GLOBAL RISK FORUM GRF DAVOS GRF planet@risk http://www.planet-risk.org

Improving Seismic Capacity of New Concrete Ductile Core High-Rises: Costs and Benefits of Managing Seismic Risk in the Legal Arena

WHITE, Mark N.[a], and OSTERAAS, John D.[b]

[a] Law Offices of Mark N. White, Berkeley, California, U.S.A., email: mark.white@mnwhitelaw.com
[b] Exponent – Failure Analysis Associates, Menlo Park, California, U.S.A., email: osteraas@exponent.com

Abstract – In San Francisco and other urban centers, developers are increasingly choosing concrete ductile core designs for their new high-rise projects (most are more than 160 feet in height and many are upwards of 40 stories). Many of these new designs incorporate only a single system for resisting lateral seismic loading. This design approach has not yet been tested by a significant earthquake in the western United States. For instance, the August 24, 2014 Napa earthquake (M 6.0) generated peak ground acceleration on the order of three percent gravity (or less) at ground zero for San Francisco's relatively new concrete ductile core high-rises, nowhere near the level of ground acceleration expected in DBE or MCE earthquakes with epicenters inside 15 miles of ground zero. ASCE 7 provides guidance to the developer when threshold seismic performance targets are selected, specifying appropriate "Risk Categories" and "Importance Factors". When the expected occupancy use is residential, most owners and structural designers use Risk Category II, with an Importance Factor of 1.00. In contrast, when the structure is expected to be used as an office building, many owners and structural designers use Risk Category III, with an Importance Factor of 1.25. Using Risk Category III and an Importance Factor of 1.25 for new high-rise residential projects employing the concrete ductile core design approach should increase the seismic resiliency and simultaneously reduce the owner's legal risk profile because of expected improved seismic performance in DBE and MCE events. Taking into account the extra costs of construction, adhering to Risk Category III design criteria should yield substantial long-term benefits for owners of these high-rises and help to manage their seismic risk in the legal arena.

Keywords – *legal risk; seismic risk; high-rises; structural design; seismic performance*

1. Introduction

Developers of high-rise towers (as used herein, tower structures taller than 160 feet) in San Francisco, Los Angeles, and other Pacific Rim urban centers in active seismic zones are faced with design resiliency choices that have significant ramifications for commercial risk and potential legal liability. Before finalizing those design choices, developers should understand that their potential legal risk profile will be shaped by the substance of the advice concerning expected earthquake performance and residual seismic capacity that they receive from their structural design consultants during the design development phase of the project. Before committing to a specific structural design for construction in the field, developers should engage advisors to predict the type of sworn testimony by its design team that a facility owner is ready to invoke to protect the owner's interests in the event the owner's high-rise performs poorly in a foreseeable earthquake. Put another way, before the structural design for the new high-rise is finalized, the developer should receive a description of the evidentiary record that its design team is developing concerning the seismic capacity of the proposed facility. This will enable the developer to make a better-informed decision about which structural design approach should be selected and how to allocate resources to implement it in the field. This information will also temper the customary proclivity of developers (and owners) to invest only enough to satisfy the minimum requirements of local building codes, as interpreted by local regulators who are not necessarily committed to minimizing personal injuries or property damage arising from foreseeable earthquakes.

Many of the practical decisions underlying the strategic course chosen by the developer (or owner, or both) will be discussed below, often in the context of San Francisco's peculiar regulatory environment for residential high-rises. For purposes of illustration, a hypothetical will be used: a developer/owner plans to demolish two vacant buildings (each less than four stories in height) and replace them with a single forty-story concrete ductile core high-rise (four hundred feet in height), to be rented as residential apartments over a thirty year period. The project is situated in a densely populated part of San Francisco, not far from the San Andreas and Hayward faults. In the process of deciding how to meet San Francisco's regulatory requirements for the proposed high-rise, the developer/owner decides which performance target its design consultants should include in the structural design for the project and considers the respective costs and benefits of available strategies for managing its seismic risk in the legal arena.

2. Targeting Resiliency for Concrete Ductile Core High-Rises: Seismic Performance Profiles

As high-rise developers increasingly choose concrete ductile core designs for their new developments, they face the seminal choice of adhering to the structural requirements for Risk Category III specified by the American Society of Civil Engineers in its design standard entitled Minimum Design Loads for Buildings and Other Structures, ASCE/SEI 7-10 (hereinafter "ASCE 7-10") or the less stringent and less costly standards of Risk Category II. Section 1613.1 of the San Francisco Building Code (and of the California Building Code) in pertinent part has long provided that "Every structure . . . shall be designed and constructed to resist the effects of earthquake motions in accordance with ASCE 7 . . . ."

