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CASE HISTORY OF THE TEMPORARY SUPPORT OF AN 11-STORY HISTORIC BUILDING IN DOWNTOWN WASHINGTON, DC

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ABSTRACT

In conjunction with the below-grade construction of a new office building at 1875 Pennsylvania Avenue in downtown Washington, D.C. an adjacent 11-story historic building was supported using a system of bracket piles, a transfer girder and flat jacks. Before Clark Foundations could begin work, an office building from the 1960's was demolished. This paper will discuss the design, construction and performance of the 65-foot deep excavation support system for the new office building.

Built at the turn of the century, the adjacent structure was first supported in 1960 by a series of bracket piles and a concrete grade beam. The new office building at 1875 Pennsylvania Avenue required subgrade to extend approximately 10 feet below the tip elevation of those original 1960's bracket pile system.

The Clark team installed a series of 25 additional bracket piles and a transfer girder between the existing bracket piles to support the older system. This system was preloaded using a series of flat jacks to minimize any additional settlement. Clark Foundations created a very unique two-tiered underpinning support system. This new system supports a 1960's system, which in turn, supports the adjacent historic structure.

Clark's innovative approach created additional below-grade space gained for the law firm tenant while maintaining the integrity of a historic structure.

PROJECT LOCATION AND SCOPE

The project is located mid block on H Street between 18th and 19th Streets NW. It is approximately 2½ blocks west of the White House in the heart of Washington DC's downtown business district. The site is bound by a 16-foot wide public alley to the north, this alley services three loading docks, and is the only access to two adjacent underground parking garages. City permitting required that this alley remain open to the public at all times. To the east the site is bordered by a 13-story Office and Retail Building. H Street boarders the project's south side and is one of Washington's most congested roadways. The city would allow only limited lane closures to service the construction site. A three foot alley separates the new office building from the 11-story historic office building to the west. The owner purchased the rights to this alley to provide as much below grade space as possible. See Figure 1 and 2 below.

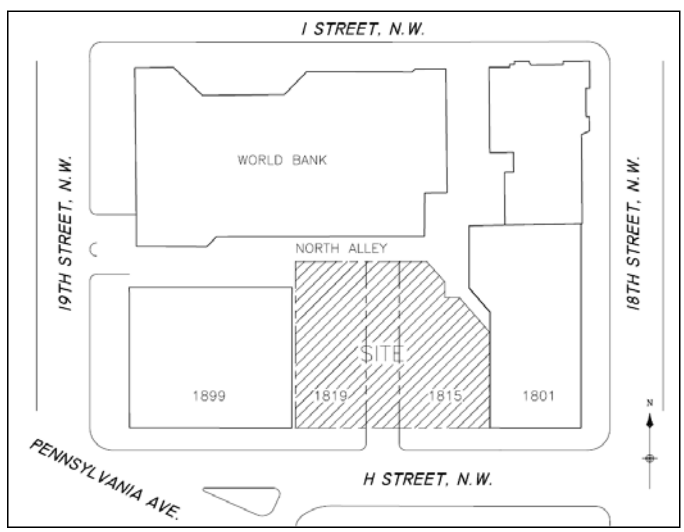

Figure 1: General Site Plan

Figure 2; Aerial Photo (provided by Google Earth.com)

Clark Foundations scope included the design and installation of a temporary support of excavation system for the construction of the new 13-story Class-A office building. A 65-foot deep excavation was required to accommodate five stories of below grade parking and office space. In conjunction with the support of excavation, special consideration was required to support the 11-story structure to the west. This building had recently undergone an interior renovation and was fully occupied at the time of construction, which meant entering on to the property to underpin internal columns was out of the question. A system of bracket piles, flat jacks and transfer girder was installed to support the existing bracket pile system to utilize as much of the below grade rental space as possible while supporting a 100-year-old structure. In turn, this system would limit additional deflection caused by the transfer of load from one system to the other.

In addition to their work on the support of excavation system, Clark Foundations was requested to designed and installed and maintained temporary construction dewatering system until the permanent sub-drainage system could be activated.

SITE GEOLOGY

The construction site lies within the Piedmont Physiographic Province of Washington, DC. This geologic region lies between the Coastal Plain Province to the east and the Blue Ridge Province to the west. Bedrock in this region typically consists of highly weathered metamorphic and igneous rock. At this site terrace deposits, associated with the nearby Potomac River overlay the Piedmont strata.

