June 18, 2021
JAE Project No. 1001

To: Mr. Ron Hamburger, PE, SE
Simpson Gumpertz & Heger, Inc.

From: John A. Egan, PE, GE

Memorandum: DISCUSSION OF MONITORING PROGRAM RESULTS THROUGH JUNE 14, 2021
Millennium Tower Perimeter Pile Upgrade
301 Mission Street
City and County of San Francisco, California

This memorandum addresses Slate Geotechnical Consultants' (Slate) memoranda that summarize results from the monitoring program for instrumentation installed at the 301 Mission Street property to monitor the Millennium Tower (Tower) prior to, during, and after the implementation of the Perimeter Pile Upgrade (PPU). In January 2021, two piezometers and two extensometers were installed in borings drilled for the PPU, one each along the Fremont and Mission Streets alignments (Slate, 2021)[1]. Some of the instrumentation, however, has been in-place for more than a decade, notably settlement markers and crack gauges that were installed in the Tower's basement level in April 2009. Survey measurements taken for those settlement markers at various time intervals between April 2009 and present time are available. That set of settlement markers was augmented with additional markers in January 2017 and survey measurements for those markers have been taken since then simultaneously with the original set. In December 2016, survey prisms were mounted on the exterior of the Tower to provide measurements of project East-West (E-W; Beale Street to the East and Fremont Street to the West) and project North-South (N-S; Mission Street to the North and the Transbay Terminal to the South) lateral deflections a six floor levels of the Tower, as well as at the roof level. The locations of the instrumentation within and on the Tower are illustrated on Figures 01A and 01B of the Slate memoranda; Slate's memoranda are submitted weekly, with the most recent dated June 14, 2021.

We are now a month into the installation of the 36-inch casings for the PPU production piles along Fremont Street, so are now able to distinguish trends in the data from the various elements of the monitoring program and interpret potential reasons for changes observed amongst those trends.

Settlement Observations

The average rate of Tower settlement from the beginning of construction activities at the site in early November 2020 through completion of the PPU geotechnical borings in late January 2021 was essentially the same as the six months immediately preceding the start of PPU site activities. That settlement rate (≈⅛ [one-eighth] inch/year) was also consistent with the continuing trend of decreasing settlement rate with time that the Tower has been exhibiting since mid-to-late 2017, following substantial completion of construction activities at adjacent and nearby sites.

There was an increase of the average rate of Tower settlement (to ≈¼ [one-quarter] inch/year) starting in late January 2021 and extending to early April 2021 that temporally coincided with the set-up and installation of the Indicator Piles. It is noted, however, that this rate was comparable to, although slightly less than, settlement rates observed in early 2020 (≈⅓ [one-third] inch/year) and less than rates observed during similar periods of previous years.

During the month that installation of the 36-inch casings for the PPU production piles along the Fremont Street alignment has been on-going (since May 12, 2021), the average settlement of the Tower has been ≈$^{1}/_{16}$ [one-sixteenth] inch, corresponding to ≈⅞ [seven-eighths] inch/year. As might be expected and as

[1] Slate Geotechnical Consultants, Inc. (2021). 301 Mission Retrofit Monitoring Report 006: Results as of June 11, 2021. Memorandum prepared for John Egan, Ron Hamburger, Phil Lovett, and Kristin Gonsar, 15p., June 14.

illustrated by Figures 04 of the Slate memoranda, the largest amounts of settlement are occurring along Fremont Street where the 36-inch casing for the production piles are currently being installed. Figure 1 below (adapted from Figure 006-04 of Slate's most recent memorandum) illustrates the locations of the two indicator piles and the 36-inch casing installations that had been completed as of the most recent settlement marker survey on June 8, 2021. As Figure 1 and Slate's Figure 006-04 illustrate, the largest change of elevation (≈$^1/_6$ [one-sixth] inch) during this time period has been measured at settlement marker LE-21, with the larger settlement contours concentrated around that marker and encompassing settlement marker SM-27 that has historically exhibited the largest settlements measured across the Tower's mat.