In San Francisco and many other municipalities, the risk category choice made by the developer is routinely endorsed by the permit-granting authority. But, as will be demonstrated below, municipal approval at the permitting stage does not automatically insulate the developer or the owner from significant commercial risk and extraordinary legal liability should the facility perform unsatisfactorily in a foreseeable earthquake. In most scenarios, before construction in the field commences, it will be advantageous for the developer to understand how its legal risk profile will be affected by the seismic performance of its proposed high-rise.

2.1. Transformation of designs for high-rise towers and three commercial considerations inherent in the "concrete ductile core" design approach

Traditionally, developers in seismically active areas of the western United States selected structural steel designs for their high-rise projects, many of which were used for commercial purposes. Since the latter part of the twentieth century and during the first decade of this century, developers of residential high-rise towers have increasingly chosen "a substantial concrete shear-wall core [design] to provide earthquake resistance" (Yanev & Thompson, 2008: 95). These new residential (and sometimes mixed-use) facilities use "concrete core-wall construction without supplemental moment frames in the seismic-force-resisting system" because this design approach "can offer advantages of lower costs, faster construction, and more open and flexible architecture" (Maffei, 2007: 28). Some leading proponents of this design approach refer to them as "concrete ductile core high-rises." [1]

Certain commercial considerations are inherent in choosing the concrete ductile core design approach for the developer's high-rise. One is that there is a "potential lack of redundancy in the structural system" (Yanev & Thompson, 2008: 95). Put simplisticly, omitting second lines of defense to protect the high-rise tower against lateral seismic demands (such as the "supplemental moment frames" referred to in the preceding paragraph) can increase the potential for poor performance during foreseeable earthquakes. "If the shear wall fails due to unexpected loading or unanticipated structural behavior, there is no second line of defense to prevent the tower from collapsing" (ibid.). The consequences of loss of structural integrity or, less frequently, collapse, can be devastating for the institutional owner: diminution in the value or utility of resources invested in the high-rise; substantial additional resource expenditure for repair or demolition or replacement; loss of commercial revenues; defense against legal claims of breach of commercial obligations; defense against claims of wrongful death or personal injury; satisfying adverse legal judgments. In many scenarios, the death, destruction and downtime that results from poor seismic performance can put the institutional owner (often a corporation) out of business after a significant foreseeable earthquake.

Another commercial concern is that these new tall concrete buildings have not been field-tested in "very long and large earthquakes" in urban centers of the western United States. Because no great earthquake has been experienced "in the mainland U.S. in modern times . . . we do not have the evidence to demonstrate the ultimate effectiveness" of the concrete ductile core structural design approach (Yanev & Thompson, 2008: 95). According to the United States Geological Survey website (`http://www.comcat.cr.usgs.gov`), the August 24, 2014 Napa earthquake (M 6.0) exposed the concrete ductile core high-rises in San Francisco to peak ground accelerations at ground zero on the order of three percent gravity or less (see also the Earthquake Engineering Research Institute website, `http://www.eqclearinghouse.org`). This level of ground acceleration is far less than the 60 percent gravity (or more) that can be expected in San Francisco during a Maximum Considered Earthquake (MCE) (`http://www.earthquake.usgs.gov/designmaps/ut/application.php`), and it is generally accepted that no such level of ground accel-

[1] When applying for the building permit for their proposed residential high-rise in San Francisco, the developer and structural engineer often describe the proposed structural system as "a ductile reinforced concrete wall system with a maximum height above [the] limit" specified in ASCE 7-10 Table 12.2-1 (more than 160 feet) and the "lateral system" in the structural design is described as "concrete shear walls."

eration has been experienced in downtown San Francisco or downtown Los Angeles since the 1903 San Francisco earthquake.

A third commercial concern is that the structural engineer of record for a high-rise taller than 160 feet in a seismically active urban center (e.g., San Francisco and Los Angeles) will not be able to routinely follow the prescriptive provisions of the operative municipal building code (usually modeled after the International Building Code ("IBC")) because most American building codes are "based around the dynamic behavior of low- and medium-rise structures, not the more complex dynamic behavior of tall buildings" (Yanev & Thompson, 2008: 95). This alternate approach is generally referred to as a performance-based design. As a practical matter, the developer will usually need to incur the extra time and expense of engaging a "peer review" panel to verify that the structural engineer of record has demonstrated that the alternate design is "at least the equivalent of that prescribed in [the local version of the IBC] in quality, strength, effectiveness, fire resistance, durability and safety."[2]

