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Unique Challenges and Solutions for an Urban Microtunneling Project

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ABSTRACT: A recently completed project for the San Francisco Public Utilities Commission presented many unique challenges for an experienced contractor. The project took place in a densely populated neighborhood in southern San Francisco and required the installation of 2,023-ft of centrifugally cast glass-fiber-reinforced polymer mortar pipe via microtunneling methods.

The Sunnydale Auxiliary Sewer Project was completed in three single-pass drives, with four, 30-foot deep shafts. The 88.6-in. OD pipe was installed through a broad range of sandy soil and rock. The inconsistent geology and the blocky fractured rock sections proved to be one of the biggest obstacles to the microtunneling operation. Another hurdle on this project was the limited storage and staging area at the launch shaft due to an urban setting. Working within these confines required resourceful efforts. In addition, the contractor had to address spoil removal, slurry separation equipment staging areas, noise control, obstacle negotiation, traffic patterns and construction impact minimization.

Attendees will be interested in the insightful project planning solutions that allowed for an efficient and successful urban microtunneling installation.

1. INTRODUCTION

The Sunnydale Auxiliary Sewer Project, owned by the San Francisco Public Utilities Commission (SFPUC) serves a population of 22,534 in the Visitacion Valley area of southern San Francisco. The existing Sunnydale Tunnel sewer is over 110-years-old and is often overwhelmed during storm events. The new tunnel collects wet weather flows, generally during the months of November through April, and remains empty during the remaining dry months of the year. Visitacion Valley is primarily residential but also contains a few parks, businesses, institutions, roadways and parking lots. The entire pipeline alignment is 5,375-ft long, with diameters ranging from 88-144-inches. It was constructed using multiple pipe installation methods including EPBM segmental tunneling, microtunneling, and open-cut construction. Crossings for the tunnel included a four-track rail station, light rail tracks, a 20-ft OD by 200-ft long culvert, plus many surface structures and buried utilities. This paper will focus on the three microtunneling drives that comprised 2,023-ft of the full project alignment.

The Sunnydale Auxiliary Sewer Project begins at the San Francisco Bay at Harney Way and ends at the intersection at Scherwin Street along Sunnydale Boulevard. It runs parallel and about 20-ft north of the existing tunnel. The grade is fixed due to tie-in locations and utilities along the alignment. This entire Sunnydale Auxiliary Sewer design-build project cost a total of $44.6 M.

The overall pipeline design required the execution of several tunneling and pipe jacking methods due to a diverse range of geological conditions and congested infrastructure. Underground construction contractor, Super Excavators

Inc. of Menomonee Falls, WI performed all the work. The project design team was Jacobs Associates of San Francisco, CA.

2. PRE-CONSTRUCTION PROJECT DETAILS

Once plans to implement the tunnel were put in motion by the SFPUC, Jacobs Associates was awarded the design contract in July 2007. A geotechnical data report was executed in November 2008. The original contract was developed in January 2010, bids were sought, and construction began in August 2010. The San Francisco Planning Department approved an amendment to the original contract in September 2011, reducing the amount of open-cut pipe installations and increasing microtunneling pipe lines while adding two shafts that were converted to manholes upon project completion.

Phase 1 of the project included 426-ft of 114-in. OD pipe installed from Harney Way to Highway 101 by open-cut methods. From Highway 101 to Bayshore Boulevard, the contractor installed a 144-in. concrete segmented tunnel with a Lovat 168-in. EPBM machine at a -0.192% grade. The last section of this phase included a 643-foot drive of 88.6-in. OD centrifugally cast, glass-fiber-reinforced, polymer mortar pipe (HOBAS) in 20-foot segments at a +1.0% grade along Sunnydale Avenue from Bayshore Boulevard to Talbert Street with an Akkerman SL 74 MTBM outfitted with an 88.5-in. increase kit (See Figure 1). Construction for the microtunneling portion of this phase began in July 2011 and concluded three weeks later.

Phase 2 construction ensued as the result of a change order to extend the Sunnydale Auxiliary Sewer Project, adding an additional 1,400-ft of 88.6-in. OD microtunneling in two drives at +1.74% grade (See Figure 1). This region is west of Phase 1, (from the Sunnydale Avenue and Talbert Street intersection), added two new shafts and a minimal amount of open-cut work to meet the tie-ins. The original contract slated this region for open-cut pipe installations. The rationale for the change was placed on the added-value and cost savings in minimized surface disruption for traffic, residents and fewer instances of utility rerouting. The San Francisco Planning Department, under the advisement from a conceptual engineering report, stated in their report that “the benefits of the modified project include fewer surface disruptions to traffic and surrounding land uses and reduced utility conflicts and relocations” (SFPUC Addendum to Mitigated Negative Declaration, 2011). Phase 2 microtunneling construction began at the end of March 2012 and concluded in mid-June 2012.