The site specific soil conditions consisted of approximately 10 feet of fill material on top of a layer of medium stiff brown and gray clay which ranged in thickness and extended to a depth of 20 feet. Below this clay layer are layers of poorly graded gravel and silt, with micaceous sand lenses. These layers in turn overlaying highly weathered and disintegrated rock to subgrade.

Ground water was encountered at elevation +35 or approximately 20 feet above the proposed subgrade elevation. Construction dewatering and a permanent sub-drainage system was required in the construction of this project.

DESIGN AND CONSTRUCTION CONSIDERATIONS

Preliminary Investigations and Preconstruction

As is the case with many older buildings in the city, drawings of the original 1899 building, constructed at the turn of the century, were not readily available during the initial design phase. Available information focused on the interior renovations and HVAC modifications that had taken place over the past 30 to 40 years of occupancy. Most structural information was collected by onsite investigations.

The original building was constructed around a courtyard or atrium and consisted of a steel-framed structure with a brick and limestone façade, having a 15’ x 15’ typical column grid. Typical footing sizes, scaled off old drawings were estimated to be 8’ x 8’ x 4’ (depth). The steel columns were encased in fireproof concrete. The floors were constructed out of terra-cotta. The structure had one floor below street grade. At some later date the courtyard was filled in to provide more office space. This infill was also a steel framed construction. At that time, footing were added to carry the added building loads.

At this point in our preconstruction site investigation the foundation system of the 1899 building was still virtually unknown. The depth of the basement floor slab and local geology led us to consider the existence of some sort of deep foundation system, possibly wood piling. Based on available soils information, tip elevations of such a system would terminate at elevation 25 to +30, well above the proposed subgrade elevation 13. In addition, details of how the site was excavated and underpinned in early-1960, was considered vital to the design of our system.

Two test pits were excavated within the three foot alley, which separated the 1899 building and the 1819 building scheduled for demolition. The soldier beams or bracket piles (14BPx102) from the early-1960 excavation system were uncovered through these investigations. In addition, it was discovered that the column footings and wall footings of the 1899 building projected into and across the three foot alley. This fact initially rendered the use of the three foot alley to install a new support of excavation system useless. Limited access to this area prohibited our test pits from extending below the existing column footings and limited our knowledge of the support of excavation installed in 1960.

As a result, two additional test pits were excavated through the foundation wall of the 1819 building. This was done in an effort to tunnel under the spread footings of the 1899 building. The test pits, along with partial support of excavation drawings discovered later by the structural engineer, confirmed that the historic 1899 building had a spread footing foundation and that its west wall was underpinned with bracket piles during the construction of the 1819 building in 1960. Figure 3 below shows the existing upper bracket detail installed in 1960 that would be eventually incorporated into our system. This detail clearly shows that a portion of the existing footing was removed prior to installing the driven soldier beam. Once the pile was installed, a half inch thick bearing plate was attached to the top of the soldier pile and the footing concrete and reinforcing was replaced

In total, 28 bracket piles were installed initially to support 128 linear feet of adjacent wall in 1960.