Administrative Bulletin 83 of the San Francisco Building Code (adopted on March 25, 2008 and updated January 1, 2014; "AB-083") is the mechanism commonly used to demonstrate to a peer review panel that the developer's proposed concrete ductile core high-rise in San Francisco will have the same seismic performance characteristics contemplated by the IBC. The structural engineer must demonstrate adequate performance of the proposed high-rise in three earthquake scenarios. First, during a "service-level" earthquake (that is, one with a 50% probability of exceedence in 30 years), the "primary structural system is required to demonstrate acceptable, essentially elastic seismic performance" (AB-083: 83-4). Only minor damage to the primary structural system is allowed. Second, during a "code-level" earthquake (defined as an earthquake with a 10% probability of exceedence in 50 years, traditionally referred to as a "Design Basis Event"), the primary structural system must be shown to adhere to the "story drift ratio limitations of the San Francisco Building Code," among other things (ibid.). Third, during a "Maximum Considered Earthquake" ("MCE" as defined in ASCE 7-10, Chapter 21, replacing the traditional definition based upon an earthquake having a 2% probability of exceedence in 50 years), "Calculated force and deformation demands on all elements required to resist lateral and gravity loads shall be checked to ensure they do not exceed element force and deformation capacities" (AB-083: 83-7).

San Francisco's AB-083 was and is based on the design recommendations presented in the Tall Buildings Initiative: Guidelines for Performance-Based Seismic Design of Tall Buildings ("TBI")[3]. The TBI design recommendations are intended to satisfy the following performance capabilities specified for Risk Category II structures in ASCE 7-10 : withstand Maximum Considered Earthquake shaking, as defined in ASCE 7, with low probability (on the order of 10%) of either total or partial collapse; withstand Design Earthquake shaking, having an intensity two thirds that of Maximum Considered Earthquake shaking without generation of significant hazards to individual lives through design measures intended to assure that nonstructural components and systems remain anchored and secured to the structure and that building drifts are maintained at levels that will not create undue hazards; and withstand relatively frequent, more moderate-intensity earthquake shaking with limited damage.

Although the starting point for the TBI guidelines is the assumption that high-rises will be required to meet the threshold performance requirements for Risk Category II structures, they also contemplate that for some structures it "may be desirable . . . [for the design] to achieve performance superior" to that required for Category II structures (TBI, 2010: 8). ASCE 7-10 Risk Category III design standards are one collection that would yield better performance in new concrete ductile core high-rises. For instance, when calculating the minimum design load for a Category II structure, the "Seismic Importance Factor" value is 1.0; for a Category III structure, a higher design load is calculated because its "Seismic Importance Factor" is 1.25 (ASCE 7-10, section 1.5.1 and Table 1.5-2).

2.2. Seismic Risk Categories and Seismic Importance Categories

Section 1.5.1 of ASCE 7-10, entitled "Risk Categorization," provides the following explanation and directives. "Buildings . . . shall be classified, based on the risk to human life, health, and welfare associated with their damage or failure by nature of their occupancy or use, according to Table 1.5-1 for the purposes of applying . . . earthquake . . . provisions. Each building . . . shall be assigned to the highest applicable risk category or categories. . . ."(ASCE 7-10, section 1.5.1)[4]. Pursuant to the directives of section 11.5.1 of ASCE 7-10, developers and their design team are required to assign an "importance factor" for their proposed high-rise project in accordance with

[2]Maffei, 2007: 28. See International Building Code, Section 104.11. In San Francisco, the operative provision is Section 104.2.8 of its 2013 version of the Building Code. See also, ASCE 7-10, section 11.1.4. When the developer chooses performance-based procedures for developing its structural design, it must meet the requirements of ASCE 7-10 section 1.3.1.3, including meeting the burden of demonstrating to the peer review panel that its design will provide seismic performance that is equivalent to the prescriptive requirements of ASCE 7-10 and the California Building Code. "Section 1.3.1.3 requires demonstration that a design has adequate strength to provide an equivalent or lower probability of failure under load than that adopted as the basis for the prescriptive requirements of [ASCE 7] for buildings . . . of comparable risk category. Tables C.1.3.1a and C1.3.1b summarize performance goals associated with protection against structural failure . . . ." Commentary to ASCE 7-10, section C1.3.1.3 at page 317. In the event of poor performance, it can be anticipated that the developer and its design team will be accused failing to satisfy their burden of "rigorously" justifying deviation from ASCE 7 guidelines. See Commentary to ASCE 7-10, section C12.1, at page 397 (any deviations from Chapter 12 of ASCE 7 "must be rigorously justified").

[3]Pacific Earthquake Engineering Research Center, Report No. 2010/05. See Yang, Bozorgnia, & Mohele (2008).

