27 December 2021

Mr. James Zaratin
General Manager
Millennium Tower
301 Mission Street
San Francisco, CA 94105

Project 147041.10 – Millennium Tower Perimeter Pile Upgrade Project

Re: Scope Revision

Dear Mr. Zaratin:

This letter explains our recommendation to modify the scope of the voluntary foundation retrofit project, currently being constructed. These recommendations were jointly prepared by Mr. John A. Egan, Geotechnical Engineer of Record, and myself, in my role of Structural Engineer of Record for the voluntary foundation upgrade project.

In 2014, I performed structural analysis of the Millennium Tower to understand the effect of foundation movement on the building's safety and stability. I determined that the foundation movement had not affected the building's safety and remained capable of resisting any likely earthquake event. I reported that structural retrofit was not necessary. I have recently updated these analyses to consider the additional foundation movement that has occurred since. I found that the building remains safe and able to resist any likely earthquake.

The Millennium Tower is founded on a 10-foot thick, heavily reinforced concrete mat supported by 942 precast, prestressed concrete piles driven into a dense sand layer at a depth of approximately 80 ft below street level. The sand is underlain by more than 160 ft of soil including clays and clayey and silty sands, with the bedrock surface present at a depth of about 250 ft. Although these soil conditions and this foundation type is typical of nearly all high-rise buildings in the San Francisco financial district, the Millennium Tower has experienced substantial settling since its construction. This foundation movement is a result of consolidation and secondary compression of the clay soils directly underlying the dense sand that the tips of the existing piles are founded in. Consolidation is a slow natural process by which water is squeezed out of clay soils by excessive pressure, resulting in volume change of

the soils. This process is self-limiting and will eventually come to a halt even if no upgrade is performed. In fact, following completion of adjacent construction projects, settlement rates have been about 1/3 in. per year.

Regardless, the Millennium Tower Association (MTA) Board wanted to perform a voluntary retrofit to arrest the settlement sooner than would naturally occur. Mr. Egan and I designed the Perimeter Pile Upgrade to arrest settlement at the building's northwest corner and allow slow recovery of some of the tilt which had occurred over time. The original Perimeter Pile Upgrade scope consisted of the installation of 52 new piles to rock, spaced at 6 ft on center, along the Mission (north) and Fremont (west) sides of the building, then jacking a portion of the building's weight onto these piles, where it is transferred directly to the rock, bypassing the consolidating soils. Analyses performed by Mr. Egan and his team confirmed that removal of this load from the existing foundation is sufficient to stop settlement at the northwest corner. I selected the number of piles, 52, because this was the maximum number that could be placed along the building's sides, where access is readily available. Similarly, I selected the amount of load per pile, 800,000 pounds, based on calculations that indicated this was an amount I could safely transfer without damaging the existing foundation. When Mr. Egan confirmed this would be sufficient to accomplish the project objectives, we never attempted to optimize the design down to the minimum number of piles necessary.

To assure that the weight jacked on to the new piles is transferred to the rock, and not placed back onto the consolidating soils through skin friction, the new piles are installed in two components: 1) a 24 in. diameter, concrete-filled steel pipe structural pile; and 2) an outer 36 in. diameter steel pipe casing that isolates the structural pile from the surrounding soil.

Construction initiated in November 2020. The contractor started installing the new piles along Mission and Fremont Streets in May 2021. During May-June, the contractor installed all of the 36 in. casings on Fremont Street. In July and August, the contractor installed approximately half of the 36 in. casings on Mission Street and six of the 24 in. piles on Fremont Street. However, we noted that the rate of building settlement increased more than anticipated as the contractor installed these casings and piles. In August, we recommended, and the MTA Board approved, a voluntary moratorium on construction until we could determine why increased foundation movement was occurring and how this could be mitigated.

We identified two potential causes of the increased foundation movement: vibration of the soils associated with pile installation activity, and unintentional removal of excessive soil as the piles were installed. During August-September, we worked with the contractor to identify potential modifications of their installation technique to reduce these effects. In October, we obtained permission from the City to install a limited series of 36 in. casings and 24 in. piles, as pilots, to confirm the efficacy of the modified installation procedures. These pilot tests have been

successful and settlement rates since October have remained at about 1/2 in. per year. However, to minimize additional building settlement, we believe it is important to minimize the amount of construction and complete it as rapidly as possible.

