Geotechnical Construction Observation Report
White Point Landslide – Ground Anchors
San Pedro District
Los Angeles, California

September 26, 2014

SHANNON & WILSON, INC.

GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

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GEOTECHNICAL CONSTRUCTION OBSERVATION REPORT
WHITE POINT LANDSLIDE – GROUND ANCHORS
CITY OF LOS ANGELES
SAN PEDRO DISTRICT, LOS ANGELES, CALIFORNIA

1.0 INTRODUCTION

1.1 General

This report summarizes the construction of ground anchors and associated structural elements on the eastern flank of the White Point Landslide. The White Point Landslide is located as shown in the Vicinity Map, Figure 1. This report incorporates our previous conclusions and recommendations described in the following White Point Landslide correspondence with the City of Los Angeles Bureau of Engineering (City):

- Final Geotechnical Report, August 15, 2012 (Final Report);
- Final Addendum Geotechnical Report No. 1, December 19, 2012 (Add-1 Report);
- Final Addendum Geotechnical Report No. 2, April 17, 2013 (Add-2 Report);
- Plans and Specifications prepared by Wagner Engineering and Survey (WES) originally dated June 7, 2013, with final revisions dated January 13, 2014 (Design Plans);
- Final Data Report for Boring B-12, July 3, 2014 (B-12 Report);
- Erosion Concerns from Removal of Palm Trees, October 24, 2013 (Palm Tree Letter);
- Slope Stability Evaluation, July 1, 2014 (Ground Crack Letter);
- Ground Anchor Performance Testing Report, December 26, 2013;
- Responses to Request for Information (RFI) from Hayward Baker, Inc. (HBI);
- Recommendations for Upper Row Ground Anchor Re-stressing, June 24, 2014;
- Ground Anchor Load Testing Report, June 27, 2014;
- Geotechnical Construction Observation Report, White Point Landslide Dewatering Drains, July 2, 2014 (Drain Construction Report); and
- Update on Instrumentation Readings, August 13, 2014 (Instrumentation Update Letter).

1.2 Project Description

On November 20, 2011, a 600-foot section of coastal bluff near White Point Nature Preserve experienced a landslide event (2011 Landslide) that collapsed the Paseo del Mar roadway as shown in the Site and Exploration Plan, Plate 1. A summary of geological conclusions and geotechnical information on the 2011 Landslide is described in our Final Report. In our Final Report, we recommended immediate mitigation work including installation and construction of post-tensioned tieback anchors with isolated concrete reaction pads to reduce the potential for future landsliding on the eastern flank of the 2011 Landslide (Eastern Flank Area). Our Add-2 Report concludes that based on results of our slope stability analyses, installing two rows of ground anchors could increase the stability of the Eastern Flank Area. The upper row is designated ground anchors A-1 through I-1, and the lower row is designated ground anchors A-2 through I-2.

The Add-2 Report and the Design Plans describe installing eighteen ground anchors (160 or 165 feet long) with each anchor having a design load of 210 kips. Our recommendations are summarized in the Geotechnical Requirements Section of this report.

1.3 Scope of Services

Our scope of services for construction observation of the ground anchors is described in our proposal dated June 21, 2013. The purpose of our services was to provide geotechnical observation and documentation during construction of the ground anchors in the Eastern Flank Area. Our services included:

- Support during bid phase;
- Construction observation during ground anchor installation;
- Review of Request for Information (RFI) and submittals, and;
- Construction observation summary report that will include as-built drawings, conclusions and recommendations relative to the slope stability.

Refer to our proposal for details on our scope of services. HBI authorized our services via City contract on December 6, 2013.

2.0 SUBSURFACE CONDITIONS

2.1 General

Our Final, Add-1, Add-2, Ground Crack Letter, and B-12 Reports provide detailed descriptions of subsurface conditions and interpretive geologic cross sections. The following briefly summarizes subsurface conditions for the Eastern Flank Area.

Quaternary-age Terrace Deposits between 3 and 7 feet thick were observed below the Paseo del Mar pavement at Borings B-7, B-10, B-11, and B-12 as shown in Cross Sections J-J' and K-K' of the Ground Crack Letter. The underlying Tertiary-age Altamira Shale consists of interbedded siltstones with claystones and fine grained sandstones. Bentonite clay beds, up to 4 inches thick, were observed typically starting about 80 feet below the ground surface. Interbedded siliceous siltstone beds were also observed at depth up to 10 feet thick.