[4]"The importance factor . . . is used throughout [ASCE 7] in quantitative criteria for strength. In most of those quantitative criteria, the importance factor is shown as a divisor on the factor R or Rp to reduce damage for important structures in addition to preventing collapse in larger ground motions. . . . For a given strength demand, reducing the effective R factor (by means of the importance factor) increases the required yield strength, thus reducing ductility demand and related damage" (Commentary to ASCE 7-10, section C11.5, at page 392).

Table 1.5-2. The Commentary to ASCE 7 explains that the "fundamental purpose" of section 11.5 of ASCE 7-10 "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 the structure. That purpose is achieved by requiring improved performance for structures that . . . [among other things, present] the potential for catastrophic loss in the event of an earthquake . . . . The first basis for seismic design in the standard is that structures will have a suitably low likelihood of collapse in rare events defined as the maximum considered earthquake (MCE) ground motion. A second basis is that life-threatening damage, primarily from failure of nonstructural components in and on structures, will be unlikely in a design earthquake ground motion (defined as two-thirds of the MCE). . . . [ASCE 7] addresses these objectives by requiring that each structure be assigned to one of the four risk categories presented in Chapter 1 and by assigning an importance factor . . . to the structure based on that risk category. . . . The risk category . . . is a primary factor in setting drift limits for building structures under the design earthquake ground motion (see Section C12.12)" (Commentary to ASCE 7-10, page 392). Section 1.2.1 of ASCE 7-10 states that the Risk Category selected by the developer and its structural consultants determines "the earthquake loads based on the risk associated with unacceptable performance. See Table 1.5-1."

According to Table 1.5-1 of ASCE 7-10, the definition of a Category III high-rise is one "the failure of which could pose a substantial risk to human life" or one "with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure." Table 1604.5 of the California Building Code provides non-exclusive examples of Category III facilities, but specifies (like ASCE 7-10) that structures should be classified as Category III if they "represent a substantial hazard to human life in the event of a failure." Section 1.5.1 of ASCE 7-10 states "Each building or other structure shall be assigned to the highest applicable risk category or categories." The Commentary to ASCE 7-10, section C1.5.1 states that risk categorization should be "based on the number of persons whose lives would be endangered or whose welfare would be affected in the event of failure." According to Figure C1-1 in the ASCE 7-10 Commentary, if the number of persons directly at risk exceeds a few hundred, the facility should be classified as Category III (ASCE 7-10 Commentary: 321 and Figure C1-1)[5].

If a developer of a new concrete ductile core high-rise is overly aggressive in slimming down its structural design, it leaves itself open to criticism that it is acting contrary to the policy of conservatism for non-redundant seismic systems. "The provisions of [ASCE 7-10] anticipate an SFRS [seismic force-resisting system] with redundant characteristics wherein significant system strength above the level of the first significant yield can be obtained by plastification at other critical locations in the structure before the formation of a collapse mechanism. If excessive 'optimization' of a structural system is performed with lateral resistance provided only by a few elements, the successive yield hinge behavior depicted in Figure C12.1-1 will not be able to form, the actual overstrength . . . will be small, and use of the seismic design parameters in the standard may not provide the intended seismic performance" (Commentary for ASCE 7-10, section C12.1, at page 399). "The seismic design parameters chosen for a specific project or system should be chosen with care. For example, lower values should be used for structures possessing a low degree of redundancy wherein all the plastic hinges required for the formation of a mechanism may be formed essentially simultaneously and at a force level close to the specified design strength" (ibid).

As a practical matter, if the structural engineer is able to satisfy the structural capacity requirements associated with Risk Category III, then a reasonable expectation will follow that, compared to a Category II structure, the probabilities favor the Category III structure to perform acceptably during foreseeable earthquakes. This is illustrated in Table C.1.3.1b of the Commentary to ASCE 7-10 at page 316: in an MCE earthquake, the likelihood of "total or partial structural collapse" is 10% for Category II structures and 6% for Category III structures; similarly, in an MCE earthquake, the likelihood of "failure that could result in endangerment of individual lives" is 25% for Category II structures and 15% for Category III structures. It is reasonable to expect Category III structures to perform better in design earthquakes as well, with less structural damage. Table One (below) summarizes the performance targets associated with the risk categories and importance factors specified by ASCE 7-10.

2.3. Implementation of the Underlying Policies of ASCE 7-10 and San Francisco's General Plan

Selecting the appropriate risk category and appropriate importance factor in Table 1.5-2 of ASCE 7-10 is an essential step in complying with San Francisco's ordinances and its General Plan. Section 101.1(b)(6) of the San Francisco Planning Code sets as a priority policy "That the City achieve the greatest possible preparedness to protect against injury and loss of life in an earthquake." This provision is routinely repeated as a project requirement when a new concrete ductile core high-rise project is granted entitlements by San Francisco's Planning Commission.