Mr. Egan and I initiated a series of calculations to evaluate whether we could install fewer piles and still accomplish the project goals. Specifically, we evaluated scenarios ranging from the six piles that had been completed in August 2021, as well as larger numbers of piles. We also evaluated, based on test data from the piles already installed, and more detailed structural calculations of the existing foundation capacity, whether it would be possible to take more load on the new piles than originally planned. We determined that it is possible to safely increase the load per pile from 800,000 pounds to 1,000,000 pounds. We also determined that with this increased loading per pile, it is possible to accomplish the design objectives, which are to arrest settlement at the northwest corner and obtain gradual tilt recovery, using as few as 18 piles. We are presently working with the Department of Building Inspection and their independent review panel to confirm the specific number of piles, which may range from 18 to 24.

We have recommended, and the MTA Board has approved, reducing the project scope to include fewer piles, with the loading per pile increased as described above. This will enable completion of the pile installation work in early 2022, and allow us to jack load off the existing foundation before the end of 2022, and accomplish the design goal of arresting settlement at the northwest corner and recovering some tilt, over time. With this reduced scope, we anticipate the building will not settle more than another 1/2 in. before construction completion. We are in the process of submitting this revised plan to the City to obtain an updated building permit. Meanwhile, construction will resume under the building permit already in place.

I have attached a Frequently Asked Questions document to assist you in responding to homeowner requests. Please let us know if you have any other questions.

Sincerely yours,

Ronald O. Hamburger, SE
Senior Principal
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MILLENNIUM TOWER

VOLUNTARY FOUNDATION UPGRADE

FREQUENTLY ASKED QUESTIONS

Q1: Is the building safe?

A: Engineers have performed extensive analyses of the building and confirmed the building remains safe. A City-appointed review panel concurs with this assessment.

Q2: Why has the building settled?

A: Settling is a result of consolidation and secondary compression of soils beneath the foundation. Consolidation occurs when pressure on the soils exceeds historic levels. The Millennium Tower's weight coupled with extended dewatering of the site for adjacent and nearby projects triggered this. This is a natural process and will eventually halt.

Q3: What is the purpose of the voluntary upgrade?

A: The voluntary upgrade is intended to stop downward movement of the building along Mission and Fremont streets, while allowing gradual recovery of tilting that has occurred.

Q4: What does the upgrade consist of?

A: The upgrade consists of installing new foundation piles, extending to rock, along the Mission and Fremont Street building faces. Once installed, the contractor will jack some of the building's weight off the original foundation and onto the new piles. This will relieve the excessive pressure on the consolidating soils and stop the settlement along the Mission and Fremont Streets faces of the Tower.

Q5: What changes to the project are proposed?

A: Engineers recommend reducing the number of piles and increasing the amount of load jacked onto each pile. This will enable more rapid completion of the project and will stop the foundation movement sooner.

Q6: Why did construction stop this summer?

A: The technique used by the contractor to install the piles was causing additional foundation movement. Engineers stopped the construction so that the contractor could develop an improved means of pile installation. The contractor just completed a series of tests of these new techniques and demonstrated they are effective.

Q7: When will the project be completed?

A: The project should be largely complete by the end of 2022, with sidewalk restoration and building access returned to normal in January 2023.

Q8: What parties will review the project as it moves forward?

A: The design team, including Simpson Gumpertz & Heger, John A. Egan, Geotechnical Engineer, and Slate Geotechnical Engineers will continue to monitor the building's performance throughout construction and for a period of 10 years thereafter. In addition, the City Department of Building Inspection, and its expert panel, including Dan Brown & Associates, will continue to monitor the project progress and building performance.

Q9: When will the new piles be attached to the building and is there anything to be concerned about when this occurs?

A: The current project schedule calls for transfer of load to the new piles in August and September 2022. This will be accomplished using a series of hydraulic jacks and will be done in slow increments, over a period of several days. The design team will be monitoring the building's behavior, including the load on the jacks, the elevation of the building, the width of cracks in the basement, and the building's overall condition as this occurs, to assure that the building is responding properly.

Q10: Will the reduced number of piles affect the way the building behaves after the retrofit?

A: The design goal remains unchanged, to arrest settlement at the building's northwest corner while the rest of the building continues to settle, at ever-reducing rates, to recover some of the tilt. With the reduced number of piles, we expect somewhat more recovery of tilt to the west than originally planned, however, there will be less tilt recovery to the north.

Q11: Is there any advantage to installing more than 18 piles?

A: If more than 18 piles are installed, the construction schedule will be extended, and the building will settle and tilt a little more during this period. We judge that the 18-pile solution offers an optimal solution between additional settlement and benefit gained. We are working with the City and their review panel to obtain their concurrence in this judgement. On the basis of discussions to date, we believe that the final design will include not less than 18 nor more than 24 piles.

Q12: Will there be any additional strain on building utilities as the building continues to settle?

A: Continued settlement of the building will place more strain on the utilities. We do not anticipate this will cause any failures. However, the design team and other consultants retained by MTA are monitoring this and will make recommendations for any necessary corrective actions.