2.2 Groundwater

Groundwater level or piezometric head measurements at the site began in December 2011 during the original phase of work for the 2011 Landslide study. We added observation sites in July 2012 (Borings B-10 and B-11) and April 2013 (Boring B-12). Currently, vibrating wire piezometers (VWPs) are installed in borings B-1, B-3, B-5, B-6, B-7, B-8, B-9, B-10, B-11, and B-12. Each boring with a VWP contains a datalogger that records hourly groundwater level or piezometric head. The measured piezometric levels from the VWPs at B-7, B-10, B-11 and B-12 during ground anchor construction are shown in Figure 2.

2.3 Instrumentation

Instrumentation installed to monitor subsurface conditions after the 2011 Landslide includes the VWPs, and inclinometers. Details of the VWP and inclinometer installations are provided in the Final, Addendum-1, and Boring B-12 Reports. During the initial excavation of the anchor construction bench, we observed ground cracks exposed in the excavation bench surface as described in the Ground Crack Letter. We installed extensometers to monitor movement of the observed ground cracks, in locations that would be subjected to minimal disturbance during ground anchor construction. The locations of VWPs, inclinometers, and extensometers are shown on Drawing No. C-1.0

3.0 GEOTECHNICAL REQUIREMENTS

The following is an overview of our original geotechnical requirements for the project. Details of our recommendations are provided in our Add-2 Report and the Design Plans provided in Appendix A.

1. We recommend installing two rows of ground anchors to improve stability of the Eastern Flank Area.
    a. Each row to consist of nine ground anchors with a center-to-center spacing of 20 feet.
    b. A minimum diameter grout hole of 6 inches.
    c. The ground anchor inclination is 45 degrees from horizontal.
    d. The upper row of ground anchors is to be installed near the top of slope at about elevation +114 feet (see Design Plans). The lower row is to be installed approximately on the slope at about elevation +110 feet.
    e. The minimum bonded length is 35 feet into the competent Altamira Shale below the bentonite clay layer projected from the critical failure surface of the 2011 Landslide.
    f. The total lengths of the ground anchors are at least 165 and 160 feet for the upper and lower rows, respectively.
2. To satisfy seismic conditions, we assume engineered improvements such as buildings will not be constructed in the Eastern Flank Area. If there are structures planned to be constructed in the area in the future, we recommend they be designed to accommodate the estimated seismic displacement as described in our Add-2 Report.
3. We recommend installing the ground anchors by drilling in a manner that minimizes ground loss and not damage previously installed dewatering drains or undermines existing pavement, storm drains, or other underground utilities.
4. We recommend that the contractor be prepared to drill through and install ground anchors through hard siliceous layers in the fractured bedrock that may require casing and a down-the-hole hammer to penetrate localized harder layers.
5. We recommend that no-load zone lengths not be left open overnight. Double corrosion protection is required for the permanent ground anchors. A bond breaker is used around the strands in the no-load zone, and the zone is filled with lean concrete fill.
6. Two performance tests are to be completed prior to installing production ground anchors.
7. The production ground anchors are to be proof tested by loading in 25 percent (0.25P) increments to 133 percent of design load (1.33P). The 133 percent load should be

held constant for at least 10 minutes with additional displacement not greater than 0.04 inch. The ground anchors should be locked off at 110 percent of the design load to compensate for long-term ground anchor relaxation.

8. We recommend the measured ground anchor elastic elongations at the maximum test load exceed 80 percent of the theoretical elastic elongations of the strand unbonded length (lower limit).
9. We recommend the measured ground anchor elastic elongations at maximum test load do not exceed 100 percent of the theoretical elastic elongations of strand unbonded length plus 50 percent of the theoretical elastic elongations of strand bonded length (upper limit).
10. The DYNA Force® electro-magnetic sensors are installed along the performance test ground anchor to monitor the load distribution in the ground anchor during the performance test and for long-term monitoring of the ground anchor performance and future slope movement.

4.0 STRUCTURAL REQUIREMENTS

The following is an overview of our structural requirements for the project. Details of our recommendations are provided in our Add-2 Report and Design Plans.