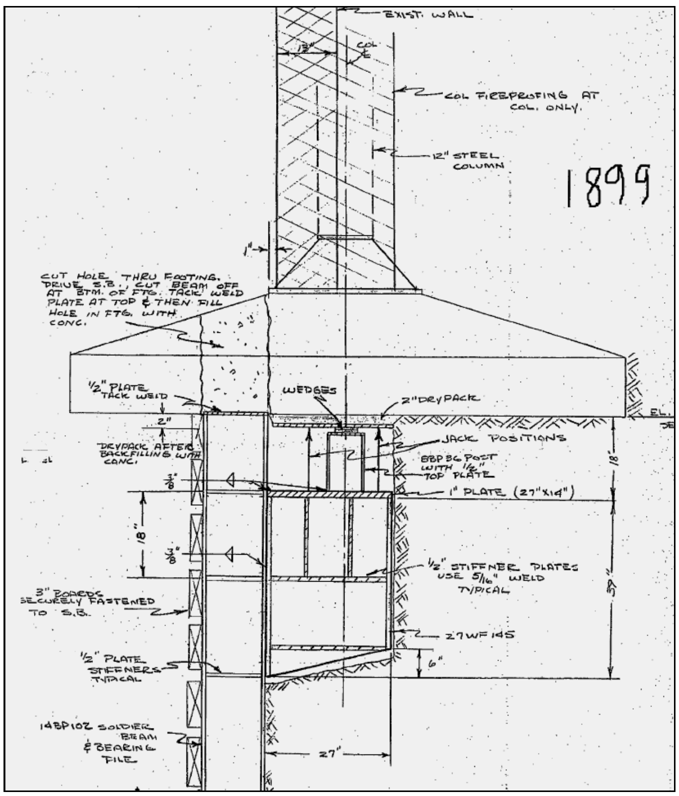

Figure 3: Upper Bracket Detail Installed 1960

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<u>Design Parameters</u>

<u>Soil parameters assumed for our design are as follows.</u>

- Soil weight: 120 pounds per cubic foot
- Angle of internal friction: 32 degrees
- Triangular loading for stage one single tier bracing
- Trapezoidal loading for multiple tier bracing

<u>Building surcharges.</u> Column loads and surcharge pressures were calculated and added where footings fell within a 45-degree influence line from the bottom of excavation. Actual column loads were determined from field measurements and standard minimum design for dead and live loads. Calculated column loads varied from 230 kips to 345 kips with an average load per column of 271 kips. Figures 4 and 5 show a typical cross-section of building 1899, the existing upper bracket, existing soldier beam horizontally supported by two tiers of tiebacks, the proposed lower bracket and transfer girder and soldier beam supported by one tier of tiebacks bracings.

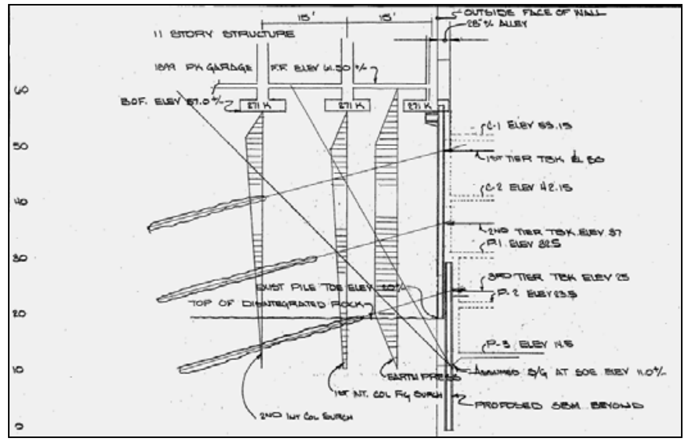

Figure 4: Typical Section at Building 1899

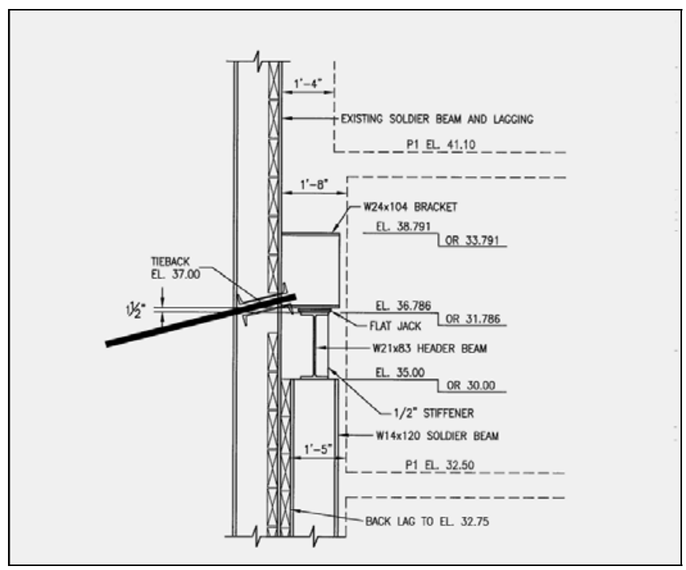

Figure 5: Lower Bracket Detail

Below, the lower bracket, lagging was installed to the back face of the new soldier beam (termed back-lagging). The foundation wall was thickened to 20 inches to incorporate the soldier beam bracket and transfer girder into the cast-in-place concrete foundation wall. It was important that the location of the transfer girder remain below the P-1 ramp to minimize the area affected by the thickened wall detail. Due to below grade space requirements of the proposed building, alternative designs such as a slurry wall, tangent pile wall, or other stiff support of excavation system were considered but deemed unacceptable.