On June 14, 2012, the Planning Commission adopted the Community Safety Element for San Francisco's General Plan[6], which has as its first objective to "reduce struc-

[5]Category III "includes buildings that house a large number of persons in one place . . . . [Selection of the appropriate Risk Category] is primarily based on the number of persons whose lives would be endangered or whose welfare would be affected in the event of failure. Figure C1-1 illustrates this concept." Figure C1-1 describes the relationship between the Risk Category and the "Number of Lives Placed at Risk by a Failure," with the threshold for Category III at approximately 300 people. "Lives at risk pertains to the number of people at serious risk of life loss given a structural failure. The risk category classification is not the same as the building code occupancy capacity which is mostly based on risk to life from fire. The lives at risk from a structural failure include persons who may be outside the structure in question who are nonetheless put at serious risk by failure of the structure" (Commentary to ASCE 7-10, section C1.5.1, at page 321).

[6]`http://www.sf-planning.org/ftp/General_Plan/Community_Safety_Element_2012.pdf`

Table 1: RESILIENCY OF A HIGH-RISE STRUCTURE IS A FUNCTION OF THE RISK CATEGORY AND IMPORTANCE FACTOR (IE) CHOSEN*

	RISK CATEGORY II, IE = 1.00	RISK CATEGORY III, IE = 1.25	RISK CATEGORY IV, IE = 1.50
EXAMPLES OF CHARACTERISTICS DETERMINING THE RISK CATEGORY FOR A HIGH-RISE			
IN THE EVENT OF FAILURE DURING AN EARTHQUAKE, THE HIGH-RISE . . .		. . . COULD POSE A SUBSTANTIAL RISK TO HUMAN LIFE**; OR HAS POTENTIAL TO CAUSE "A SUBSTANTIAL ECONOMIC IMPACT"; OR HAS POTENTIAL TO CAUSE "MASS DISRUPTION OF DAY-TO DAY CIVILIAN LIFE"	. . . COULD POSE A SUBSTANTIAL HAZARD TO THE COMMUNITY; OR
OTHER CRITERIA	IT IS OUTSIDE I, III AND IV		IT IS AN "ESSENTIAL FACILITY"
THE RISK CATEGORY DETERMINES EXPECTED PERFORMANCE DURING AN MCE, INCLUDING MAXIMUM PROBABILITY** OF THE FOLLOWING:			
TOTAL OR PARTIAL STRUCTURAL COLLAPSE	10%	6%	3%
FAILURE THAT COULD RESULT IN ENDANGERMENT OF INDIVIDUAL LIVES	25%	15%	10%

* Compiled from ASCE 7-10 section 1.5 and Tables 1.5-1 and 1.5-2.

** "The lives at risk from a structural failure include persons who may be outside the structure in question who are nonetheless put at serious risk by the failure of the structure" (compiled from ASCE 7-10 Commentary, including table C.1.3.1b and section C1.5.1, page 321).

tural and non-structural hazards to life safety and minimize property damage resulting from future disasters." Policy 1.3 in turn is intended to "Assure that new construction meets current structural and life safety standards. . . . The purpose of the Community Safety Element is to facilitate community resilience and reduce future loss of life, injuries, property loss, environmental damage, and social and economic disruption from natural or technological disasters. The Community Action Plan for Seismic Safety . . . [and] the Earthquake Safety Implementation Program . . . are based on five objectives: [the first of which is] that residents will be able to stay in their own homes following a disaster . . . ." (id. at p. 4). This program provides that structural engineering professionals "should be encouraged to design buildings to tiered, 'enhanced' levels of seismic performance that are performance-based, and developers to finance these enhanced levels, by offering incentives such as priority processing" (id. at p. 23). All of this coincides with the fundamental purposes of ASCE 7: "It is important to recognize that the requirements of ASCE 7 . . . are intended to go beyond protection against structural failure and are also intended to provide property and economic protection for small events, to the extent practical, and to improve the probability that critical facilities will be functional after severe . . . earthquakes, and similar events" (Commentary to ASCE 7-10, section C1.3.1.3, at page 317).

2.4. The Expected Additional Out of Pocket Cost of Choosing Risk Category III for Residential Concrete Ductile Core High-rises in San Francisco.

Review of San Francisco Department of Building Inspection records by Exponent, Inc. (a consulting firm in Menlo Park, California) indicates that most new office towers in San Francisco are being designed to meet Risk Category III requirements, while most new residential towers in the same San Francisco neighborhoods are being designed to meet Risk Category II requirements. What would be the expected cost consequences of using Risk Category III instead of Category II for a new residential concrete ductile core high-rise, say 15-40 stories tall, built on non-fill soil in San Francisco? Exponent, Inc.'s review of recently completed designs that have been approved by San Francisco's Department of Building Inspection indicate that the price differential for additional steel and concrete should be on the order of three to five percent of total project costs.

