

December 11, 2014

Juan Luis Magro, STP
Construction Manager
Seattle Tunnel Partners
999 3rd Avenue, Suite 24224
Seattle, WA 98104

Re: SR 99: Shaft Excavation Status Report & Action Items for Discussion
TBM Access Shaft, Seattle, WA

Dear Juan Luis,

The following memo addresses several issues and concerns that have been identified as excavation of the SR99 access shaft has progressed. In response to these issues and concerns, a list of action items has been developed.

Survey As-built & Monitoring

Inclinometer Readings

Recently, inclinometer reading have shown movements of the top of the shaft walls inward (radially) and tangentially. Inward movements vary from 0.08 inches to 0.38 inches and tangential movements between 0.08 inches and 0.25 inches. Survey movements at the top of the shaft do not correspond to the inclinometer movements. The exact cause of these movements is unknown; however possible causes include the crane surcharge adjacent to the shaft; thermal influence on the instrumentation; and, movements of the surrounding area associated with the regional geology.

In order to assess the behavior and safety of the excavation, we need to have accurate inclinometer and survey data. The importance of this data is further heightened due to the presence of differing site conditions and structural wall inadequacies that have been encountered.

SESMP Pile As-built

As excavation of the shaft has progressed, structural discontinuities in the form of zones of untreated soil within the designed structural in-fill areas have been observed. The size of these zones, location, communication between the zones of untreated soil and seepage observed through these zones have raised concerns about the continuity of the wall and its ability to function as a compression ring cylinder as intended in the design. To date the untreated soil zones have been probed in an effort to determine their size, depth, and the consistency of the material within the zones. The success of the probing has been mixed and has not been capable of accurately defining the as-built condition of the untreated zones.

Reviewing the as-built locations of the shaft piles at regular vertical intervals, we are concerned that there is a potential for much larger untreated soil zones to exist than initially considered in the design, depending on the location of the SESMP piles. The design pile layouts shown in Figure 1 and Figure 2 indicate the originally expected in-fill or void areas in solid gray.

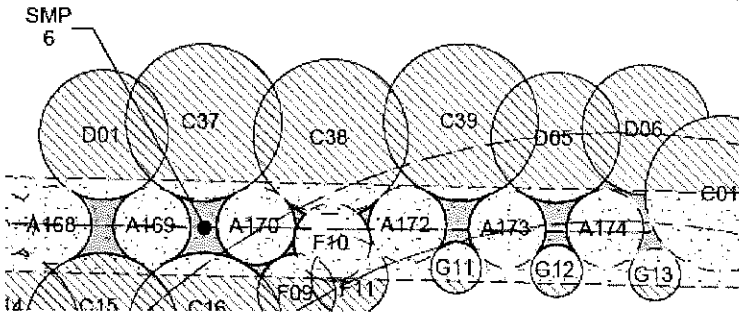


Figure 1: West Shaft Wall Design In-Fill Areas (Solid Gray Shaded Areas)

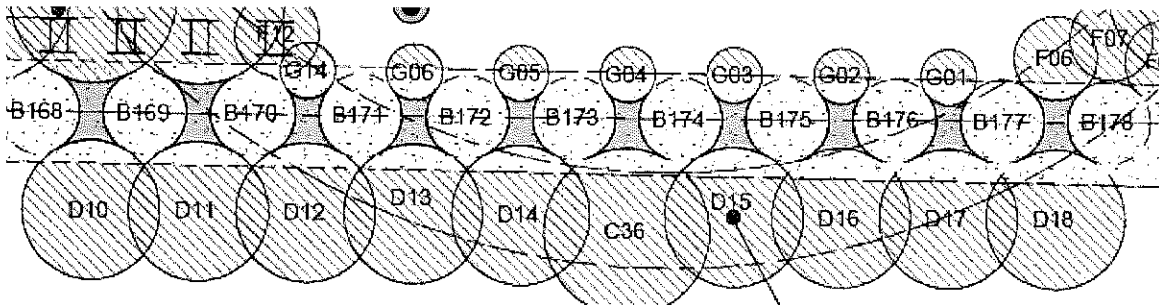
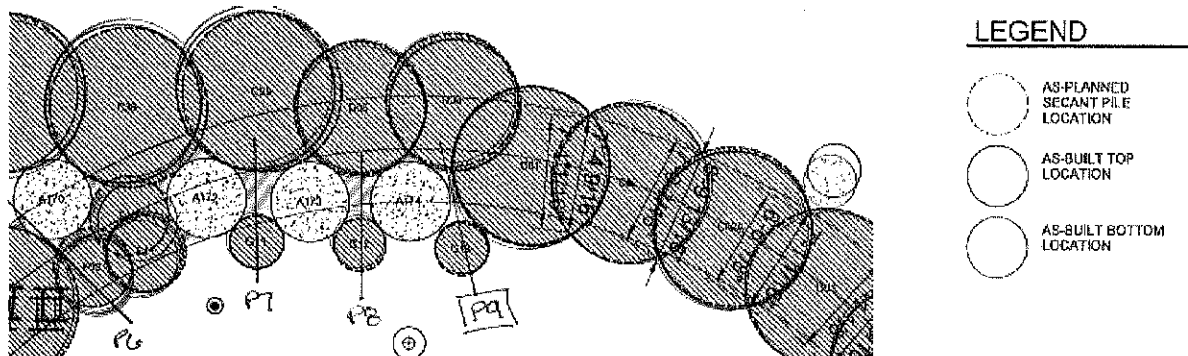