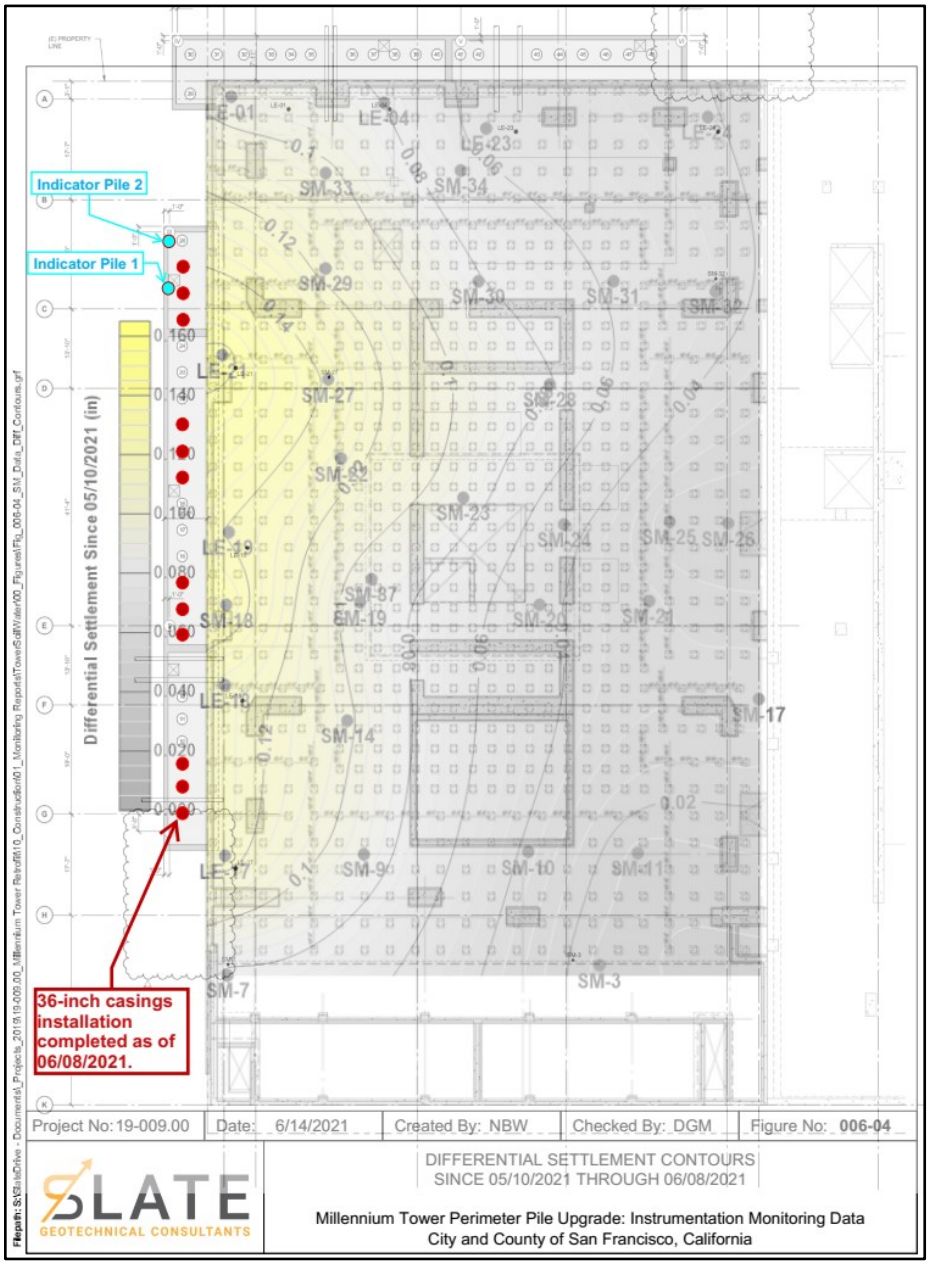

Figure 1. Locations of PPU 36-inch Casings Installed Between 05/12/2021 and 06/08/2021 Relative to Measured Incremental Settlement During that Time Period.

The cause of the settlement increase that has occurred under the western portion of the Tower over the past month is not known. However, the spatial proximity of the 36-inch casing installations along the Fremont Street alignment during this time suggests a hypothesis that vibrations from the pile rig and from insertion and drilling clean-out of the casings may be producing small amounts of densification of the Marine/Colma Sands below the tips of the existing concrete piles that support the Tower. The amplitudes of construction vibrations typically attenuate (diminish) relatively quickly with distance from the source, so the pattern of settlement illustrated by the contours on Figure 1 and Slate's Figure 006-04 would be consistent with vibration-induced densification of the Marine/Colma Sands.