1. Each ground anchor consists of 6 seven-wire strands designed in accordance with ASTM A416 (Standard Specification for Steel Strand, Uncoated Seven-Wire, Stress-Relieved Strand for Prestressed Concrete).
2. The ground anchors incorporate the PTI Class I double corrosion protection (highest protection). The wedge plates are electro-zinc coated per ASTM B633. The bearing plates, trumpets and steel end caps are hot dip galvanized per ASTM A153 or epoxy coated per ASTM A775.
3. Ground anchor grout consists of Portland cement, sand, and water. Encapsulation shall consist of Portland cement and water. Both grouts develop a minimum compressive strength of 6,000 psi prior to stressing. Cement, fine aggregate, and water are in accordance with the American Concrete Institute (ACI).
4. Concrete for ground anchor bearing pads have a minimum compressive strength of 5,000 psi prior to stressing. Cement, aggregate, and water are in accordance with the American Concrete Institute (ACI).
5. The reinforcing steel bars for ground anchor bearing pads comply with ASTM A706, low alloy steel, Grade 60.

5.0 CONSTRUCTION PROCEDURES

5.1 General

HBI constructed the ground anchor system at White Point Landslide, with subcontractor Specialty Crane and Rigging, Inc. and subconsultant WES. Representatives of the City and Shannon & Wilson observed ground anchor construction and testing.

We observed the ground anchor construction performed by HBI and their subcontractors from October 28, 2013 to June 17, 2014. Specific tasks that we observed on a full-time basis included:

- Ground anchor drilling;
- Grouting of ground anchors;
- Ground anchor testing;
- Test pit excavations described in the Ground Crack Letter;
- Instrumentation readings including crack meters, extensometers, VWPs, inclinometers, and DYNA Force® electro-magnetic sensors, and;
- Drain flow measurements from the dewatering drains.

Specific tasks that we observed on a part-time basis included:

- Pumping water from containment area;
- Bearing pad excavation and shotcrete, and;
- Micropile and drilling platform installation.

We summarized the daily construction observations in our field activity reports (FARs) with our tasks above shown in Table 1, and FARs provided in Appendix B. A summary of the construction procedures are presented below. Our opinions on the construction procedures are described in the "Findings and Conclusions" section of this report.

5.2 Equipment On-site

HBI and their subcontractors used the following equipment to perform ground anchor construction:

- Hennessy International HD-180B Hydraulic Crawler Drill (HD-180B Drill)
- Krupp GMK 5160 Crane
- CAT 305E Excavator

- John Deere Gator HPX 4x4
- Krohne Optiflux 5000 flow meter
- Hydraulic Ram DSI-3490 Model Hoz 3000
- Geokon Load Cell Model 3000-600-5

5.3 Ground Anchor Installation

Ground anchor construction consisted of drilling and installing 18 ground anchors consisting of 6 seven-wire strands between 160 feet and 165 feet long using cased air rotary drilling techniques in accordance with the Design Plans. The recorded dimensions and construction measurements are summarized in Table 2. The contractor installed the ground anchors as shown in the Design Plans. The horizontal spacing of the ground anchors is typically 20 feet; however, field adjustments were necessary to avoid potential obstructions, including the HDD drains and storm drain structure. An HD-180B Drill was used to install the upper row ground anchors on the relatively level ground surface after the construction bench was cut to approximately elevation +112 feet. Once the upper row was installed, the HD-180B Drill was removed from the crawler and attached to a cantilever platform to perform drilling for the lower row ground anchors. The cantilever platform extended over the slope and was pinned by micropiles installed into the Altamira Shale underlying the construction bench (see Photo 3 of FAR No. 68 in Appendix B). HBI designed and installed the platform and micropile supports. Shannon & Wilson did not observe the micropile installation.

Each ground anchor strand bundle was inserted into the drilled holes using a Krupp GMK 5160 Crane. For pre-production ground anchors C-1 and G-1, DYNA Force® electro-magnetic sensors were attached to the strands during strand bundle assembling and inserted into the ground anchor hole with the bundle.

Grout was pumped from the bottom of ground anchor hole through grout tubes. A Krohne Optiflux 5000 flow meter was used to measure grout volumes and flow rates.

5.4 Survey

Surveyors from WES setup the initial alignment for drilling at each ground anchor per Design Plans prior to drilling operation. The Design Plans also required ground anchors at a minimum separation distance of 5 feet from the existing dewatering drains described in our Drain Construction Report.

HBI submitted Gyro-theodolite (Gyro) surveys of the anchor hole alignments. The survey data was incorporated into the As-Built Plans (Drawings C-1 and C-2). During drilling, the alignment of drilled hole was surveyed with the Gyro survey device to measure deviations in both horizontal and vertical direction. For ground anchors A-1, C-1, G-1 and D-2, the Gyro surveys were typically performed at 15-foot intervals along the hole alignment. For the remaining ground anchors, three Gyro surveys were typically performed at hole depths of 35, 90 and 150 feet.