Figure 2: East Shaft Wall Design In-Fill Areas (Solid Gray Shaded Areas)

Upon review of the as-built secant pile locations with respect to the SESMP piles, there appears to be a potential for much larger in-fill areas than initially intended in the design. Given the observed untreated soil zones in the in-fill areas to date, the as-built pile layouts shown in Figure 3 and Figure 4 indicate the extent of potential untreated areas in yellow. Potentially untreated soil zones that fall within the theoretical design compression ring. A continuous compression ring of adequate thickness and strength is essential for the structural stability of the wall.



- LEGEND**
-  AS-PLANNED SECANT PILE LOCATION
 -  AS-BUILT TOP LOCATION
 -  AS-BUILT BOTTOM LOCATION

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Figure 3: West Shaft Wall Pile As-built (Potential Void Areas Highlighted in Yellow or Hatched)

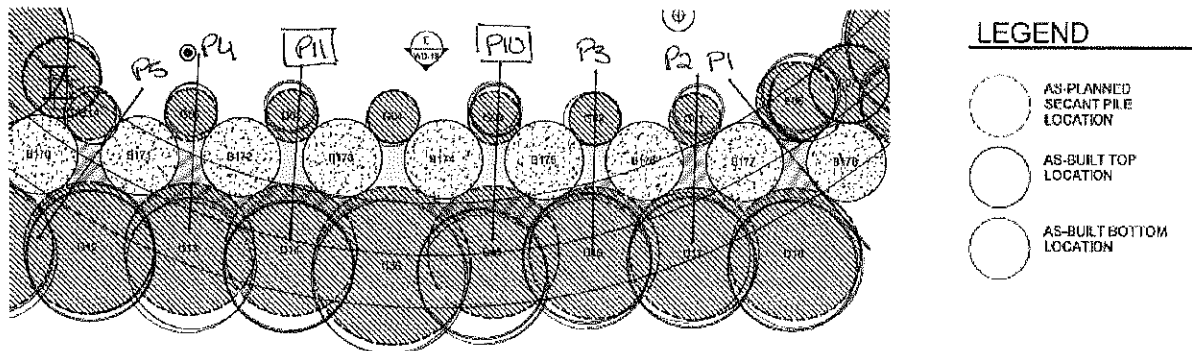


Figure 4: East Shaft Wall Pile As-built (Potential Void Areas Highlighted in Yellow or Hatched)

While it is likely the in-fill areas and associated untreated soil zones are larger than initially intended, we do not believe they are as extensive as shown in the as-built pile layouts of Figure 3 and Figure 4. For example, Figure 4 shows the potential for a nearly continuous void through the entire width of the shaft wall between piles B177/F06 and B178/D18. However, if this were the case, we believe that significant seepage and ground loss would have been observed during the course of excavation to date. Given the rate of seepage observed and the lack of ground loss outside the shaft, it is likely there is some continuous wall present between piles B177/F06 and B178/D18.

The source of the uncertainty for the as-built condition is the lack of as-built data for the SESMP piles. Once the as-built of the SESMP piles is incorporated into the existing overall shaft as-built, a more refined analysis of the ring-structure can be completed and critical in-fill repair locations identified.