Tilt Observations

Figure 006-05 of Slate's memorandum indicates that tilt of the Tower (as reflected by lateral deflection at the roof level) has increased since the beginning of construction activities at the site in early November 2020. The prism data indicates that lateral deflection at the roof level in the E-W direction has increased slightly less than 2½ inches toward Fremont Street and ≈⅓ [one-third] inch toward Mission Street. Figure 006-05 also indicates that the estimated deflections based on planar analyses of the settlement data are somewhat less for this period than the prism data.

Similar to the settlement observations above, different amounts and rates of tilt increase correspond to the various periods of construction activity described above. To illustrate that, the portion of Slate's Figure 006-05 from January 1, 2017, to the present is adapted and presented in Figure 2; the prisms were installed in December 2016 and measurements initialized on December 15, 2016. Figure 2 includes all of the prism data for comparison of the tilt increase during PPU construction activities to historical increases of tilt; the periods of PPU construction activities are depicted by the colored symbols in 2021.

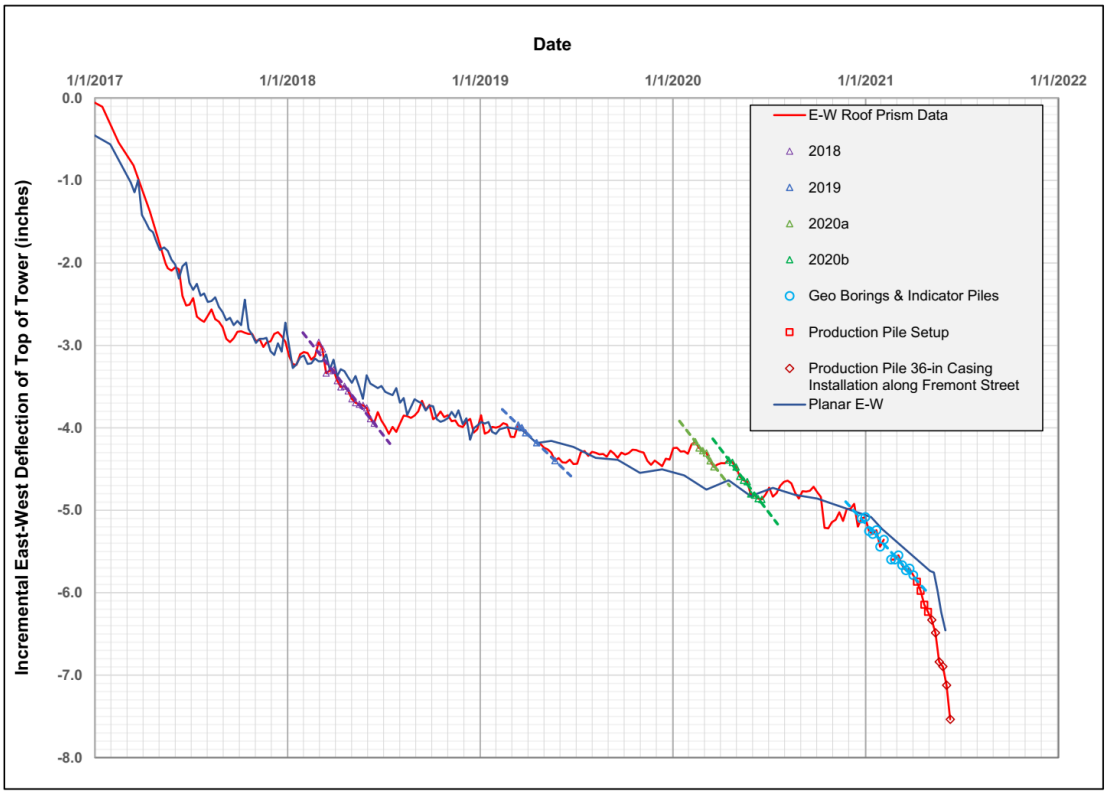

Figure 2. Lateral Deflection at Tower Roof Level Toward Fremont Street from Prism Data; installed and initialized 12/15/2016.