5.5 Ground Anchor Bearing Pads

The 18 ground anchor bearing pads were constructed with shotcrete per Design Plans. For the upper row bearing pads, formwork was used during shotcreting and casting. For the lower row, a 2 to 3-inch-thick layer of shotcrete was used to temporarily stabilize the sides of excavation and protect the subgrade for the bearing pads prior to construction of the pads. The shotcrete for the lower row bearing pads was unfinished and colored for aesthetic purposes.

5.6 Ground Anchor Load Testing

HBI performed two performance tests on ground anchors C-1 and G-1 and proof tests on the remaining production ground anchors. The testing was performed in general accordance with Section 8.0 of PTI DC35.1-04, "Recommendations for Prestressed Rock and Soil Anchors" by Post-Tensioning Institute (PTI, 2004).

HBI used a hydraulic ram to stress the ground anchors. The test loads were measured using a pressure gauge (attached to a hydraulic jack), a Geokon load cell and DYNA Force® electro-magnetic sensors. Elongations of the test ground anchor were measured with a dial gauge. Settlements of ground anchor bearing pad were also measured with a dial gauge. The elongations and settlements could be measured up to 0.001 inch. The test results are included in Appendix E.

5.7 Instrumentation Monitoring

We performed weekly instrumentation readings during the ground anchor construction as part of the ongoing instrumentation and monitoring program for the project. We included our readings during construction in the FARs (see Table 1) and Instrumentation Update Letter. Shannon & Wilson monitored the instrumentation below:

- Vibrating Wire Piezometers at Borings B-7, B-10. B-11 and B-12 as shown in Figure 2;
- Inclinometers at Borings B-7, B-10, B-11 and B-12 as shown in Figure 3;

- Extensometers at EX-1 through EX-4 as shown in Figure 4;
- Dyna Force sensors at ground anchors C-1 and G-1 as shown in Figure 5 and Table 3.

6.0 SCHEDULE

Construction of the ground anchor system began on October 28, 2013 with excavation of the construction bench. We observed a ground crack exposed in the bedrock of the construction bench and began monitoring for ground movement on the same day as described in the Ground Crack Letter. Drilling of the upper row commenced on November 6, 2013 with performance testing of ground anchors C-1 and G-1 occurring on December 19, 2013. The upper row of ground anchors was completed on February 27, 2014. Construction of the lower row of ground anchors commenced on March 18, 2014 and was finished on June 17, 2014.

7.0 CORRESPONDENCE

We reviewed submittals and RFIs from HBI and responded with design modifications and recommendations as appropriate. Appendix C contains our responses to RFIs directed to us, which included:

- Frequency of Gyro Surveys and Alignment Load for Anchor Testing (RFI-01);
- Grout Tube Size (RFI-03);
- Formwork for Bearing Pads (RFI-04);
- Strand Cutting and Backfill (RFI-05);
- Backfill around Bearing Pads (RFI-06);
- Reinstallation of Anchor D-2 (RFI-08);
- Soil Stabilization Shotcrete (RFI-09); and
- Row 2 Shotcrete Bearing Pad Placement (RFI-11).

Note that RFI-02, 07, and 10 were not related to geotechnical engineering and were responded to by the City.

We prepared the following letters to the City during construction:

- Address erosion concerns from removal of palm trees as described in the Palm Tree Letter;
- Instrumentation Update Letters on December 16, 2013, and February 21 and July 16, 2014; and
- Clarification for Groundwater Discharge from the containment area to the sanitary sewer below Paseo del Mar (January 29, 2014).

Copies of these letters are attached in Appendix D.

8.0 FINDINGS AND CONCLUSIONS

8.1 General

We observed the ground anchor drilling, reviewed survey data, observed strand installation and grouting, observed excavation and subgrade conditions for bearing pads, monitored ground anchor load testing, reviewed instrumentation readings, and prepared responses to contractor RFI's. We reviewed our daily field reports which were prepared following our construction observations. To the best of our knowledge, there are no outstanding construction items that require correction.

In our opinion, the geotechnical aspects of the construction described in the following sections were in conformance with the Design Plans and in general accordance with the above referenced geotechnical reports and recommendations. Our opinion is based on our observations, which were made on a full- and part-time basis at the site during construction, and the results of the anchor testing program.

