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

Mark N. White(1)

(1) *Principal, Law Offices of Mark N. White, mark.white@mnwhitelaw.com*

Abstract

The 1989 Loma Prieta earthquake (October 17, M 6.9) was a wakeup call for most municipalities and constituent regulatory agencies in the San Francisco Bay Area, including the Department of Building Inspection ("DBI") in San Francisco itself. More than 40 people died and scores were seriously injured when the Cypress Structure collapsed in Oakland. The commute patterns of hundreds of thousands of citizens were hampered when the Embarcadero Freeway and Bay Bridge performed poorly when challenged by moderate ground acceleration (less than 0.25 PGA). Loma Prieta reminded San Francisco's municipal government, and in particular the DBI, that antecedent steps had to be taken to avoid a repeat of poor structural performance in foreseeable earthquakes.

In Administrative Bulletin 083 (March 25, 2008), DBI mandated virtual elasticity as the performance target in service-level earthquakes for "New Tall Buildings" that were designed using "Non-Prescriptive Seismic-Design Procedures" ("AB-083"). "Tall Building" is defined as a structure with an "*hn* greater than 160 feet above average adjacent ground surface." Section 1. Service-level ground motion is defined as "having a 43-year mean return period (50% probability of exceedance in 30 years)." Section 4.2. With regard to the "primary structural system," the latter section requires the project design team ***"to demonstrate acceptable, essentially elastic seismic performance at the service-level ground motion".*** The design team must demonstrate no more than "minor yielding," requiring no more than "minor repair." Commentary at 83-5.

Adherence to the requirements of AB-083 is obtained through a Peer Review process denominated "Structural, Geotechnical, and Seismic Hazard Engineering Design Review" spelled out in DBI's Administrative Bulletin 082 ("AB-082"). The extent to which members of the Peer Review team require the design team to justify the substance of their compliance with applicable performance targets has increased since AB-082's original adoption in 2008. These refinements were, in part, the results of lessons learned from the complex civil litigation involving unexpected settlement at the ***Millennium Tower*** (58 story, 605 foot height), currently pending in San Francisco Superior Court (related cases are also pending in United States District Court). Publicly available information indicates that legal fees in those cases already exceed $50 million and that the first phase of remedial work will cost more than $100 million.

The gist of the charging allegations of these cases is that since commencement of construction, the amount of settlement sustained by the Millennium Tower far exceeds that predicted by members of the project design team and that such information was wrongfully concealed from both the owner association and unit purchasers (among others) before sales of individual units took place. The actionable situation is a settlement ***performance gap***: settlement in the field far exceeds that predicted by members of the design team before structural construction commenced. Among other things, DBI's amendments to AB-082 were intended, before construction, to catch and cure design errors in future projects that could otherwise lead to seismic performance problems.

Another lesson learned from the ***Millennium Tower*** litigation is that the best practice is for the Peer Review team and DBI to preserve all documents generated during the design review process. The better argument is that such project-related materials should be preserved because they are covered by California's Public Records Act and by San Francisco's Sunshine Ordinance. When a vulnerability is discovered after construction commences, the design review materials actually used during construction often efficiently illuminate the source of the problem and facilitate its correction before property is damaged or lives are lost in foreseeable earthquakes. Collecting and retaining these design review materials are an essential part of DBI's ongoing program to improve the earthquake resiliency of its high-rise stock.

Keywords: performance gap, virtual elasticity, high-rises, Millennium Tower

1. Introduction

The 1989 Loma Prieta earthquake (October 17, M 6.9) was a wakeup call for most municipalities and constituent regulatory agencies in the San Francisco Bay Area, including the Department of Building Inspection ("DBI") in San Francisco itself. More than 40 people died and scores were seriously injured when the Cypress Structure collapsed in Oakland. [1] The commute patterns of hundreds of thousands of citizens were hampered when the Embarcadero Freeway and Bay Bridge performed poorly when challenged by moderate ground acceleration (less than 0.25 PGA). Loma Prieta reminded San Francisco's municipal government, and in particular the DBI, that antecedent steps had to be taken to avoid a repeat of poor structural performance in foreseeable earthquakes.