Figure 1: Microtunneling drives and shaft locations.

The project alignment impacted many local parties, in addition to area residents. Most of these constituents were affected in Phase 1 but there were also several in Phase 2. An encroachment permit was required for permission to tunnel below a 20-foot OD culvert owned by the California Department of Transportation (CalTrans) where the 144-in. EPBM tunnel was constructed. The SFPUC also had to obtain easement permissions from several businesses, the Union Pacific Railroad (UPRR), the San Francisco Metropolitan Transportation Agency (SFMTA) light rail station, the California Department of Toxic Substance Control (in the throes of an environmental clean-up for forthcoming development on a private property) and the Bay Conservation and Development Commission due to its proximity to the San Francisco Bay. The SFPUC held community outreach meetings with the many stakeholders to educate them about their construction methods and ease concerns about potential settlements, disruption and noise pollution.

A rigorous meeting and reporting schedule was required of Super Excavators Inc. throughout the duration of the project. They were involved in all planning meetings, weekly progress meetings and attended the project dispute review board meetings. The contractor had to submit daily progress reports to the SFPUC and also have contingency plans in place for all possible concerns.

A local subcontractor was hired for geotechnical monitoring using specialized instrumentation to assess noise levels, vibrations and movement throughout the microtunneling process.

The geology in the area slated for microtunneling was identified as a combination of Colma Sand and Franciscan Complex which includes sand, shale, sandstone, clay, silt and a mixture of rock with varying resistance and density factors all below a layer of fill material. Despite the fact that the three microtunneling drives were all in succession, the conditions varied greatly from one point of advancement to the next. The layered rock with bay mud layers in between proved to be the most challenging geology and impacted the advancement rates the most. The cutter head repeatedly got caught up on the layers of harder rock which increased the torque loads thus reducing the RPM’s and advancement rates.

Many electrical, gas, water, sewer and fiber optic/telecommunications utilities were identified in the locale, some known to be within three feet of the proposed alignment (The Sunnydale CSO Tunnel, 2010). Two potholing/probing programs were conducted, locating some utilities and identifying others for relocation, mostly those residing at the intersection of Bayshore Boulevard and Sunnydale Avenue. Four known high-voltage electrical lines and one gas line that intersected with the new alignment could not be rerouted. These lines were documented but initial probing and locating efforts only located one of the electrical lines. A second location effort began from the vault where the lines connected which resulted in the detection of two more of the electrical lines, although in different locations than initially suspected. The gas line was located at an angle under a concrete slab beneath the light rail tracks (The Sunnydale CSO Tunnel, 2010) and just two feet above the new tunnel alignment.

The SFMTA operates a light rail station where street-level tracks cross the tunnel’s path in the north/south direction along the median of Bayshore Boulevard, at the Sunnydale Avenue intersection. The light rail tracks were 16-ft above the tunnel, representing minimal cover above the crown of the MTBM jacking operation.

One of the major logistical complications for the contractor was the lack of available staging area around the shafts (see Figure 2 and 3). Due to the urban setting, there was limited available surface area alongside the shaft to stage the pipe, control container, crane and the additional equipment required to complete the work. At the SFPUC’s request, the contractor had to keep ancillary microtunneling equipment at the approved Phase 1 staging area, 700-ft from the first drive of stage 2 and 1,250-ft from the second drive of stage 2. The staging area, near the Bayshore and Sunnydale Boulevards shaft was an empty lot of a former manufacturing facility, and held the slurry separation plant, project pipe and ancillary equipment. The contractor used many lengths of slurry pack to tunnel this distance, carrying the power and communication cables on top of the slurry pack within the tunnel. Since microtunneling requires a closed and continuous flow of slurry to the face of the cutter head, multiple booster pumps were used to keep the slurry flowing to the separation plant then back to the cutter face for recirculation. Traffic flow along Sunnydale Avenue was generally limited to one lane and on street parking was reduced near the shaft locations. The contractor had to be very organized to work within these confines to keep installation moving in a swift fashion.

Figure 2: Shaft at the Talbert Street and Sunnydale Boulevard intersection showing the limited stage area.

Figure 3: Photo demonstrating the limited stage area.

All the excavated spoil material was transported and disposed of off-site. This resulted in the travel of many dump truck loads of spoil removal. The modified Phase 2 project details estimated that "a total of 4,975 cubic yards of material would be generated by shaft excavation and mircrotunneling, requiring 724 one-way trips (362 round trips)[1]" (SFPUC Addendum to Mitigated Negative Declaration, 2011). The average installation and advancement of the MTBM operation was six-feet-per-hour, which generated roughly 1.6 cubic yards of spoil per foot of tunnel. The spoil was transported to two locations based on its classification. The majority of the spoil was deemed clean and hauled about two miles away to the Baylands Soil Processing Plant in Brisbane. Spoils that contained potentially contaminated materials, mostly excavated during the EPBM run, were hauled about 40 miles away to a landfill in Livermore, CA.

