
The project site

The Benefits of Early Contractor Involvement

The Biosolids Digester Facilities Project (BDFP) is located in southeast San Francisco. The jobsite is bounded by active Caltrain and Union Pacific Railroad tracks on the west side and the existing Southeast Treatment Plant (SEP) on the north, south and east sides. The existing SEP was constructed in the 1950s and portions of the facility have reached their operational life. The $2 billion BDFP will replace and relocate the outdated existing solids treatment facilities with more reliable, efficient and modern technologies and facilities. In addition, the nearby Bayview and Hunters Point neighborhoods will benefit from the improved odor control.

Core Trade Partner

In 2017, the San Francisco Public Utilities Commission (SFPUC), the owner of the project, selected MWH/Webcor, a joint venture, as the construction manager general contractor (CMGC) for the project. As part of an alternate delivery method set forth in the prime contract, the CMGC was permitted to propose the use of a core trade subcontractor partner for the SFPUC's approval to provide preconstruction services. The CMGC identified three major scopes (electrical, mechanical and foundation) where a core trade partner would be able to assist


Jobsite overview

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the project in design build, design assist, value engineering and or other necessary preconstruction activities. In 2018, Malcolm Drilling Co., was approved by the SFPUC and brought on board as the foundation core trade partner.

The foundation partner participated in weekly meetings with the CMGC, SFPUC and the SFPUC's design team to provide value engineering on several major scopes of work. It proposed continuous flight auger (CFA) piles at certain structures, in lieu of the more traditional drilled shafts, which brought immediate schedule and cost savings to the project. In order to verify the capacities of the CFA piles and drilled shafts, the team performed an early-work onsite load test program, which gave the SFPUC design team confidence in the pile foundation selection.


Shoring system with the excavation at full depth at Facility 610

Malcolm also provided guidance on the selection of temporary shoring systems to be utilized at the two major excavations (Facility 610 and Facility 600). Several cutter soil mix (CSM) shoring wall options utilizing deep soil mixing or even jet grouting plugs, as well as deeper secant pile walls, were considered. Initially, a 70 ft (21 m) deep CSM shoring wall was envisioned for both excavations, however after reviewing the available geotechnical information it was uncertain if the wall would be deep enough at the Facility 610 to provide effective groundwater cut-off. As part of another early-work onsite test program, the foundation team installed and performed a pump test program to provide the design team with more information about the groundwater conditions. It was discovered that two underground aquifers (one at 40-60 ft [12-18 m] below grade and another at 80-100 ft [24-30 m] below grade) were connected and that a 70 ft (21m) deep CSM wall would not provide an effective cutoff to control groundwater drawdown outside the excavation.

Due to the close proximity of two nearby active railroad lines, the project could not utilize a shoring system that might allow uncontrollable drawdown outside the shored excavation. Options for a drilled secant shoring wall and a temporary diaphragm shoring wall were evaluated since they could both reach greater depths than the CSM wall option. Ultimately, a temporary diaphragm shoring wall was selected for the shoring system at Facility 610 due to the faster install

Level three tieback drilling

time, greater depths it could penetrate and its ability to meet strict deformation criteria.