As will be shown below, after Loma Prieta, more than 50 "New Tall Buildings," comprising more than 30 million square feet of new occupiable space, were built in the heart of San Francisco, virtually all with a height of greater than 160 feet, using "Non-Prescriptive Seismic-Design Procedures," as those terms are used by DBI in San Francisco. This group of facilities will be referred to as "Post Loma Prieta High-Rises" and as will be shown below, ***most that were designed and built after 2008 have been predicted to demonstrate "essentially elastic seismic performance at the service-level ground motion."*** [2] When any of these high-rises fails to deliver elastic seismic performance in a foreseeable service-level (or lighter) earthquake, legal claims will inevitably be made requiring discovery of the reasons for substandard performance. Put another way, owners and design teams of such high-rises will be required to describe, under oath, the way that performance targets and structural design approaches were chosen. This paper is intended to rationalize changes in the way that owners and design professionals make those choices and preserve the evidence that illustrates them.

2. Post Loma Prieta High-Rises in San Francisco

At least 26 Post Loma Prieta High-Rises were permitted and completed for residential occupancy after 1989. See Table One for details. [3] Of these 26, the reported "structural system" for 18 towers is "RC Shear Wall," with no supplemental braced frame or moment frame systems, as opposed to the reported supplemental systems in the other eight. The occupiable area of these 26 residential high-rises is in excess of 13 million square feet.

The situation is similar for the 28 non-residential high-rises that were completed after the October 1989 Loma Prieta earthquake. See Table Two for details. [4] Of these 28, the reported "structural system" for nine towers is "RC Shear Wall," with no supplemental systems, as opposed to the reported systems for the other 19, which either had supplemental systems or employed non-RC Shear Wall systems. The occupiable area of these 28 non-residential high-rises is in excess of 16 million square feet.

Accordingly, in the heart of San Francisco, after the Loma Prieta earthquake in 1989, in the 54 new high-rises, roughly 30 million square feet of new occupiable space was added, with an aggregate retail market value of in excess of $25 billion in 2020 dollars. [5]

3. High-Rise Resiliency and the Reality of Reduced Property Damage Targets after Loma Prieta

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, such as San Francisco's Community Safety Element to its General Plan, as well as Federal NEHRP legislation (passed in December 2018) which finances research and "an effective earthquake hazards reduction program," in order to achieve "the purpose of Congress . . . to reduce the risks of life and property from future earthquakes and increase resilience of communities" (28 United States Code section 7702).

3.1 Issues of property damage and resiliency on the One Rincon Hill Project

The largest residential high-rise to be built in San Francisco after Loma Prieta is ***One Rincon Hill***, 56 stories and 550 stories in height, completed in 2008. It is situated immediately adjacent to the approach to the Bay Bridge and was assigned an ASCE Importance Factor of 1.0, as has been the case with most Post Loma Prieta residential high-rises (indeed, most residential towers designed in accordance with ASCE 7-10 are assigned Risk Category II, not III, by the structural design team). The history of the design development and permitting of One Rincon Hill left open the question as to how much damage it would sustain in a service level earthquake, and whether repairs would take considerable time.

Shortly before the commencement of construction, DBI refused to issue a building permit for One Rincon Hill until the project structural engineers addressed questions "about whether it would withstand a major earthquake and remain habitable." [7] According to reporters, the chief engineer of DBI ordered, on November 17, 2005, that no construction permit be issued without his authorization, "after he raised questions about whether the city was requiring sufficient seismic safety standards to guard against injury and property damage." [7] The structural engineering team was asked to address the issue of magnitudes of property damage, not just the avoidance of collapse. A segment of the citizenry concurrently asked if DBI was authorizing the construction of "throwaway" high-rises.

Many in the engineering community consider the ultimate approval of the One Rincon Hill Project to be a watershed, in part because DBI effectively was "establishing precedent in the way high-rise condominiums are being built in California." [7] Among other things, the chief engineer asked the structural design team "What is the expected building performance?" and "What is the expected damage?" A member of the peer review team who had previously recommended advancement of the project stated "I think it is likely that this building would resist a repeat of the 1906 earthquake" and "I think there's a good probability that the building would be immediately re-occupiable." [7] However, the chief engineer of DBI "characterized the design-review panel's recommendation of a construction permit as 'premature.'" [7] In response, the structural design team asserted that the design was code compliant, although ***"it could still suffer irreparable damage in a large quake."*** [7] (Italics and emphasis added.) The essence of the structural engineer's stated position was that "It is our interpretation that the intent of the code is to provide ***design procedures that will result in structures that may be significantly damaged or perhaps unrepairable***, but remain standing following a major earthquake." [7] (Italics and emphasis added.)