8.2 Ground Anchor Installation

The ground anchors were installed to the designated depths from the Design Plans. During ground anchor drilling, we observed drilling difficulty in shale and siltstone beds. The drill rod was sometimes blocked by return cuttings. When this occurred, the contractor removed the drill rods and cleared the blockage.

8.3 Ground Anchor Deviations

The maximum deviations of ground anchor drilling paths measured during the Gyro surveys are summarized in Table 2. Maximum horizontal deviations ranged between 0.2 to 2.0 feet. Maximum vertical deviations ranged between 0.7 and 4.5 feet. The deviations are within acceptable limits per the Design Plans.

8.4 Ground Anchor Grouting

The ground anchors were grouted in accordance with the Design Plans. Ground anchor D-2 was re-drilled and re-grouted after the pump malfunctioned and could not complete filling the anchor bonded zone. Admixtures were at times added to the grout to aid in the pumping and/or curing process. Grout volume in each ground anchor ranged between 247 and 439 gallons, or between 110 and 197 percent of theoretical volume. A summary of grout volumes is shown in Table 2.

The variability of the grout volumes is likely due to grout filling adjacent fractures in the bedrock and/or size anomalies in the drilled anchor holes.

8.5 Ground Anchor Bearing Pad

We observed the subgrade for ground anchor bearing pads, which consisted of weathered shale, siltstone or sandstone of the Altamira Shale. In our opinion, the excavated subgrade has sufficient bearing capacity of 6,000 pounds per square foot (psf) as recommended in the Design Plans. Some bearing pad locations, particularly in the lower row of ground anchors, required additional excavation to expose suitable bearing subgrade.

8.6 Load Testing

The results from ground anchor load testing indicated the ground anchors have achieved the design capacity specified in the Design Plans. The measured elastic elongations at the maximum test load exceeded 80 percent of the theoretical elastic elongations of the strand unbonded length (lower limit). The measured elastic elongations at maximum test load did not exceed 100 percent of the theoretical elastic elongations of strand unbonded length plus 50 percent of the theoretical elastic elongations of strand bonded length (upper limit). The creep movements at the maximum test load were within acceptable tolerance of 0.04 inch in 10-minute holding duration. The load testing results are attached in Appendix E.

8.7 Instrumentation and Monitoring

During ground anchor drilling and grouting, we observed correlations between the proximity of drilling or grouting activities and rapid increases or decreases in the local groundwater pressure (Figure 2). It is our opinion that air pressure during drilling or grout fluid pressure during ground anchor installation caused the temporary changes in pressure recorded in the VWPs. We did not observe displacements of the slope or discernable movement from the inclinometers and extensometers.

9.0 RECOMMENDATIONS FOR FUTURE CONSTRUCTION

In addition to the ground anchors, we provided recommendations for toe-of-slope protection along the beach area of the Eastern Flank Area in our Add-2 Report and backfill of the anchor construction bench. Riprap consisting of quarried rock with an average diameter of 3 feet was recommended to be keyed below the beach deposits to a depth of at least two feet or firm soil/bedrock, whichever is shallower. A Reno mattress consisting of woven wire mesh filled with rock of similar dimensions and specifications as the riprap was recommended as an alternative.

We understand from the City that the beach area work and anchor construction pad backfill will be deferred to a future project. If the riprap or Reno mattress is planned to be constructed in the future, we should be informed to provide services for design and construction observation.

10.0 LIMITATIONS

The professional opinions presented in this report were developed using the degree of care and skill, ordinarily exercised under similar circumstances and at similar locations, by reputable geotechnical consultants. No other warranty, express or implied, is intended as to the professional advice included in this report. The report has not been prepared for use by other parties, and may not contain sufficient information for purposes of other parties or other uses. The scope of our services did not include the responsibility for either job safety or surveying.

Shannon & Wilson, Inc. has prepared the document, "Important Information About Your Geotechnical/Environmental Report," in Appendix F to assist you and others in understanding the use and limitations of this report.

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Geologic items related to geology, geologic setting, stratigraphy, and groundwater were prepared by or prepared under the direct supervision of Dean G. Francuch, P.G., C.E.G.

Geotechnical items related to the geotechnical field observations, engineering analyses and recommendations were prepared by or prepared under the direct supervision of R. Travis Deane, P.E., G.E.

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