Existing Site and Subsurface Conditions

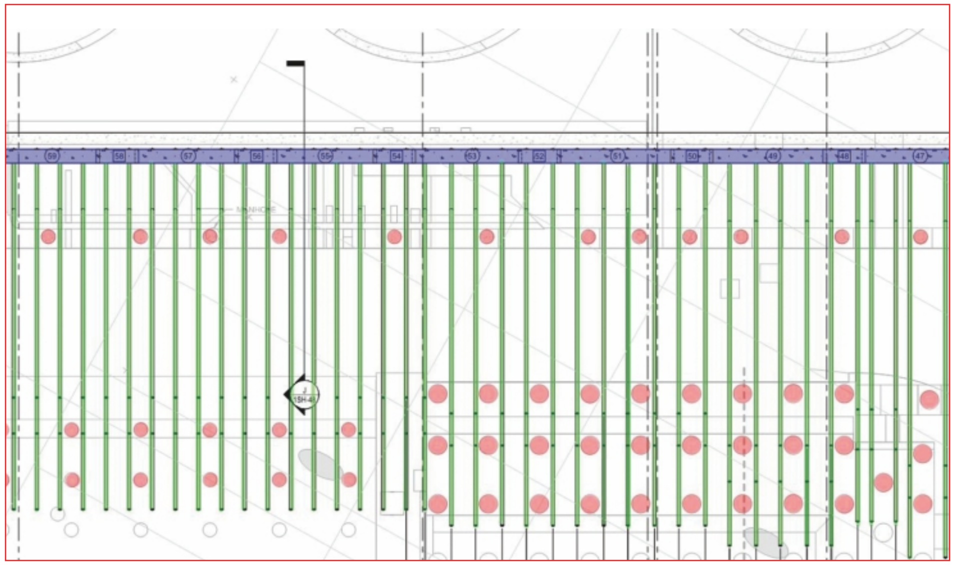
The project site is located within the Hunters Point Shear Zone. The project site is generally level at about elevation +3 ft (1 m) and the groundwater level was observed at a depth varying between 7-12 ft (2-4 m) below existing grade, although the piezometric head in the deeper soil strata is generally higher than the unconfined near surface groundwater level. In general, the geologic units encountered at the project site consisted of artificial fill extending to a depth ranging from 10-18 ft (3-5 m). The fill was underlain by young Bay mud, then upper layer sediments of interbedded sands and clays, which was underlain by old Bay clay, followed by older colluvium and then the Franciscan complex.

Design Considerations for Facility 610

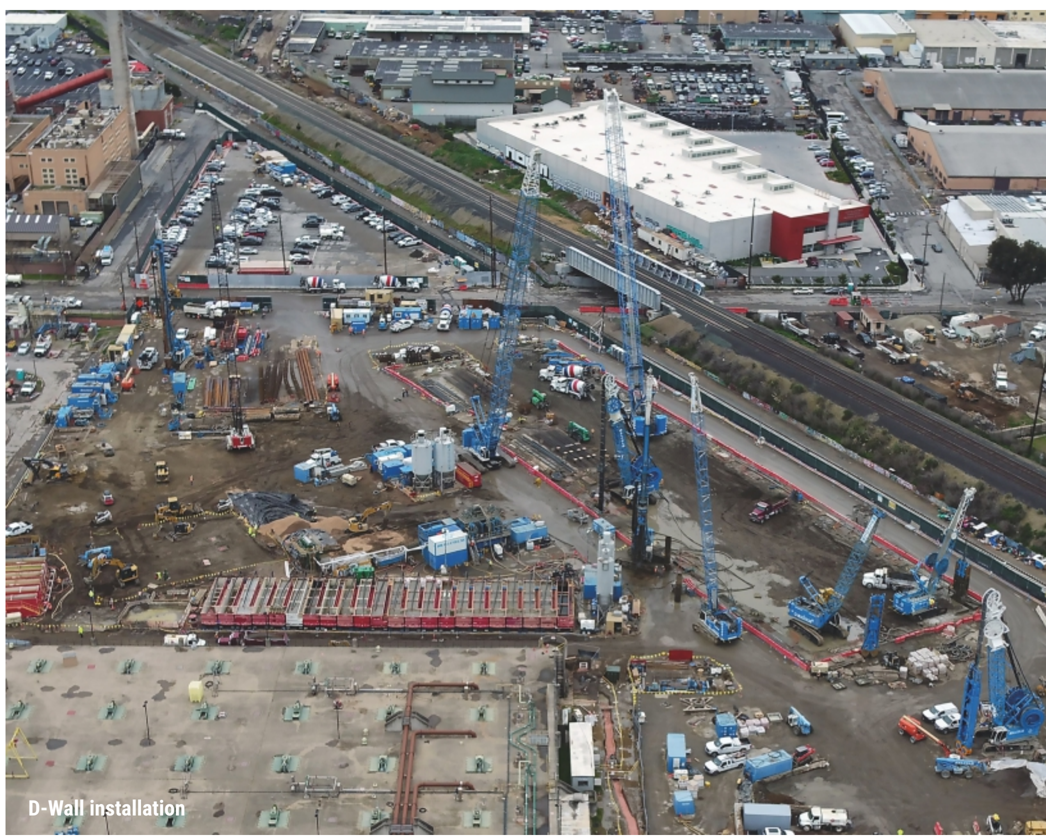
The Facility 610 Anaerobic Digestion structure consists of five digester tanks that extend from a lower basement level that is approximately 34 ft (10 m) below grade to maximum height of approximately 65 ft (19 m) above grade. Because the excavation is approximately 40 ft (12 m) deep with numerous site constraints, including two adjacent railroads that could not be impacted by the construction, a rigid shoring system was required. Excavation extended through the artificial fill and Bay mud and bottomed out in the upper layer sediments. To ensure bottom cutoff, the perimeter shoring wall was extended 160 ft (49 m) below grade to penetrate into the relatively impermeable old Bay clay for a bottom seal.