[1] This figure is based on a one-way or round trip excursion for a 8-cubic-yard dump truck to complete spoils removal from the project site.

3. CONSTRUCTION

Table 1: Microtunneling Drive Details

Phase	Location	Length/ Grade	Diameter	Start Date	End Date	Ground Conditions	Advance Rate
Phase 1	Along Sunnydale Ave. from Bayshore Blvd. to Talbert St.	643 ft. +1.0 % grade	82.8/88.6-in. ID/OD HOBAS Phase 1 – 20 ft. sections Phase 2 – 10 ft. sections	7/19/11	8/8/11	Sandy to rock in the last 2/3 of the drive	10-ft per hour
Phase 2	Along Sunnydale Ave. from Talbert St. to Rutland St.	550 ft. +1.74%		3/28/12	4/20/12	Mostly rock complex progressing into sand	5-ft per hour
Phase 2	Along Sunnydale Ave. from Rutland to Schwerin	830 ft. +1.74%		5/15/12	6/14/12	Mostly rock complex and wet sand	6-ft per hour

The first drive was driven westward from the shaft at Bayshore Boulevard and progressed 643-ft to the shaft at Talbert Street (used both a reception and jacking shaft) from the median on the west corner (See Figure 4 and Table 1). The new tunnel closely paralleled the existing tunnel, approximately seven feet below, and about 10-ft to the north (right) of it. The first 150-ft of the 643-foot drive, under Bayshore Boulevard, passed beneath a concentrated number of buried utilities, and the SFMTA rail station and lines. The tunnel required shallow cover in this area to negotiate the obstacles, 18-ft below the surface to the crown of the pipe at a +1.0% grade. The shaft at this intersection was 40-ft long and 28-ft deep. The geology encountered on this drive was mostly sand then transitioned to a rock complex toward the final third of the drive. The rate of advancement per shift on this drive averaged 10-foot-per-hour over the entire length of the drive.

Figure 4: Showing orientation from Bayshore Boulevard looking east at the auxiliary sewer alignment.

The second drive, 550-ft in length, was launched from the Talbert Street shaft, oriented at a +1.74% grade westward, and emerged at the new shaft constructed at the intersection of Rutland Street and Sunnydale Avenue (See Figure 1 and Table 1). The new shaft was 29-ft deep and 24-ft in diameter. Shaft excavation took approximately three weeks and generated about 1,500 cubic yards of spoils. The geology in this area was more rock laden than the baseline reports indicated. The cutter face, equipped with a mixed ground configuration was significantly worn and eroded and required the replacement of many of the bullet bits, cutter discs and scrapper teeth prior to the launch of the final drive in Phase 2. The spoils generated were mostly rock complex progressing towards sandy spoils towards the last half of the drive. The rate of advancement per shift in this region was five feet-per-hour.

The third and final drive, 830-ft long, was launched from the second drive's reception shaft at Rutland Street and progressed westward at a +1.74% grade towards a new shaft at Schwerin Street (See Figure 1 and Table 1).The shaft design, approximately 30-ft deep by 24-ft in diameter, was altered due to the presence of ground water, the top was created with ring beam and lagging, the mid-section with interlocked sheet piles and the steel plates were placed on the bottom. Microtunneling for this drive was delayed since the contractor had to wait for the rebuilt cutter face to begin. The average rate of advancement per hour was six feet. The MTBM crossed under the existing tunnel at about 400-ft into the drive and 18-ft below it.

The shaft at Schwerin was temporarily filled and will be converted to a manhole at a future date in anticipation of other project tie-ins. Upon the completion of the final drive, Super Excavators Inc. finished the construction for the manhole at Rutland Street.

Super Excavators needed to abide by a strictly enforced working schedule of Monday through Friday, 7 a.m. to 5 p.m. to keep noise and construction disturbances at a minimum for area residents. The average crew size was six staff members per shift. Crew reported their best production rate at 57-ft in an 8-hour shift.

4. CONCLUSION

The Sunnydale Auxiliary Sewer Project illustrates what can transpire when the contractor, owners and the design team mutually collaborate to offer the best project solutions possible. This project contract required an ingenious approach from an experienced trenchless contractor to handle a complex set of challenges. The contractor's demonstrated approach in Phase 1 lead to increased linear footage using microtunneling methods during Phase 2. Super Excavators Inc., played a pivotal role in the education of their methods, exceeded safety and noise concerns and worked creatively with the owner and design team to deliver a quality tunnel system with a high level of regard for the surrounding community.

6. REFERENCES

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