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SIMPSON GUMPERTZ & HEGER
Engineering of Structures
and Building Enclosures

Mayor Dan Sullivan
Municipality of Anchorage
632 West 6th Avenue, Suite 840
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Project 130356 – Peer Review of Global Stability Analyses of Open Cell Sheet Pile Structures, Port of Anchorage Intermodal Expansion Project, Anchorage, AK

Dear Mayor Sullivan:

At your request, we prepared this Executive Summary of our peer review of the CH2MHILL Suitability Study of the Open Cell Sheet Pile (OCSP) structures at the Port of Anchorage (POA). The intent of this Executive Summary is to provide our opinions on specific portions of our peer review to date. We intend to perform further review of the CH2MHILL study and will provide additional opinions at the appropriate time.

Our fundamental findings are as follows: (1) that the method of analysis used by PND Engineers, Inc. (PND) is insufficient since it failed to adequately consider the shape of the potential failure slip surface; (2) that the method used by PND to estimate the shear strength of the soil needed to verify global stability is insufficient since it failed to adequately consider the full extent of the directional dependence of the shear strength of the Bootlegger Cove Formation clay stratum; and (3) in each of these aforementioned instances, CH2MHILL used an approach consistent with the standard of practice.

PND and CH2MHILL used, among other design parameters, different values for superimposed live load, groundwater elevation on the land side, presence of estuarine deposits, elevation of top of Bootlegger Cove Formation clay stratum, and peak ground acceleration. The differences in these respective values do not materially affect our conclusions because we reach the conclusions discussed in this Executive Summary regardless of whether we use the values by PND or by CH2MHILL.

Based on these findings, and without considering construction defects related to the installation of the steel sheeting, we conclude that the existing OCSP structures at the North Extension 1 and 2 have factors of safety for long-term static global stability and for pseudo-static seismic global stability that do not satisfy the design criteria set for the project. Qualifications for, and extensions of, this statement are given in the body and the Conclusions of this Executive Summary. We have not yet performed a peer review of the Wet Barge Berth.

# 1. INTRODUCTION

## 1.1 Background

The design and construction work performed to date on the Port of Anchorage Intermodal Expansion Project (PIEP) includes the Dry Barge Berth (DBB), Wet Barge Berth (WBB), North Extension 1 (NE1), and North Extension 2 (NE2). The WBB and NE1 are designated as Essential Facilities.

CH2MHILL, an independent consultant retained by the US Army Corps of Engineers, Alaska District, to perform a Suitability Study of the PIEP[1], concluded, among other findings, that as-designed OCSP structures of the NE1, NE2, and WBB portions of the PIEP are inadequate with respect to static global stability and seismic global stability. PND, the designer of the OCSP structures, disagreed with these conclusions by CH2MHILL.

Simpson Gumpertz & Heger Inc. (SGH) was retained to perform a peer review to opine on the reasonableness of the conclusions regarding global stability of the OCSP structures as reported in the CH2MHILL Suitability Study.

### 1.2 Objective

The objective of this portion of our work is to determine if the minimum factors of safety for global stability of the OCSP structures at the Port of Anchorage meet the design criteria set for the PIEP project, without considering construction defects related to the installation of the steel sheeting.

### 1.3 Scope of Work

Our peer review to date consists of the following tasks:

- Independently assess the site subsurface conditions based on available geotechnical explorations and soil testing data.

- Perform global stability analyses of representative sections of OCSP structures for the NE1 and NE2 under the following conditions:

    - A critical static condition of long-term undrained loading at minimum low-level water elevation.
    - A pseudo-static seismic condition considering the Maximum Considered Earthquake (MCE) for NE1 and the Contingency Level Earthquake (CLE) for NE2.

- Evaluate the impact of certain design parameters used by PND in its original global stability analysis[2] and as highlighted in its response to the CH2MHILL Suitability Study.

We have not yet analyzed the global stability of the OCSP structures for the DBB and WBB. The DBB, according to CH2MHILL, meets the minimum-required factor of safety; therefore, we will not perform a peer review of the DBB. The WBB, according to CH2MHILL, does not meet the design criteria set for the PIEP project; therefore, our next task will be to perform a peer review of the WBB.