3.2 Issues of resiliency and property damage on the Salesforce Tower Project

The same structural team made similar written statements concerning the recently-completed (2017) ***Salesforce Tower***, the tallest high-rise in San Francisco (61 stories and 1,070 feet in height). Unlike the residential towers assigned to ASCE 7-10 Risk Category II, Salesforce Tower was assigned Risk Category III, with an Importance Factor of 1.25, but the possibility of infeasible repairs after an MCE was nonetheless reiterated:

> "For this Occupancy [sic] Category III structure, the probability of collapse is lower than that expected for a comparable Occupancy [sic] Category II structure. ASCE 7-10 sec. C1.3.1 suggests that code-compliant designs have a probability of collapse given occurrence of MCE shaking of 10% and 6% respectively for Occupancy [sic] Categories II and III. . . . ***Extensive structural damage may occur; repairs to structural and non-structural systems are required and may not be economically feasible***." [8] (Italics and emphasis added.)

The underlying logic employed by the structural design team for the Salesforce Tower is spelled out in their June 2017 article in Structure Magazine. [9] "Given the scale of Salesforce Tower, the calculated number of building occupants will far exceed the building code threshold of 5,000 people, triggering the building's consideration under Occupancy [or Risk] Category III. Category III buildings require additional safety for wind and seismic demands, thus prompting new challenges for the engineering team." Id. at p. 45. Part of the extra seismic capacity required for Risk Category III high-rises is implemented "by applying code-defined seismic forces that have been amplified by an Importance Factor (1.25 for Category III buildings)." Ibid. Consistent with ASCE 7 Commentary, the Salesforce structural design team "targeted a reduction to 6% (from 10%) of the probability of collapse under a Maximum Considered Earthquake (MCE) ground shaking." Id. at p. 46. "Since the vertical elements of the tower's seismic force-resisting system include only shear walls . . . , the City of San Francisco's Administrative Bulletin 083 (AB-083) . . . applied." Id. at pp. 46-47. As a result, the structural design team chose a performance target of ***elastic performance in service-level earthquakes.*** "The lateral design of Salesforce Tower was driven by seismic loading in conditions for three levels of ground shaking: ***Elastic performance targeted for service-level shaking (with a mean recurrence interval of 43 years). . . .***" Id. at p. 47. (Italics and emphasis added.) The structural design team reported that during the peer review process, it was able to demonstrate, among other things, that as-designed, the "***wall shear demands remain elastic***, and vertical wall strains are quite modest with only limited yielding predicted." Ibid. (Italics and emphasis added.)

4. AB-083 and its Role in Hypothetical Litigation

What if (i) One Rincon Hill collapses in a replay of the 1906 San Francisco earthquake (M7.9) or (ii) Salesforce Tower sustains substantial damage and is shut down in a service level earthquake (say PGA 0.20)? If we assume, in each hypothetical, that innocent bystanders are injured as a result of the unacceptable performance (cladding detaches and concrete chunks hit the passers-by), then the likelihood is high that a skilled lawyer for each victim would persuade a judge (or jury or both) to consider whether the owner and its design team members should be held legally culpable because the seismic performance of each high-rise fell short of predicted seismic performance—a performance gap theory of liability.

The potentiality of this theory comes into focus if we take a closer look at Administrative Bulletin 083 (March 25, 2008) ("AB-083"). [10]

In AB-083 DBI mandated virtual elasticity as the performance target in service-level earthquakes for "New Tall Buildings" that were designed using "Non-Prescriptive Seismic-Design Procedures" [10] "Tall Building" is defined as a structure with an "*hn* greater than 160 feet above average adjacent ground surface." Section 1. Service-level ground motion is defined as "having a 43-year mean return period (50% probability of exceedance in 30 years)." Section 4.2. With regard to the "primary structural system," the latter section requires the project design team ***"to demonstrate acceptable, essentially elastic seismic performance at the service-level ground motion."*** (Italics and emphasis added.) The design team must demonstrate no more than "minor yielding," requiring no more than "minor repair." Commentary at 83-5. Specifically, ***"essentially elastic seismic performance"*** includes a prediction of no worse than "minor yielding of ductile elements of the primary structural system, provided such results do not suggest appreciable permanent deformation in the elements, strength degradation, or significant damage to the elements requiring more than minor repair." Ibid.