SITE EXCAVATION AND CONSTRUCTION

Preconstruction Survey and Site Monitoring

Prior to demolition and construction, the adjoining properties' utilities and surface features, such as sidewalks, curbs and gutters, were surveyed by an independent contractor. This survey included interior and exterior photographs to record existing conditions and prior settlement issues. The recently completed renovation of building 1899 made this process difficult. Drywall and freshly installed marble flooring covered any signs of pre-existing cracks due to settlement. Most of the existing cracks were observed in the parking garage or exterior brickwork that had not been renovated. These cracks were monitored using Avongard grid crack monitors. Brick mortar joints were thoroughly inspected. Finally, selected interior columns in the parking garage were monitored for vertical settlement as an added precaution. It should be noted that none of the interior columns selected exhibited settlement during construction of this project. Some minor pointing was required to replace old, deteriorated cement mortar.

Similarly, adjacent utilities were video recorded to clearly identify any pre-existing damage. A request to repair damaged water and sewer pipes was made.

Monitoring was installed to record both horizontal and vertical movement of the east wall of building 1899. These monitoring stations were installed at 25-foot centers approximately 10-feet above street grade. Three baseline readings were made before the start of construction at the site. Scheduled readings were made two times per week during excavation and later reduced to weekly as the proposed structure was completed to street grade.

The existing soldier beams were also monitored for both horizontal and vertical movement. These monitoring points were located approximately one foot below bottom of existing footing grade. Scheduled readings were made two times per week during excavation, daily as the lower bracket piles were installed, and then reduced to weekly as the proposed structure was completed to street grade.

Demolition of The 1819 Building

Before the excavation for the new office building could begin the site had to be cleared. Two, 11-story office buildings were razed. Building 1819 was closest to the historic 1899 building. The typical precautions were taken by the demolition subcontractor to protect the historic building 1899 during above grade demolition of the site. With only three feet separating the buildings, much of the outer three column bays were removed by hand, leaving only the center core to be demolished by conventional drop-ball method. To protect the public most inter-city demolition activities occur at night leaving cleanup and hauling for daytime operations. The demolition required for this project was no different.

Prior to razing building 1819, it was determined that the below grade foundation walls should be supported to minimize the deflection that often occurs as each below grade floor slab is removed during excavation. Several options were considered. One option was to install rakers to support the wall at 16-foot centers. Protecting the rakers from damage as the building was demolished and subsequently excavated became problematic. Clark's final approach included the placement of compacted backfill, crusher run material, for a minimum of two bays starting at the lowest level and continuing to street elevation. This method eliminated all potential voids that generally occur when uncontrolled building rubble is used to fill the below grade voids. Although this method added time to the overall demolition schedule, the technique worked extremely well and movement of both the foundation wall and existing soldier beams was minimal.

Excavation and Support

With demolition complete, installation of soldier beams around the perimeter of the site could begin. To comply with local noise ordinances and to limit vibrations to the adjacent structures all soldier beams at the site were drilled full length and backfilled with a flowable-fill cement mix.

Once soldier beams were installed along the North Alley and H Street to the south, excavation of the site adjacent to building 1899 could proceed in four-foot lifts. It was confirmed though calculations that a portion of the existing 1899 footing could be removed to the face of bracket pile. See figure 6.

As the excavation proceeded, the foundation wall was removed and the 40-year-old bracket piles were exposed. Each pile was inspected for corrosion. Some minor repairs were made-mostly in the form of cover plating the outside flange and web as required. In addition, a portion of the concrete encasement around each of the 28 brackets was removed in an effort to visually inspect the 40-year-old bracket connection. The brackets had very little, if any, corrosion and needed no repair. Finally the wood lagging was automatically replaced.

As the excavation advanced to elevation 48.0, the top tier tiebacks were installed using a Bonne Esperance FBE-2T tieback drilling rig. At a depth of six-feet below bottom of footing elevation there was some concern that grout under pressure would find its way into the basement garage. Regrouting quantities and pressures were kept low to prevent such an occurrence. Figures 6 through 8 are photographs showing the sequence of activities required to install the top tier tieback.

Figure 6: Existing Bracket Piles Supporting 1899

Figure 7: FBE-2T Drilling Top Tier Tiebacks

Figure 8: Testing Top Tier Tiebacks & Old Foundation Wall (to be removed)

Excavation to the 2nd tier tiebacks occurred in much the same fashion as the top tier. Internal tieback wales were designed and installed to limit interferences with the new lower bracket pile installation.

With the 2nd tier tiebacks installed and tested, the existing slab on grade and caissons could be removed. Where possible, new piles were installed with a SoilMec R-622 HD drill rig. The piles were located center span of the existing piles. The pile drill holes were installed at a slight batter with an oversized 30-inch diameter auger in an attempt to locate the bracket pile as close to the existing pile alignment as possible. This would limit the cantilever moment of the lower bracket and minimized the wall thickness below. During this operation, the existing piles were monitored twice a day for possible settlement. No settlement was observed.