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[1] Port of Anchorage Intermodal Expansion Project Suitability Study, Final Summary Report prepared by CH2MHILL for Port of Anchorage, US Maritime Administration, and US Army Corps of Engineers, dated 14 February 2013.

[2] Port of Anchorage Marine Terminal Redevelopment Geotechnical Analysis Report, prepared by PND Engineers, Inc. and GeoEngineers for Integrated Concepts & Research Corporation (ICRC), March 2008.

## 2. GLOBAL STABILITY ANALYSES

### 2.1 Subsurface Conditions

We correlated the soil stratification and soil types noted in the available soil boring logs and other subsurface exploration reports into generalized subsurface conditions used to prepare simplified cross-sections for use in global stability analyses. Our simplified cross-sections compare well to those used by CH2MHILL in its Section 3-3[3] for NE1 and Section 2-2[4] for NE2. We noted that the sections used by PND for design of the OCSP structures (Section G for NE1 and Section F for NE2) contain Bootlegger Cove Formation (BCF) clay stratum at elevations inconsistent with the soil boring logs. In addition, the PND analysis sections do not include the estuarine deposit below the OCSP granular fill and land-side common fill, which was not completely removed as originally planned. Our slope stability analyses consider both the presence and the absence of the estuarine deposit and both the CH2MHILL and the PND elevations for the top of the BCF clay stratum.

### 2.2 Soil Shear Strength Design Parameters

Based on our review of the available laboratory and field test data and the design shear strength properties developed by both CH2MHILL and PND, we determined that the soil strength properties used by CH2MHILL for each of the soil strata at the site adequately represent the soil conditions at the site, and we adopted them for our analyses. In general, the soil shear strength parameters used by CH2MHILL for the granular and common fill materials are higher than those used by PND. For the BCF clay stratum, we determined that CH2MHILL's use of three zones with different shear conditions and different shear strengths for global stability analyses is necessary to properly account for the shear strength anisotropy[5] of the BCF clay. PND's analyses for NE1 and NE2 considered only two zones with different shear conditions and different shear strengths within the BCF clay stratum. Similarly, CH2MHILL appropriately considered the unloading conditions due to dredging on the seaside of the OCSP, leading to reduced shear strength values in this area compared to the values used by PND.

For pseudo-static seismic global stability analyses[6], we included a reduction of 20% in the undrained shear strength of the BCF clay stratum, estuarine deposits, and common fill, to account for strength reductions that can occur during seismic cyclic loading in these strata. This is consistent with the CH2MHILL analyses and recommendations contained in the published literature[7]. We did not apply a reduction factor to the undrained shear strength of the granular fill consistent with CH2MHILL and PND assumptions for this material.

### 2.3 Global Stability – Critical Static Condition

Our global stability analysis focuses on the as-designed conditions of the OCSP structure and does not consider any impacts from potential construction defects related to the installation of

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[3] Figure 5.1.6 in the CH2MHILL Suitability Study.
[4] Figure 5.1.5 in the CH2MHILL Suitability Study.
[5] Anisotropy is to have material properties that are directionally dependent.
[6] In a pseudo-static seismic stability analysis, the peak ground acceleration is converted into a pseudo-static inertia force and applied horizontally.
[7] Stark, T.D. and Contreras, I.A., "Fourth Avenue Landslide During 1964 Alaskan Earthquake", ASCE Journal of Geotechnical and GeoEnvironmental Engineering, February 1998, p. 109.

the steel sheeting. We performed our static global stability analyses for sections of NE1 and NE2 using the computer program SLIDE v. 6.022. Our analyses included three zones with different shear conditions and different shear strengths to account for the anisotropic properties of the BCF clay stratum and included searches for both circular and noncircular failure surfaces, consistent with the standard of practice. PND did not perform searches for noncircular failure surfaces for their static global stability analysis for the OCSP structures at NE1 or NE2.

The design criteria adopted for the original design required a factor of safety of 1.5.