Excavation Support System

The design and construction of the shoring system navigated several site constraints to ensure the constructability of the tieback/bracing system and the ability to perform the excavation efficiently. The geometry of the excavation would have been ideal for an internally braced shoring system to avoid possible tieback conflicts beyond the structure. However, blockouts through the cast-in-place digester tanks were not allowed, and the size and shape of the tanks would have required excessively large spans for the internal bracing that could not meet the tight deformation criteria. Other challenges included: high groundwater levels (excessive drawdown outside the excavation was not permitted), very soft and compressible young Bay mud and protecting the active rail lines to the west. The support of excavation system had to be coordinated with existing and new adjacent structures including an existing sewer vault and a forest of piles for new structures and improvements surrounding the Facility 610 excavation.



The diaphragm wall (blue) and designed tieback locations (green) relative to existing pile foundations (red)



D-Wall installation

BC40 hydro cutter mounted on MC96 crane

The 41.5 ft (13 m) deep excavation is supported by a 3 ft (1 m) thick, rebar-reinforced diaphragm wall (D-Wall), which is typically restrained by three levels of tiebacks.

Tiebacks were typically installed at 5 ft (1.5 m) on center and were installed at 30-degree angles with sufficient unbonded length such that bond zone reached the competent upper layer sediments that are below the young Bay mud. The tiebacks were installed through pipe block-outs that were pre-tied in with the diaphragm wall rebar cages.

Two hydro cutters and one hydraulic grab

Drilling the level two and level three tiebacks below the groundwater table and risking excessive water and soil inflow to the excavation was a challenging part of the construction. However, the team used a wall mounted preventer system and developed cased drilling and grouting techniques to minimize the amount of soils and water that entered the excavation during the tieback install. Ultimately, hydroactive grout was pumped into the locked-off tieback wedge plate to stop the leaking water.

All tiebacks were either performance or proof tested prior to lock-off. To allow for future site build out all tiebacks were required to be detensioned.

It was very important that the drilled shaft foundation piles were installed first to avoid the risk of drilling through tensioned tiebacks. The diaphragm wall and the 100 ft (30 m) long tiebacks had to be drilled straight in order to miss the already existing pile foundations.

Because the construction sequence for the adjacent buildings was uncertain at the initial phase of the design, the Facility 610 system had to be designed such that all structures could be excavated at the same time, which was extremely challenging due to the complex interaction between the adjacent excavations.

Monitoring and Performance Criteria

Movement of the top of the slurry wall was monitored on a weekly basis using optical survey techniques.

The contract specifications set threshold horizontal deflection limits of the diaphragm wall at 0.5 in (12 mm) with a maximum movement limit of 1.0 in (25 mm). The baseline measurements were established prior to excavation, and monitoring will be continued until the structure is constructed to grade.

At the time of preparation of this paper, build-out of the basement was underway and lateral deflections had been limited to approximately 0.5 in (12 mm) or less. The as-built deflection numbers were comparable to estimates made during the design process.