Figure 9: SoilMec Installing New Bracket Piles

Once the 25 new bracket piles were installed, the transfer girder (W21x83) and lower bracket (W24x104) installation could begin. The brackets were located and installed first. These brackets, were welded directly to the existing piles. Again, special consideration for corrosion was given to the 40-year old pile at the bracket location. The flange and web were cover plated to beef up the section as required. The newly installed soldier beams were cut off to provide enough space to install the W21x83 transfer girder plus two-inch gap for the flat jack. A one-inch thick plate was welded to the top of each pile to provide bearing. This plate connection detail required slight adjustments at each pile based on the final pile and transfer girder as-built locations. The transfer girder was then installed in 40-foot sections and placed as tight to the existing pile as possible to limit the moment induced by the bracket load.

Figure 10: Installing lower brackets

Figure 11: Completed Lower Jacking System

Preloading the Lower Bracket Support System

To reduce deflection each bracket of the lower bracket system was preloaded to 80 percent of the design load with a Freyssi model 30 epoxy resin permanent inflatable flat jack. This jack was chosen because it could provide 100 percent of the total design load required at each bracket. The epoxy resin was injected into the flat jack bladder using a low volume, ½ gallon per stroke, high pressure ram specifically designed for this system. The brackets supporting the existing column footers were jacked in pairs to insure that the column would be loaded in one jacking cycle. This in turn would be distributed the pre-stressing force evenly to the entire footing above.

During the jacking operations the existing piles were monitored for vertical uplift using standard monitoring procedures. A dial gage indicator was used to monitor the newly installed bracket piles for settlement. The intent was to limit the possible of over jacking the footing which could in turn induce stress cracks. Throughout the jacking process, no cracking or appreciable movement was observed, maximum deflections of 0.01 to 0.02 inches were noted.

The pre-stressing load was applied in three stages of 33, 67, 100 percent of the pre-stressing force. Each stage was held only long enough to take readings on adjacent piles. Additionally, at each stage, visual observations, of the footing being jack were made to insure that we were not overstressing the footing.

Figure 12: Three Brackets Pre-stressed Simultaneously

Excavating to Subgrade

Once the lower bracket system was installed, excavation could continue to the third tier tieback elevation and then ultimately to subgrade. Newly installed soldier piles were laced at 12-foot intervals to account for weak axis bending as a result of back lagging. As an extra precaution, the upper piles were laterally braced two-feet above the tip elevation with MC18x58 channel.

Figure 13: Site Excavation Completed Looking West at Supported Wall (copyright Dan Cunningham Photography)

MONITORING PREFORMANCE

Monitoring data was graphed and evaluated from the field surveys taken. The existing soldier beams showed movements of 0.75” to 1.25” horizontally and 0.25” to 0.50” vertically, well within the range of what should be expected during a 65-foot-deep excavation. These movements occurred during the initial excavation to top tier of tieback elevation, and as the lower brackets were being installed.

During that same period, building 1899 showed some residual vertical movement of 0.125” to 0.250” vertical. No horizontal movement was observed. Although this movement was a major concern during construction, only minor cosmetic cracks were observed along grout joints on the second floor, which were repaired once construction was complete.

The Avongard grid crack monitoring gages also worked well. Prior to installing these gages, the field engineer sealed the crack to be monitored with a thin layer of plaster. The idea behind the plaster layer is that if true movement were to occur the plaster would crack before the gage could detect movement. This added step worked well as a back-check to the value of the gage reading.

CONCLUSIONS

The bracket pile, Freyssi flat jack and transfer girder support system used to extend the existing underpinning of the 11-story historic building performed exceptionally well. The flat jacks were an essential component, preloading the system, and in turn limiting deflections that are often associated with transferring load from one system to another.

Secondly, the brackets and soldier beams encased in concrete showed little or no signs of corrosion, from 40+ years of exposure to groundwater. This lends credence to the often used theory that concrete backfill provides adequate protection against corrosion for steel brackets.

Clark Foundation’s, extensive preliminary site investigations, and work with the structural engineer early on in a project, proved invaluable in providing a safe and adequate underpinning design solution, and in turn the ultimate use of space in the design of below grade structures.

ACKNOWLEDGEMENTS

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