In addition, "it is expected that the ***building cladding will remain undamaged*** and that egress from the building will not be impeded when the building is subjected to the service-level ground motion." Ibid. "The evaluation ***shall demonstrate that the elements being evaluated exhibit serviceable behavior***." Ibid. (Italics and emphasis added.)

Thus, in our hypothetical involving serious damage to the Salesforce Tower, a judge will likely find that an actionable performance gap exists between (i) what owner's design team predicted in the service level scenario and (ii) what the completed high-rise delivered in the field, when exposed to 0.20 PGA. Automatic legal immunity for defendants is unlikely.

Adherence to the requirements of AB-083 is obtained through a Peer Review process denominated "Structural, Geotechnical, and Seismic Hazard Engineering Design Review" spelled out in DBI's Administrative Bulletin 082 ("AB-082"). [11] The extent to which members of the Peer Review team require the design team to justify the substance of their compliance with applicable performance targets has increased since AB-082's original adoption in 2008. These refinements were, in part, the results of lessons learned from the complex civil litigation involving unexpected settlement at the ***Millennium Tower*** (58 story, 605 foot height), currently pending in San Francisco Superior Court (related cases are also pending in United States District Court). Publicly available information indicates that legal fees in those cases already exceed $50 million and that the first phase of remedial work, currently scheduled to commence later in 2020, will cost more than $100 million.

5. Lessons of the Millennium Litigation, Harbinger of Performance Gap Lawsuits after Future Earthquakes

The Millennium Tower litigation is a precursor of the above-described hypothetical earthquake-driven litigation. It continues to be played out in state and Federal courtrooms (and, most important, in the chambers of settlement judges), even as the parties struggle to finalize a $100 million partial resolution of the underlying performance failure. Several pending lawsuits arose from unexpected settlement experienced by the Millennium Tower, and involves other substantial facilities, including Salesforce Tower and the Transbay Transit Center. One lawsuit is being pursued on behalf of the homeowner's association for the Millennium and seeks more than $200 million against developer entities and members of the design team, the general contractor, the developer of a nearby high-rise (the Salesforce Tower), as well as the public entity developing the nearby transit center. ***Millennium Tower Association v. Mission Street Development LLC, et al*** (S.F. Sup. Ct.) Case No. CGC-17-557830. None of these entities have been able to establish automatic immunity from claims by the association. Similarly, many lawsuits have been filed on behalf of individual owners of Millennium Tower units, including ***Butterly et al v. Millennium Partners Management LLC, et al*** (S.F. Sup. Ct.) Case No. CGC 17-556292. These two cases, and several others, have been consolidated for all pretrial purposes with an earlier-filed lawsuit, Case No. CGC-16-553758; a provisional trial date is on calendar for February 16, 2021, in the event any part of the litigation remains unsettled at that time.

The gist of the charging allegations of these cases is that since commencement of construction, the amount of settlement sustained by the Millennium Tower far exceeds that predicted by members of the project design team and that such information was wrongfully concealed from both the association and unit purchasers (among others) before sales of individual units took place. The actionable situation is a settlement ***performance gap***: settlement in the field far exceeds that predicted by members of the design team before structural construction commenced.

Based on current, publicly available information, in the event most claims are not settled by mutual consent, it would be expected that some experts in the ***Millennium*** litigation will testify along the following lines:

> The original design anticipated one inch of settlement under Millennium Tower by the time of construction completion, and additional long-term settlement due to compression of the underlying clay layers of five inches. Settlement was expected to be uniform over the Tower foundation area. See, e.g., page 2 of the letter report prepared by G. Deierlein; M. Schotanus; C. Shields, ***Structural Safety Review of the Millennium Tower*** (July 29, 2017). [12]

> Contrary to the predicted performance, it appears that the Millennium Tower settled six inches at the time of construction completion, instead of one inch. And, as of July 2017, settlement was on the order of 17 inches instead of the five predicted for the long-term. Moreover, settlement has not been uniform and the Tower leans to the west on the order of 14 inches and leans to the north on the order of six inches as of July 2017. This is roughly twice what would be considered acceptable construction tolerance for out-of-plumb. [12] Id. at pp. 1, 5, 11.

Because the Tower has experienced unexpected and excessive settlement and tilt, and lack of stabilization of the settlements, in-depth investigation was undertaken to determine whether it meets the minimum structural and seismic safety requirements expected under San Francisco and California building codes. Id. at pp. 2 and 11.

