Memo

Date: January 27, 2015

To: Eric Jacobson, Senior Project Manager, Portland Development Commission

From: Mark Tobin, S.E.

Re: Fire Station at NW 3rd and Glisan – Foundation Study

This memorandum is meant to document the findings of our foundation study for the fire station at NW 3rd Avenue and NW Glisan Street in Portland, Oregon in accordance with our proposal dated December 11, 2014. The discussion below is based on the geotechnical information provided by Hart Crowser regarding the soil conditions at the site. Their report concluded the following:

- The site has experienced significant static settlement in the past resulting in damage to the fire station building and other site structures.
- The site is at significant risk to liquefaction, with liquefiable soils to a depth of 100 feet.
- Settlement due to liquefaction is anticipated to be between two and four feet.
- Liquefaction is likely to be accompanied by lateral spread of the soils – on the order of two to ten feet.
- Proposed structural solutions to these risks include using deep foundations (e.g. drilled shafts) or placing the building on a mat foundation.

KPFF studied the proposed structural solutions and found the following:

Deep foundations, such as drilled shafts, would be effective in supporting the building in the event that liquefaction occurred. Large grade beams would be placed beneath the bearing walls and building columns to transfer the load of the building to the drilled shafts if the supporting soil liquefied and settled. However, the drilled shafts would not be effective in mitigating the lateral spread issue. When the soil moves laterally, it imposes a significant horizontal load on the drilled shafts. Based on the loading diagrams provided by Hart Crowser, it was determined that the shafts could not be reinforced adequately to resist the applied loads due to the magnitude of the loads and the substantial length of the cantilever. Increasing the diameter of the shafts is not effective because the load on the shaft increases proportionally to its diameter. Adding more piles is also not effective because each pile gets loaded independently from the others (i.e. it is not a total load that can be shared by several piles). Therefore, we concluded that drilled shafts alone are not an adequate solution due to their inability to resist the loads generated by the lateral spread.

The other solution that was studied was to place the existing fire station building on a thick, rigid mat foundation such that it would move monolithically and resist any differential settlement that would occur due to liquefaction and lateral spread. The construction of this solution would be quite challenging as the building would need to be adequately shored while the walls and columns were under-mined to place the mat foundation. This procedure would likely have to be performed in “strips” (say on the order of six feet wide) so that only small portions of the walls were under-mined at one time. The depth of the under-mining would be significant to accommodate the depth of the mat itself plus the over-excavation and back-fill with lightweight materials such that no net weight is added to the site. Reference the report by Hart Crowser for further discussion on this topic.

While the mat foundation solution appears to make sense intuitively, it is not one that we would recommend. We cannot justify or state with any confidence based on engineering principles that the mat foundation would be able to adequately support the building given the types and magnitudes of the estimated settlements. That, coupled with the notable challenges in its construction, led us to conclude that the mat foundation solution is not feasible.

In our opinion, the lateral spread displacements would need to be mitigated in order to develop a feasible foundation system for the building. If the lateral spread is controlled, then a system of drilled shafts with large grade beams supporting the building's bearing walls and columns would be a feasible way to support the building and mitigate the risk from liquefaction. It should be noted that the ground floor slab would have to be re-structured such that it does not rely on bearing on the soils for its support in case of liquefaction settlement. We believe that this system, while expensive and time consuming to construct, would be feasible and would address the liquefaction issue, provided that the lateral spread is mitigated separately.