During the approximately 3-month time period from the beginning of construction activities at the site in early November 2020 through completion of the PPU geotechnical borings in late January 2021, the lateral deflection at the roof level of the Tower increased ≈⅓ [one-third] inch toward Fremont Street and ≈1/16 [one-sixteenth] inch toward Mission Street. That increase of E-W roof deflection (toward Fremont Street) corresponds to a rate of ≈⅛ [one-eighth] inch/month. During the time period that coincided with the set-up and installation of the Indicator Piles (late January 2021 to early April 2021), the rate of E-W roof deflection increase was somewhat higher than the previous time period (≈1/5 [one-fifth] inch/month). But, as Figure 2 illustrates, it is difficult to discern any real difference in rate between these two periods of construction activities. As such, for purposes of assessing increases of lateral deflection, I have considered these two time periods together. For the five months beginning when construction activities started at the site, the lateral deflection at the roof level increased ≈¾ [three-quarters] inch toward Fremont Street and <1/10 [one-tenth] inch toward Mission Street. The E-W increase corresponds to a rate of ≈1/6 [one-sixth] inch/month. For perspective, this rate is lower than rates of lateral roof deflection increase indicated by the prism data for several months during the first half of the previous three years. Figure 2 illustrates trendlines of lateral deflection increase during winter and spring seasons of 2018 (≈¼ [one-quarter] inch/month), 2019 (≈1/5 [one-fifth] inch/month), and 2020 (≈¼ [one-quarter] inch/month) that are steeper than the ≈1/6 [one-sixth] inch/month rate for this initial five months of PPU construction-related activities at the site. It is noted that the rate of lateral roof deflection during early 2017 was substantially greater (≈½ [one-half] inch/month) than this early-2021 rate, as well as the 2018, 2019, and 2020 rates cited previously; but there were still construction activities on-going at adjacent and nearby sites until mid-2017.

> **Commentary** - An interesting observation in the prism data is the higher rate of lateral roof deflection increase during the winter and spring seasons of the previous three years than occurs during the subsequent summer and autumn seasons of these years. Reasons for these seasonal differences is not known. But, noting that the higher rates coincide with the winter and spring seasons during which days are growing longer and hence, there is more warming sunlight shining on the Tower. It could be speculated that the Tower may be responding to those effects (i.e., expanding) and enhancing the prism measurements. Conversely, during summer and autumn seasons, days are growing shorter and with lessening amounts of warming sunlight, rates of lateral roof deflection from the prism measurements may correspondingly diminish. The reason for addressing this observation about the prism data is that we do not see similar trends in changes of lateral deflection at the roof level estimated based on planar analysis of the Tower's settlement observed from measurements of the survey makers in the basement of the Tower. As Figure 2 illustrates, over the long run, lateral deflections at the roof level based on the prism data and estimated from the settlement data are in generally good agreement. The deflections estimated from the settlement data do not, however, exhibit the seasonal fluctuation observed in the prism data; rather, the estimates from the settlement data reflect on-going processes of consolidation and secondary compression of the Old Bay Clay and, perhaps during the recent PPU construction activities, vibration-induced densification of the Marine/Colma Sands, that underlie the Tower foundation.

During April, PPU construction activities at the site included movement and set-up of drilling equipment along the Fremont Street alignment in preparation for installing the 36-inch casings for the PPU piles. Although no drilling activity was undertaken during this period, the prism data indicates that there was an increase of the rate of lateral deflection at the roof level (to ≈½ [one-half] inch/month) between the completion of the Indicator Pile testing and the beginning of the 36-inch casing installation. No settlement survey data are available for this explicit time period, but survey measurements taken just prior to beginning the 36-inch casing installation indicate the rate of settlement and lateral deflection at the roof level (see Figure 2) were similar to the three-month time period immediately preceding April.