Research at the Pacific Earthquake Engineering Center indicates that over intermediate time frames (e.g., 50 years), compared to lesser design approaches, certain structural systems will prove far more resilient and much less costly to repair when exposed to foreseeable moderate earthquake demands; and the savings usually are far in excess of the three to five percent (or more) of additional construction costs that may be required for the better system during original construction (Terzic, Mahin & Comerio, 2014). It is reasonable to assume that the same will be true when the direct and indirect costs of earthquake repair for Risk Category III structures are compared to those of Risk Category II structures over the next 50 years and beyond. It is highly likely that properly designed and built Risk Category III structures will provide a better return on investment than Risk Category II structures if both are exposed to moderate, strong or severe earthquakes in San Francisco and Los Angeles during their service lives.

3. Legal Ramifications of Designing New Concrete Ductile Core High-rises to Meet Risk Category III Performance Standards

In the legal arena, the owner who has chosen to pursue the Risk Category III design path should be better able to reduce his or her possible exposure to legal liability for unsatisfactory seismic performance because the owner may be in a better position to demonstrate that he or she reasonably relied upon the technical advice of a competent structural consultant. In California, for instance, the basic rule of tort liability for property owners (including an owner of a new concrete ductile core high-rise) is that the owner must use ordinary care in the management of his or her property to prevent injury to another[7]. Recent California legal precedent suggests that the owner of a concrete ductile core high-rise will be expected to act to prevent unsatisfactory seismic performance that may result from foreseeable earthquakes.

3.1. The Myrick v. Mastagni Litigation

In California's leading legal precedent concerning commercial owner liability for poor seismic performance, the California Court of Appeal ruled that the test for the trier of fact (often a jury) is whether the owner has acted as a reasonable person in view of the probability of injury. Myrick v. Mastagni (2nd District 2010) 185 Cal App. 4th 1082, 1087 ("Myrick"). In the Myrick case, the owners of a commercial building (the "Acorn") were found liable for the deaths of two women who were struck by a collapsing roof during moderate shaking during the 2003 San Simeon earthquake[8]. The plaintiffs in the Myrick lawsuit sustained their burden of proving to and persuading the jury that by failing to correct known structural vulnerabilities in the Acorn, the owners failed to use ordinary care in its use and operation leading up to the earthquake that triggered its collapse. A jury required owners to pay $2 million in compensation mainly because the owners failed to act promptly to increase the seismic capacity of their building (by retrofit) after becoming aware of its seismic vulnerability. The owners appealed on the theory that they had no duty to retrofit until 2018, the deadline established by local municipal ordinance and, as a matter of law, owners' duty "was limited to compliance with the ordinance." The appellate court rejected that argument, reasoning that in California the "general rule is that statutory compliance is not a complete defense in a tort action." Among other things, "a statute, ordinance or regulation defines a minimum standard of conduct" and mere adherence to that minimum standard "does not preclude a finding that a reasonable person would have taken additional precautions under the circumstances." Myrick, supra, 185 Cal.App.4th at 1087-1090.

As one would expect, the defendant owners in Myrick argued that a policy underlying the retrofit ordinance was the protection of the owners' property interests, which should have prevailed, as a matter of law, over the interests of the plaintiffs whose family members had died. The appellate court rejected that argument: "Certainly, the city considered the interests of the building owners in setting the deadline for compliance. But the overriding policy behind the seismic retrofit ordinance, taken as a whole, is not the promotion of the interests of building owners. Instead, the overriding policy is public safety" (Myrick, supra, 185 Cal.App.4th at 1090). Most courts would agree that the "overriding policy" of San Francisco's Community Safety Element in its General Plan (Ordinance No. 218-12) is "public safety" as well. It follows that some courts would rely on San Francisco's Ordinance No. 218-12 to conclude that the developer/owner of a new high-rise has an affirmative duty to exercise reasonable care to protect neighbors and visitors to the new facility, including preventing or minimizing harm to third parties during the design and construction phases of developing the new facility. See, e.g., American Law Institute, Restatement of the Law Third, Torts: Liability for Physical and Emotional Harm (2012) sections 38, 39, 51, 59 and 62.