The ***Millennium Tower*** litigation reveals patterns that unfolded in the ***Myrick*** litigation [13], and that will unfold in future cases arising from unsatisfactory high-rise performance during foreseeable earthquakes. Take our Salesforce Tower hypothetical: before the substandard performance during a service level earthquake, say the tower owner becomes aware of troublesome mechanisms (tangible vulnerabilities) in elements of the lateral force-resisting system; and further, before the flaws are corrected, innocent bystanders are harmed by them during the earthquake. In turn, hypothetically, this leads to litigation which requires evidentiary disclosure of performance targets implicitly or explicitly adopted by the structural team and the tower owner; they, in turn, will be required to testify under oath whether they, individually, were aware of the tangible vulnerabilities before the earthquake, and if so, what was done about it. Able adverse counsel will ask tough questions, including whether the tangible vulnerabilities tended to undercut adopted performance targets, and whether the actual harm in the field was reasonably foreseeable. Needless to say, legal counsel defending the owner and the design team will predict both how expert testimony will play out and how the judge and jury will respond to it. [14]

Another pattern that will emerge after future severe earthquake shaking in the heart of San Francisco is controversy over whether Post Loma Prieta residential high-rises were designed with sufficient seismic capacity. In our hypothetical collapse of the One Rincon Hill Tower, able counsel for innocent victims will likely develop the argument that Importance Factor 1 was not enough under ASCE 7 and that instead of meeting the functional equivalent of Risk Category II, the structural design team should have used stricter requirements analogous to those of Risk Category III, which in turn would have increased the Importance Factor to 1.25. Most judges will be reluctant to accept the defense argument that meeting code minimum automatically immunizes design professionals and owners from potential liability, in light of the contrary holding in ***Myrick.*** [13]

6. Conclusion

Another lesson learned from the ***Millennium Tower*** litigation is that the best practice is for the Peer Review team and DBI to preserve all documents generated during the design review process. The better argument is that such project-related materials should be preserved because, once circulated with the Peer Review team, they are covered by California's Public Records Act and by San Francisco's Sunshine Ordinance. When a vulnerability is discovered after construction commences, the design review materials actually used during construction often efficiently illuminate the source of the problem and facilitate its correction before property is damaged or lives are lost in foreseeable earthquakes. Collecting and retaining these design review materials are an essential part of DBI's ongoing program to improve the earthquake resiliency of its high-rise stock, which necessarily includes migration from avoidance of collapse to reduction of property damage.

7. References

[1] White, M.N., Yanev, P.(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, *17th World Conference on Earthquake Engineering, Paper No. 0184,* Sendai, Japan (hereinafter "White Managing Risk 2020") pp. 3-5

[2] For most post Loma Prieta high-rises, the San Francisco DBI maintains digital records of construction permits and some design drawings used in the peer review and permitting process, available at the fourth floor of its offices at 1660 Mission Street, San Francisco, California. For certain high-rises listed in Tables One and Two below, DBI's records were accessed in January and February 2020, as described below. The bolded and italicized language quoted in the second paragraph is taken from City and County of San Francisco, Department of Building Inspection, Administrative Bulletin 083, *Requirements and Guidelines for the Seismic Design of New Tall Buildings using Non-Prescriptive Seismic-Design Procedures*, 7 pages (March 25, 2008, revised January 1, 2014).

[3] Residential high-rises are identified in the inventory and database of 156 buildings that are 240 feet or taller in San Francisco's northeastern neighborhoods that was published by ATC in December 2018, entitled *San Francisco Tall Buildings Study,* Applied Technology Council, 201 Redwood Shores Parkway, Suite 240, Redwood City, California 94065. Table One is based on that inventory, as well as DBI's records identified in [2] above. Errors and omissions are solely attributable to the author.

[4] As used herein, non-residential high-rises means those which are not restricted to residential use above ground floors; accordingly those which include office use along with limited residential use will be denominated "non-residential" here. Table Two is based on the materials identified in [2] and [3] above. Errors and omissions are solely attributable to the author.

[5] The assessed value of modern high-rises in San Francisco's urban core often exceeds $850 per square foot, and frequently approaches $1,000 per square foot. For instance, Salesforce Tower has 1,370,000 square feet and was assessed at $1.3 billion. See, e.g., Li, R (July 22, 2018): San Francisco's 10 Most Valuable Buildings, *San Francisco Chronicle.* Real estate consultants have confirmed to the author in person that these are realistic estimates and he is aware of financial district transactions where the per square cost of acquiring an entire facility exceeds $1,250 in 2020.