Installation of the 36-inch casings for the PPU production piles along the Fremont Street alignment has been on-going for about a month (since May 12, 2021). Figure 1 illustrates where the 12 of these casings installed as of June 8, 2021, are located. Figure 1 also illustrates that, during this period, larger settlements have

occurred along Fremont Street where the 36-inch casings for the PPU piles are currently being installed than across the rest of the Tower footprint. Given this pattern of settlement, it is not surprising that the lateral deflection toward Fremont Street at the roof level has increased during this time period. According to the prism data, this increase was ≈1 inch, corresponding to a rate of increase of ≈1 inch/month; whereas, based on planar analysis of the Tower's settlement observed from measurements of the survey makers in the basement, the estimated increase during this time period is ≈¾ [three-quarters] inch. Shimmick/Legacy has indicated that installation of the 36-inch casings along the Fremont Street alignment will be completed by June 25, 2021, so an additional two weeks beyond the last prism data illustrated on Figure 2. Presuming that the current rate of lateral deflection remains applicable, an additional ≈¾ [three-quarters] to 1 inch of deflection toward Fremont Street at the roof level could be experienced by completion of the 36-inch casings installation along Fremont Street.

Piezometers

Several sharp increases of piezometric head have been observed in the PB-1 piezometer at a depth of 85 feet bgs (located in the Marine/Colma Sands). The spike on May 15, 2021, between 6AM-12PM corresponds to a known influx of water onto the crane mat/sidewalk during installation of the 36" casing as the auger is retracted and soil is removed. The Building Engineer for the Tower also noted water infiltration into the basement. Similar increases were not observed in SB-1 and PB-2, as these piezometers are not situated close to the source of this water influx.

Additional spikes were observed on May 28, 2021, June 1, 2021, and June 7, 2021, all between 6AM and 12PM, and on June 11, 2021, between 6AM-9AM. The cause of the May 28 and June 1 spikes is not known, but likely is similarly due to an influx of water as described above. The spike on June 7 corresponds to advancement of the 36-inch casing for Pile #27 to a depth of ≈89 feet feet bgs and on June 11, the spike corresponds to advancement of the 36-inch casing for Pile #28 similarly to a depth of ≈89 feet feet bgs and observed water addition; both Piles #27 and #28 are located in close proximity to Piezometer PB-1.

For the piezometers in the Old Bay Clay (OBC), piezometric head at the PB-1 piezometers was influenced (increased) by the installation of the nearby Indicator Piles and has exhibited a general trend of decrease (dissipation) since then. Small increases of the head in the PB-1 piezometers at depths of 105 feet bgs, 120 feet bgs, and 135 feet bgs was observed on May 17, 2021, but piezometers at greater depths were not noticeably affected. Advancement of the 36-inch casing for nearby Pile #25 achieved its tip depth of ≈102 feet bgs on that day. Sharp decreases in the PB-1 piezometer at 105 feet bgs was observed on June 7, 2021, between 3PM-6PM and on June 11, 2021, between 6AM-9AM and 12PM-3PM. The decrease on June 7 corresponds to advancement of the 36-inch casing for nearby Pile #27 to a depth of ≈101 feet bgs and the decreases on June 11 correspond to advancement of the 36-inch casing for nearby Pile #28 to depths of ≈89 feet bgs and then ≈103 feet bgs. The decreases may be result of release of water from OBC into the casing, as the length over which the head loss occurs is much shorter after removing the soil inside the casing.

Extensometers

After commencement of the installation of the 36-inch casings for the PPU piles along the Fremont Street alignment, instruments along the Mission Street side of the Tower initially indicated negative differential settlement (i.e., extension) at project Northeast side of the Tower, potentially from increased settlement along the West side of the Tower. Now a month into the installation, the instruments along the Mission Street side are indicating settlement (i.e., compression). It is noted that the extensometer displacement referred to herein are thus far no greater than $^{1}/_{25}$ [one-twenty-fifth] inch.

Conclusion

There have been increases of both total and differential settlement of the Tower, as well as associated increase of tilt toward Fremont Street (as reflected by lateral deflection at the roof level) since construction activities began at the site in early-November 2020. These increases have most notably coincided with installation of the 36-inch casings for the PPU piles along the Fremont Street alignment over the past several

weeks (since May 12, 2021). Based on the temporal relationships discussed above, I expect that when installation of the 36-inch casings along Fremont Street is completed, both additional settlement and increased lateral deflection at the roof level toward Fremont Street will diminish significantly. Similarly, as installation of the 36-inch casings begins along Mission Street, I expect to see increases in the rate of settlement along Mission Street side of the Tower and increased lateral deflection at the roof level toward Mission Street.

Reference

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