3.2. Managing Seismic Risk in the Legal Arena in Light of the Myrick v. Mastagni Litigation

In many ownership scenarios, judges and juries will extend the logic of the Myrick precedent to ask whether the owner acted reasonably after it became aware that its structure had a seismic vulnerability. The judge and jury will want to know when owner was on notice (or should have been on notice) of the vulnerability and how it related to the foreseeable performance of the structure. In many scenarios, the judge and jury will want to know if owner proactively engaged a structural consultant to predict the seismic performance of the vulnerable structure in foreseeable earthquakes. The prudent owner should be prepared to defend against the argument of an aggressive plaintiff attorney that before the earthquake in question, it should have engaged a competent structural consultant to predict for owner whether significant load-bearing assemblies of the structure (the masonry walls and the roof in the case of the Acorn) (i) would perform elastically or inelastically during (ii) three or more earthquake scenarios, and if the prediction was inelastic performance, (iii) whether that performance would likely result in falling hazards, collapse or other injurious patterns of unsatisfactory structural (and non-structural) behavior.

[7] California Civil Code, section 1714. See White & Perry, 2014: 5-7.

[8] On December 22, 2003, at 11:15:56 a.m. PST (19:15:56 UTC), a magnitude 6.5 earthquake (denominated San Simeon) occurred roughly 24 miles (39 km) west/northwest of Paso Robles, California, a city with a population on the order of 27,000. Peak ground acceleration in downtown Paso Robles was on the order of .24-.27 gravity and shaking was reported to be brief, on the order of four seconds. Hardenbeck et al, 2004: 155-172.

3.3. *Hypothetical Example of Managing Seismic Risk in the Legal Arena*

How do these principles operate in the following hypothetical scenario? A developer/owner plans to demolish two vacant buildings (each less than four stories in height) and replace them with a single forty-story concrete ductile core high-rise (four hundred feet in height), to be rented as residential apartments over a thirty year period. When fully rented, the high-rise is expected to house more than 400 residents. The project is situated in a densely populated part of San Francisco, not far from the San Andreas and Hayward faults. Several existing residential high-rises are within the collapse shadow of the proposed high-rise, each housing more than 300 residents. In the event of a strong earthquake, if the proposed high-rise collapses, it could also disable the only source of electrical energy for the San Francisco financial district or it could disable the Bay Bridge, located less than 1,000 feet away.

In the process of deciding how to meet San Francisco's regulatory requirements for the proposed high-rise, the developer/owner confers with its structural consultants as to which performance target be should included in the structural design for the project, and considers the respective costs and benefits of available strategies for managing its seismic risk in the legal arena. Considering the ASCE 7-10 provisions summarized in Table One above, the structural consultants explain to the developer/owner that choosing Risk Category III would be advisable because: failure during an earthquake of the proposed high-rise when it was fully occupied could pose a "substantial risk to human life"; failure during an earthquake of the proposed high-rise has the potential to cause "a substantial economic impact" on San Francisco given its proximity to the only source of electrical power for the financial district and its proximity to the Bay Bridge; and failure during an earthquake of the proposed high-rise has the potential to cause "mass disruption of civilian life" in San Francisco. Indeed, the structural consultants may recommend adoption of Risk Category IV, because in extreme circumstances, loss of either the main electrical substation or loss of the Bay Bridge could conceivably pose "a substantial hazard to the community."

If it is further assumed that the developer/owner is aware that in certain foreseeable earthquake scenarios, the single lateral force resisting system in the proposed concrete ductile core high-rise makes its more vulnerable to failure than other design approaches, then it would be prudent for the developer/owner to know ahead of time how its structural consultants would testify under oath concerning its statutory duty to use ordinary care in the management of the facility to prevent injury to another (see Civil Code section 1714) The prudence of this approach is magnified if it turns out that the proposed high-rise performs poorly in a foreseeable earthquake and collapses. For instance, how would the structural consultants demonstrate through sworn testimony that they "rigorously justified" their non-prescriptive performance-based design (see footnote 2 above)? How would the structural consultants demonstrate through sworn testimony that the structural design chosen adhered to the policy directives of ASCE 7-10 and San Francisco's General Plan and Community Safety Element to: "achieve the greatest possible preparedness to protect against injury and loss of life in an earthquake"; "reduce structural and non-structural hazards to life safety and property damage resulting from" future earthquakes; "facilitate community resilience"; reduce "social and economic disruption"; assure "that residents will be able to stay in their homes" following an earthquake; and that the design chosen goes "beyond protection against structural failure and . . . [provides] property and economic protection" (see section 2.3 above)? This is the type of testimony that most jurors would consider when deciding whether the developer/owner "acted as a reasonable person in view of the probability of injury."