[6] The San Francisco DBI maintains digital records of construction permits and some design drawings used in the peer review and permitting process for One Ricon Hill and the Salesforce Tower, which is the source for information included in this article; it is available at the fourth floor of its offices at 1660 Mission Street, San Francisco, California and was accessed in January and February 2020.

[7] Goodyear, C. (December 8, 2005): Rincon Hill's Huge Towers Put On Hold / S.F. Building Agency Withholds Permit Over Seismic Concerns, *San Francisco Chronicle*

[8] Permit and plan documents for 101 1st Street, on file at DBI on the fourth floor, reviewed February 2020. 101 1st Street was the designated address for the original proposed Transbay Tower, which was re-named Salesforce Tower, and given the new address of 415 Mission Street. The structural design team described the Lateral Force-Resisting System as follows: "Lateral forces are resisted by coupled concrete structural walls placed around the central elevator and stair core of the tower. Wall coupling is provided by diagonally reinforced coupling beams, conventionally reinforced coupling beams, or embedded composite steel coupling beams." Basis of Design, dated May 2, 2014. The Salesforce Tower structural design team calculated a building period of $T = 6.3$ and employed seismic response spectra found in ASCE 7-10. DBE "ground motions are determined in accordance with ASCE 7-10." The mapped spectral acceleration selected was $S_1 = 0.607$; in addition, $S_{D1} = 0.607$.

The structural design relied on several soils reports prepared by ARUP, some of which are available at DBI offices (second floor) and were reviewed in February 2020. In its July 31, 2013 soils report (p. 63), ARUP states: "The earthquake scenarios used in our analyses correspond to a geometric mean MCE peak ground acceleration (PGA) of 0.50g based on a site-specific study in accordance with ASCE 7-10." ARUP designated a site class of D and assumed a maximum moment magnitude of 7.9 and expects settlement of the tower to range "between 1 to 4 inches" (p. 1, Executive Summary). Figure Three is ARUP's depiction of the location of the Salesforce Tower relative to San Francisco's 19th century shoreline.

Surprisingly, DBI indicates that it does not have the ARUP soils report used by the structural consultants entitled *Seismic Hazard Analysis and Ground Motion Development Report*, dated August 30, 2013 (see, e.g., p. 63 of the ARUP July 31, 2013 report: "A separate report will be produced which covers the ground motion study by Arup and is currently underway. Additionally, a separate report will be produced for the soil-structure interaction study"). As of February 2020, DBI does not appear to have either of the latter two reports.

[9] Klemencic, R, Valley, M, Hooper, J (June 2017): Salesforce Tower, *Structure Magazine,* pp. 45-48, accessed February 9, 2020 at https://www.structuremag.org.

[10]City and County of San Francisco, Department of Building Inspection, 2014, Administrative Bulletin 083, *Requirements and Guidelines for the Seismic Design of New Tall Buildings using Non-Prescriptive Seismic-Design Procedures*, 7 pages (March 25, 2008, revised January 1, 2014)

[11]City and County of San Francisco, Department of Building Inspection, Administrative Bulletin 082, *Guidelines and Procedures for Structural, Geotechnical, and Seismic Hazard Engineering Design Review*, 10 pages (March 25, 2008, revised December 19, 2016 and November 21, 2018)

[12]Deierlein, G.G., Schotanus, M, Shields, C. (2017): *Structural Safety Review of the Millennium Tower* 14 pages (delivered to Naomi N. Kelly, City Administrator, City and County of San Francisco on July 28, 2017)

[13] See White Managing Risk 2020, cited in [1] above, at pp. 6-7.

[14] See White Managing Risk 2020 at p. 3 and note [3] therein.