Mobilization and Site Utilization

Logistics was a primary challenge for the construction of this project due to multiple concurrent activities to meet the project schedule. In addition to the diaphragm wall construction, the foundation partner also installed 290 each 3 ft (0.9 m) and 4 ft (1.2 m) diameter auger cast piles, 233 each 4 ft (1.2 m) diameter cased drilled shafts and 526 each 1 ft (0.3 m) diameter tie down anchors. For three shallower structure excavations (up to 26 ft [8 m] in depth), the foundation partner installed a temporary CSM shoring wall that was supported by one level of internal bracing. More than 50 dewatering wells were installed to manage and treat the groundwater at the various excavations.

The site configuration, including access/egress, installation sequence and support equipment layout, was carefully planned prior to mobilization. Onsite daily meetings included all drilling superintendents and subcontractors to plan the next day's activities, and a unique coordination map was created each day to reflect the new work areas. This level of coordination was required to manage the large site and ensure that spoils were efficiently off hauled and ready-mix concrete made on time deliveries to drilling locations. At the peak, 80 trucks of spoil were being loaded out while 80 trucks of concrete were being delivered to the jobsite daily.

The equipment used to install the diaphragm wall included a Bauer BC40 hydro cutter mounted on a Bauer MC96 crane, one hydraulic grab mounted on a MC64 crane, one mechanical grab mounted on Liebherr HS 885, one 300T support crane, one 150T support crane, a Bauer BE550 desander unit, a centrifuge, and twenty-two 21,000 gal (80,000 L) open top mixing tanks.

Diaphragm Wall Construction

Temporary reinforced concrete guide walls were constructed along the alignment of the diaphragm wall to be utilized as a guide for the excavation equipment and the setting of the rebar cages.

Quality control of the panel excavation is critical for the water tightness of the diaphragm wall system. Prior to concrete and rebar placement, the panel excavation is independently checked via a Koden drilling monitor, which uses ultrasonic waves to measure a precise profile of the panel excavation to confirm it meets dimensional tolerances.

Panel reinforcing cages were assembled horizontally on the ground at the project site and lofted to a vertical position for installation. Bracing embeds with shear studs and tieback blockout pipe sleeves were all installed in the rebar cage prior to lifting and installation.

Placement of the 5,000 psi (34,475,000 MPa) design strength concrete was achieved via tailgate placement into multiple gravity tremies. In total approximately 25,000 cu yd (19,000m3) of structural concrete were placed for the slurry diaphragm wall.

Primary panel concrete placement with simultaneous excavation in background

Rebar cage installation in tandem with slurry wall excavation

Quality control of the concrete mix design is a critical factor for the slurry diaphragm wall system. An extensive preproduction trial batch program was implemented prior to mobilization for this project to develop a mix with local suppliers that met the required design strengths and workability parameters. During construction, continuous testing of the delivered concrete for flow, flow retention and segregation following the EFFC-DFI Guide for Tremie Concrete was implemented prior to the concrete going in the ground.

Conclusions

The early involvement of a core trade subcontractor proves successful to the design and construction of mega infrastructures that are complex and require intensive coordination between owner, CMGC, design team and contractors to overcome the many challenges a project like this presents.

In 2018 and 2019, the foundation partner spent many hours traveling to, and attending, in-person meetings with the design team and the CMGC, which were indeed necessary. With online meetings so commonplace now, this collaboration process only became more efficient as the project progressed.

For this megaproject, not only did the foundation team deploy nearly every type of drilling method in its arsenal, but also undertook many scopes that normally the general contractor handles. In addition, the foundation partner had to meet a local small business hiring goal for the project, which essentially meant that any subcontractor hired had to be a small business based in San Francisco. Through community outreach meetings, and partnering with local companies, the team successfully found and managed multiple local subcontractors for the following scopes of work: excavation, spoil off-haul/disposal, rebar cage fabrication, surveying, site security and dust control.

Many valuable lessons were learned on this project and while they don't come around often, Malcolm and Brierley are well suited to take on the next future challenging megaproject.

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