** includes the following elements. "**WREST**" is a mnemonic for the analysis that answers the question "**W**hose **Re**lationship plays out in **S**pace and **T**ime following a significant earthquake?" **Re**lationship refers to the legally cognizable interconnected interests and duties of two parties. **W**hose refers to two entities who are interconnected. **S**pace refers to relevant physical characteristics of the built environment, such as the demand/capacity ratios calculated by the structural consultant for an element of the structural system of a facility. **T**ime refers to events before and after one seminal event (or more than one), which often is an earthquake that triggers unacceptable performance by the facility. The analysis includes formulating a series of questions posed by trial counsel to an expert design professional, and the corresponding answer, in a specific hypothetical scenario (for example, how would the base isolaters at the retrofitted San Francisco City Hall perform if they were exposed to ground acceleration replicating the 1906 San Francisco earthquake?).

[4] Cable restrainer units were installed at all hinges in the 1977 retrofit. Yashinsky, M. (1998): The Loma Prieta, California, Earthquake of October 17, 1989 – Highway Systems, *U.S. Geological Survey Professional Paper 1552-B*, United States Government Printing Office, Washington, D.C, USA, p.19. Information concerning the Loma Prieta earthquake and the Cypress Viaduct collapse was derived from the following sources:Thiel Jr., C., ed. (1990): Competing Against Time, *Report to Governor George Deukmejian from the Governor's Board of Inquiry on the 1989 Loma Prieta Earthquake*, State of California, Office of Planning and Research, Sacramento, California, USA (hereinafter "Board of Inquiry Report"); Nims, D.K., Miranda, E., Aiken, I.D., Whittaker, A.S., Bertero, V.S. (1989): Collapse of the Cypress Street Viaduct As A Result of the Loma Prieta Earthquake, *Report No. CB/EERC-89/16*, University of California at Berkeley, Berkeley, California, USA; Harris, R.A., (1998): The Loma Prieta, California , Earthquake of October 17, 1989 – Forecasts, *U.S. Geological Survey Professional Paper 1550-B*, United States Government Printing Office, Washington, D.C., USA.

[5] Board of Inquiry Report, Finding No. 34.

[6] Lundgren, D.E. (June 25, 1992): News Release, *Office of the Attorney General of the State of California,* Sacramento, California, USA. *See also* Wojcik, J. (June 29, 1992): State ADR Program Speeds Settlement of Quake Claims, *Business Insurance,* Crain Communications Inc, Detroit, Michigan, USA.

[7] Board of Inquiry Report, *see, e.g.,* Finding Nos. 30 and 31.

[8] Board of Inquiry Report, Finding No. 32.

[9] Board of Inquiry Report, Finding No. 32.

[10] Board of Inquiry Report, Finding No. 34.

[11] Osteraas, J. (2020): Earthquake Engineering in an Aggressive Legal Climate, *17th World Conference on Earthquake Engineering, Paper No. 2426,* Sendai, Japan (hereinafter "Osteraas 2020").

[12] ASCE (2010): Minimum Design Loads for Buildings and Other Structures, *ASCE/SEI 7-10*, American Society of Civil Engineers, Reston, Virginia, USA ; ASCE (2016) Minimum Design Loads and Associated Criteria for Buildings and Other Structures, *ASCE 7-16,* American Society of Civil Engineers, Reston, Virginia, USA.

[13] White, M.N. (2020): The Virtual Elasticity Performance Target for High-Rises in San Francisco After 2008: From Preventing loss of Life to Reduction of Property Damage and Related Performance Gap Patterns, *17th World Conference on Earthquake Engineering, Paper No. 1091,* Sendai, Japan (hereinafter "White High-Rises 2020").

[14] https://generalplan.sfplanning.org/Community_Safety_Element_2012.pdf. The first stated objective is: "REDUCE STRUCTURAL AND NONSTRUCTURAL HAZARDS TO LIFE SAFETY AND MINIMIZE PROPERTY DAMAGE RESULTING FROM FUTURE DISASTERS."

[15] White: High-Rises 2020.

[16] Osteraas 2020.

[17] http://sfdbi.org/property-owners, accessed on January 29, 2020, referring to Ordinance No. 66-13 of the City and County of San Francisco (signed April 18, 2013). Proposed seismic evaluations and retrofit plans must demonstrate satisfaction of certain performance objectives. *See, e.g.,* section 3406B.2. The City of Santa Monica was among the first to require assessments of soft-story structures and developed a comprehensive program in 2017. *See, e.g.,* https://www.latimes.com/local/lanow/la-me-ln-santa-monica-earthquake-retrofit-20170328-story.html, accessed January 29, 2020.

[18] Ordinance Nos. 183893 and 184081 of the City of Los Angeles.

[19] Ordinance No. 183893 of the City of Los Angeles, amending Division 95 of Article 1 of Chapter IX of the Los Angeles Municipal Code. San Francisco has not yet adopted a similar plan.

[20] Ordinance 183893, section 91.9509.2