TABLE ONE

POST LOMA PRIETA HIGH-RISES

PERMITTED AND COMPLETED FOR RESIDENTIAL USE AFTER 1989

HIGH-RISE NAME	ADDRESSS	YEAR COM-PLETED	PERMIT DATE	STORIES ABOVE GRADE	HEIGHT (FEET)	AREA (SQUARE FEET)
BridgeView	400 Beale Street	2003	1999	26	358	449,567
The Watermark	501 Beale Street	2004	2004	22	225	149,000
The Metropolitan at 355 1st St	355 1st Street	2005	2000	28	240	597,982
The Metropolitan at 333 1st St	333 1st Street	2005	2000	21	178	141,960
The Paramount	680 Mission Street	2005		41	475	681,251
Infinity I North	301 Main Street	2006	2006	36	350	409,556
Infinity II South, aka 300 Spear Street	338 Spear Street	2006	2006	41	401	454,990
One Rincon Hill South	425 1st Street	2008	2006	56	550	757,137
Millennium Tower	301 Mission Street	2009	2005	58	605	1,100,000
One Hawthorne Street	1 Hawthorne Street	2010		25	239	290,607
Trinity Place Apartments	1188 Mission Street	2010		24	223	328,055
LUMINA II	338 Main Street	2012	2012	37	381	487,000
LUMINA I	301 Beale Street	2012	2012	42	429	487,000
Jasper	45 Lansing Street	2013	2012	40	430	471,334
Ava 55 Ninth	55 9th Street	2014	2011	18	187	308,000
NEMA North Tower	1411 Market Street	2015	2014	39	352	951,676
399 Fremont Street	399 Fremont Street	2016		42	400	596,400
340 Fremont Street	340 Fremont Street	2017	2005	42	400	290,000
The Harrison, aka One Rincon Hill North	401 Harrison Street	2017	2013	47	450	485,000
1500 Mission - Residential	1500 Mission Street	2017	2017	39	397	767,200
Solaire (Transbay Block 6)	299 Fremont Street	2017		33	330	476,705
500 Folsom	500 Folsom Street	2017	2017	42	402	743,500
Oceanwide Center II	526 Mission Street	2017	2017	54	605	631,638
MIRA, aka Folsom Bay Tower	160 Folsom Street	2018	2017	40	400	480,000
33 Tehama Street	33 Tehama Street	2018	2018	34	366	278,097
The Avery aka 450 Folsom	450 Folsom Street	2019		56	550	906,472