Structural Review

As we discussed during design, a primary challenge in designing and constructing the ring-structure shaft was in crossing over the existing SESMP piles, which are discontinuous, heavily reinforced, and constructed with high strength concrete. Per our design computations, our original concentric ring thickness was presumed to be 67-inches typically and a minimum of 56-inches at the bottom due to tolerances in drilling. Secant walls were located to meet these tolerances. At interfaces with the existing SESMP piles, we specified tangent piles that cannot be interconnected like secant piles, and required the spaces between the tangent piles to be excavated and filled with structural concrete or grout.

Based upon our excavation to elevation -68', we have continuous secant walls where expected. But the infill areas at wall crossings at the SESMP piles were not in all places filled with concrete or grout. These areas are numbered in order of their importance to the structure, based upon our visual review of the structure and the concentric circle design shown in Figure 3 and Figure 4. This concentric circle design has been used for many years in such structures and is known to be adequate or slightly conservative. We believe that the main area of concern is on the east side at the two crossing points, in particular at the northeast side. Seepage indicates that areas P1 and/or P3 are not continuous.

Once an accurate pile as-built is developed, a more in depth review of the ring-structure can be completed to identify the in-fill repair areas that must be targeted. Brierley Associates is currently in the process of updating the BIM model with the recently provided pile as-built data through excavation elevation -74'.

Action Items

The following actions have been identified and should be discussed before excavation proceeds.

1. Removal of G Piles

As excavation has progressed it has been observed that the tangent G piles have deviated away from the SESMP piles, particularly on the eastern side of the shaft. Therefore, the G piles offer little confinement for the in-fill areas between the SESMP piles and can actually inhibit the repair efforts by preventing clear access to the areas and obstructing a thorough visual investigation. Furthermore, with the G piles in place it is difficult to obtain an as-built survey of the SESMP piles.

Given the uncertainty of the SESMP pile locations and the extent of the corresponding in-fill area, we recommend the following G piles be removed to better provide access to the in-fill areas and to obtain a clear SESMP pile as-built.

Piles G01, G02 and G06 shall be removed as excavation progresses. This will require this piles above the current bottom of excavation to be anchored to the surrounding shaft wall.

2. Probing Data

In an effort to obtain more detailed data from probing in areas of concern, a Brierley Associates representative shall be present for all probing operations moving forward. This will require adding a second, full-time person in the field.

3. Permanent Survey Prisms

Given the inconclusive data collected by the inclinometers, permanent survey prisms shall be installed. Recommended locations for the permanent survey prisms are piles C16 (SW corner), C02 (NW Corner), C13 (NE Corner), and C24 (SE Corner). Survey points shall be installed at the ground surface, at increments of 20 feet along the height of the current excavation, and at the base of excavation prior to proceeding with the next stage of excavation. Survey of the permanent prisms shall be completed daily and results uploaded to GeoScope no later than noon of the following day.

4. Repair and Excavation Sequencing

To date repairs to the wall have been completed as excavation progresses in lifts, meaning that necessary wall repairs below the base of excavation are not completed until the entire lift height is exposed. We are concerned that the walls could begin to move inward below the base of excavation where repair has not yet occurred. The likelihood of wall movement below grade increases as the depth of the excavation increases and the corresponding loads on the shaft walls approach design limits. Similarly, the risk of

pipng through the unrepaired untreated soil zones below the base of excavation increases with depth. Once piping begins it can be difficult if not impossible to stop.

Therefore, it may become necessary that the repair of untreated soil zones below the base of excavation be completed prior to excavation proceeding. The means and methods of how to complete these repairs below the current base of excavation are a topic that requires further discussion.

In summary, we believe that the untreated soil zones observed at the intersections of the tangent and SESMP piles could have a significant negative impact on the structural, geotechnical and hydraulic adequacy of the shaft structure. If we continue the current "repair as we go" method of excavation, we significantly increase the risk of a catastrophic failure. Therefore excavation shall not proceed past elevation -74' until the action items listed above are completed and Brierley Associates has concluded a structural review based on the as-built pile and in-fill data collected to elevation -74'.

Sincerely,
BRIERLEY ASSOCIATES

David Berti, PE, SE
Senior Consultant

Arthur J. McGinn, PhD, PE
President-CEO

Cc: Eric Lindquist, PhD, PE, Brierley Associates
Russell Lutch, PE Brierley Associates
Phil Burgmeier, PE, Brierley Associates
Chris Dixon, Seattle Tunnel Partners
Miguel Alonso, Seattle Tunnel Partners
Greg Hauser, Seattle Tunnel Partners
Tony Stirbys, Seattle Tunnel Partners
Scott Bender, Bender Consulting