4. Conclusions

In our hypothetical collapse scenario, the developer/owner would likely not avoid a jury trial by arguing, as a matter of law, that it was insulated from liability for wrongful death or injury simply because it chose to develop the high-rise as a Risk Category II structure in accordance with AB-083 and California's Building Code, as adopted by San Francisco. These most likely would be treated as "minimal standards" by the trial court and the jury would be authorized to consider whether "additional precautions" should have been taken in order to satisfy the "reasonable person" standard of care. Ordinarily, the developer/owner and its consultants would be required to testify as to how the developer/owner relied upon the advice of the consultants concerning which performance standards, Risk Category II or III (or higher, such as Category IV), were selected. Common sense dictates that if all other factors are held constant, the legal exposure of the developer/owner who relies on its consultants to choose Category III (or Category IV) standards will be more favorable to owner than if it chooses Category II standards. In most instances, the difference in legal exposure alone will be well worth the expected three to five percent increase in original construction costs.

References

American Law Institute (2012): Restatement of the Law Third, Torts: Liability for Physical and Emotional Harm, Philadelphia, Pennsylvania: American Law Institute.

American Society of Civil Engineers (2013): Minimum Design Loads for Buildings and Other Structures, ASCE/SEI 7-10, Reston, Virginia: American Society of Civil Engineers.

California Building Standards Commission (2013): 2013 California Building Code, California Code of Regulations, Title 24, Volume 1 of Part 2, Sacramento, California: California Building Standards Commission.

California Civil Code, section 1714.

Hardenbeck, J. L.; Boatwright, J.; Dreger, D.; Goel, R.; Graizer, V.; Hudnut, K.; Ji, C.; Jones, L.; Langbein, J.; Lin, J.; Roeloffs, E.; Simpson, R.; Starks, K.; Stein, R.; Tinsley, J.C. (2004): Preliminary Report on the 22 December 2003 M6.5 San Simeon, California, Earthquake, Seismological Research Letter, 75(2), 155-172.

International Code Council, Inc. (2009): International Building Code, Country Club Hills, Illinois: International Code Council, Inc.

Maffei, J. (2007): Seismic Performance and Design Requirements for High-Rise Concrete Buildings, STRUCTURE Magazine, April 2007: 28.

Myrick v. Mastagni (2nd District 2010) 185 Cal.App.4th 1082, rehearing denied July 16, 2010, review denied September 15, 2010.

Pacific Earthquake Engineering Research Center (2010): Tall Building Initiative: Guidelines for Performance-Based Seismic Design of Tall Buildings, Report No. 2010/05, Berkeley, California: Pacific Earthquake Engineering Research Center.

Terzic, V.; Mahin, S.; Comerio, M. (2014): Life-Cycle Cost and Performance Comparisons of Different Code-Compliant Systems. Northridge, Northridge 20 Symposium.

The City and County of San Francisco (2014): 2014 San Francisco Planning Code, Cincinnati, Ohio: American Legal Publishing Corporation.

The City and County of San Francisco (2013): 2013 San Francisco Building Code, Cincinnati, Ohio: American Legal Publishing Corporation

The City and County of San Francisco (2012): Community Safety Element of the San Francisco General Plan (http://www.sf-planning.org/ftp/General_Plan/Community_Safety_Element_2012.pdf), adopted by the San Francisco Board of Supervisors on October 16, 2012, and signed by the Mayor of San Francisco on October 23, 2012, Ordinance No. 218-12.

URL=http://www.comcat.cr.usgs.gov/earthquakes/eventpage/nc72282711#shakemap (14 October 2014).

URL=http://www.earthquake.usgs.gov/designmaps/ut/application.php (14 October 2014).

URL=http://www.eqclearinghouse.org/2014-08-24-south-nanpa/files/2014/08/2-Napa-EQ-EERI-PEER-Briefing_Dawson-2014_09_15.pdf (14 October 2014).

URL=http://www.sf-planning.org/ftp/General_Plan/Community_Safety_Element_2012.pdf (14 October 2014).

White, M.; Perry, C. (2014). Paved with Incomplete Intentions: Using Predictions of Seismic Performance to Navigate the Bumpy Highways and Byways of Seismic Risk in the Legal Arena—Case Notes from L'Aquila (2009) and Paso Robles (2003). Anchorage, Tenth U.S. National Conference on Earthquake Engineering.

Yanev, P.; Thompson, A. (2008): Peace of Mind in Earthquake Country, San Francisco, California: Chronicle Books LLC.

Yang, T.; Bozorgnia, Y.; Mohele, J. (2008): The Tall Buildings Initiative. Beijing, 14th World Conference on Earthquake Engineering.

Citation

White, M. N. and Osteraas, J. D. (2015): Improving Seismic Capacity of New Concrete Ductile Core High-Rises: Costs and Benefits of Managing Seismic Risk in the Legal Arena. In: Planet@Risk, 3(2): 292-299, Davos: Global Risk Forum GRF Davos.