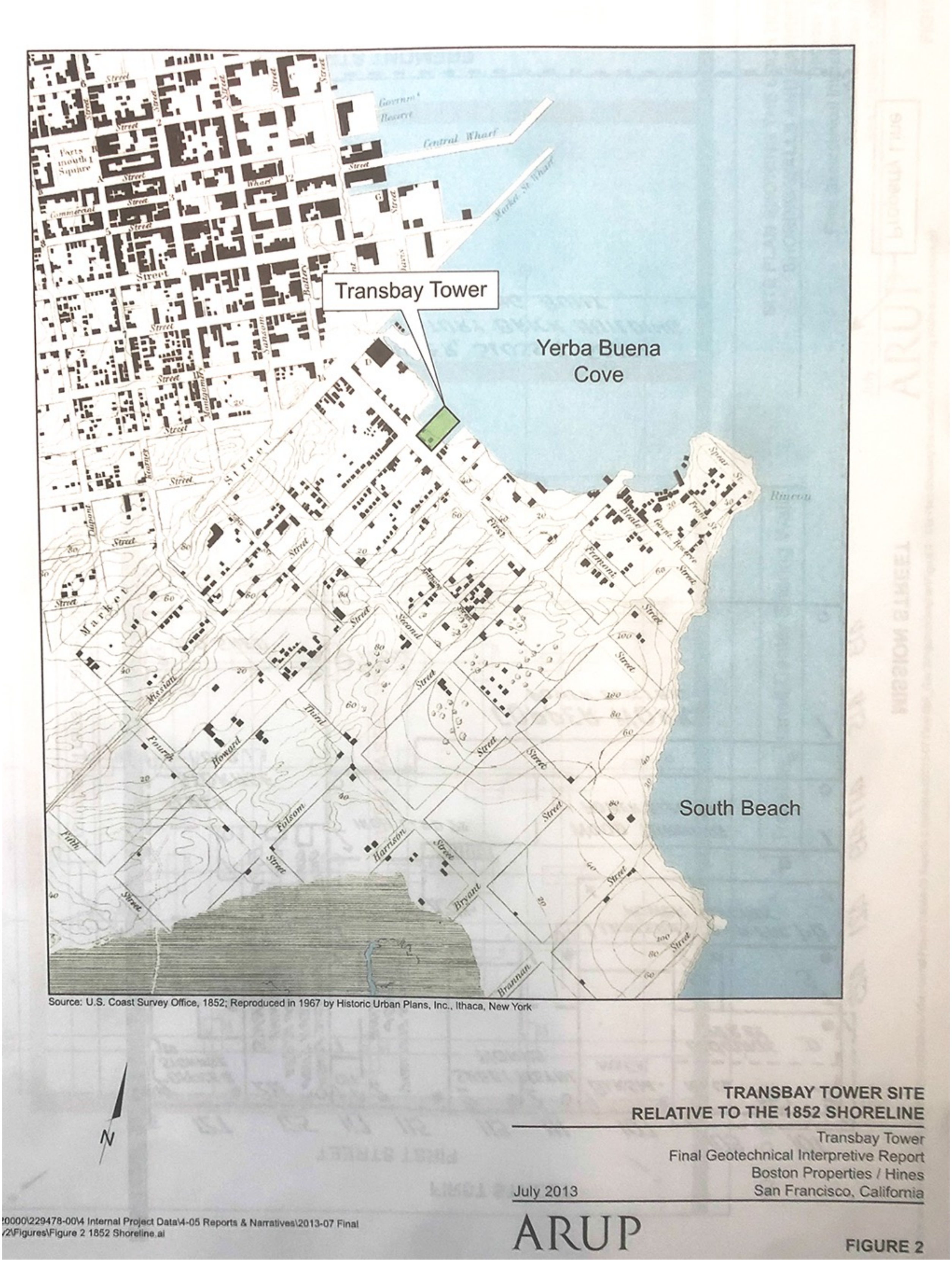
TABLE TWO

POST LOMA PRIETA HIGH-RISES

COMPLETED FOR NON-RESIDENTIAL USE AFTER 1989

HIGH-RISE NAME	ADDRESS	YEAR COMP-LETED	PERMIT DATE	STORIES ABOVE GRADE	HEIGHT (FEET)	AREA (SQUARE FEET)
121 Spear Street	121 Spear Street	1990	1985	24	280	572,535
600 California Street	600 California Street	1991		20	270	403,629
505 Montgomery	505 Montgomery Street	1992		24	420	308,297
160 Spear Street	160 Spear Street	1993		19	250	289,253
Four Seasons Hotel	757 Market Street	1998	1998	36	449	1,110,500
W Hotel	181 3rd Street	1999	1997	31	298	289,040
101 2nd Street	101 2nd Street	1999		25	340	441,412
199 Fremont Street	199 Fremont Street	1999	1998	28	350	400,000
150 California Street	150 California Street	2000		23	317	247,500
GAP Building	2 Folsom Street	2001		15	222	780,000
JPMorgan Chase	560 Mission Street	2001		31	434	779,000
33 New Montgomery Street	33 New Montgomery St	2001		19	287	240,000
55 2nd Street	55 2nd Street	2002		25	330	404,437
St. Regis San Francisco	125 3rd Street	2007	2000	42	449	736,000
InterContinental San Francisco	888 Howard Street	2008	2007	35	350	564,614
555 Mission St	555 Mission Street	2008		35	487	625,524
706 Mission Street	706 Mission Street		2010	44	480	57,482
SF PUC Headquarters	525 Golden Gate Avenue	2012		15	187	277,511
1190 Mission at Trinity Place	1190 Mission Street	2013		22	215	338,053
535 Mission Street	535 Mission Street	2014	2014	27	378	355,000
222 2nd Street	222 2nd Street	2016	2016	26	367	523,150
Salesforce East, aka 350 Mission Street	350 Mission Street	2017	2011	30	384	490,000
181 Fremont	181 Fremont Street	2017	2013	58	746	706,617
Salesforce Tower, aka Transbay Tower, aka 101 1st street	415 Mission Street	2017	2014	61	1,070	1,370,000
Oceanwide Center I	50 1st Street	2017	2017	61	850	1,432,872
33 8th at Trinity Place	33 8th Street	2017		19	229	961,816
350 Bush Street	350 Bush Street	2017	2017	21	259	420,000
1500 Mission	1500 Mission Street	2017	2017	19	255	573,560
Park Tower	250 Howard Street	2017	2018	45	568	743,000

FIGURE THREE



Source: U.S. Coast Survey Office, 1852; Reproduced in 1967 by Historic Urban Plans, Inc., Ithaca, New York

TRANSBAY TOWER SITE
RELATIVE TO THE 1852 SHORELINE

Transbay Tower
Final Geotechnical Interpretive Report
Boston Properties / Hines
San Francisco, California

July 2013

ARUP

FIGURE 2

20000\229478-00\4 Internal Project Data\4-05 Reports & Narratives\2013-07 Final
2\Figures\Figure 2 1852 Shoreline.ai