Given that differences in certain design parameters exist between CH2MHILL and PND[8] and that our current assignment did not include determining the correctness of these respective design parameters, we performed our global stability analyses using both the CH2MHILL and the PND values for these design parameters. Regardless of the differences in some of the design parameters between CH2MHILL and PND, our results show that the factor of safety for global stability for the OCSP structures is controlled by a noncircular failure surface. PND did not perform a search for noncircular failure surfaces in its evaluation of global stability.

We obtained factors of safety of 1.2 at NE1 and 1.3 at NE2 for the critical static condition of long-term undrained loading at minimum low-water elevation when using the PND design parameters for superimposed live load (a surcharge live load of 200 psf within 200 ft of the face of the OCSP structure, increasing to 1,000 psf beyond), no estuarine deposits present, top of BCF clay stratum elevation (El. -25 ft at NE1 and El. -50 ft at NE2) and groundwater elevation on the land side (El. 18 ft).

We obtained factors of safety of 1.1 at NE1 and 1.1 at NE2 for the critical static condition of long-term undrained loading at minimum low-water elevation when using the CH2MHill design parameters for superimposed live load (a surcharge live load of 1,000 psf immediately behind the face of the OCSP structure), estuarine deposits present, and groundwater elevation on the land side (El. 20 ft).

Therefore, even when adopting the PND design parameters, our work substantiates the conclusions of CH2MHILL that the as-designed OCSP structures of NE1 and NE2 do not satisfy the design criteria set for the PIEP project with respect to static global stability. As stated above, the factors of safety are higher for the design parameters used by PND than for those used by CH2MHILL; however, they still are lower than the factors of safety in the design criteria.

### 2.4 Global Stability – Pseudo-static Seismic Conditions

Our global stability analysis focuses on the as-designed conditions of the OCSP structure, and does not consider any impacts from potential construction defects related to the installation of the steel sheeting. Our independent pseudo-static analyses of the critical seismic conditions for the representative sections of NE1 and NE2 (MCE for NE1 and CLE for NE2) included three zones with different shear conditions and different shear strengths to account for the anisotropic properties of the BCF clay stratum, and included searches for both circular and noncircular failure surfaces consistent with the standard of practice[9]. PND did not perform searches for

[8] Including superimposed live load, groundwater elevation on the land side, presence of estuarine deposit, and elevation of top of BCF clay stratum.
[9] USACOE EM 1110-2-10-2, 31 October 2003, p. C8.

noncircular failure surfaces for their pseudo-static seismic global stability analysis for the OCSP structures at NE1 and NE2.

Our independent pseudo-static seismic global stability analyses were also performed with the computer program Slide v. 6.022. Given that differences in certain design parameters exist between CH2MHILL and PND[10] and that our current assignment did not include an independent assessment of these design parameters, we performed our global stability analyses using both the CH2MHILL and the PND values for these design parameters. Regardless of the differences in some of the design parameters between CH2MHILL and PND, our results show that the factor of safety for global stability for the OCSP structures is controlled by a noncircular failure surface. PND did not perform a search for noncircular failure surfaces in its evaluation of global stability.

We adopted a lateral seismic coefficient of 50% of peak ground acceleration (PGA) for pseudo-static seismic global stability analyses, consistent with CH2MHILL, PND, and other published recommendations[11]. We have not independently verified this lateral seismic coefficient.

The design criteria adopted for the project required a factor of safety of 1.0 for the Essential Facilities during MCE loading at NE1 and a factor of safety of 1.1 for the CLE loading at NE2.

We obtained factors of safety of 0.9 at NE1 for the MCE, and 1.0 at NE2 for the CLE when using the PND design parameters for PGA (0.26 g for the MCE and 0.18 g for the CLE), no superimposed live load, groundwater elevation on the land side (El. 16.5 ft), tide level (El. 16.5 ft), no hydrodynamic loading on the front face of the OCSP structure, no estuarine deposit present, and top of BCF clay stratum elevation (El. -25 ft at NE1 and El. -50 ft at NE2).

We obtained factors of safety of 0.6 at NE1 for the MCE and 0.7 at NE2 for the CLE when using the CH2MHill design parameters for PGA (0.4 g for the MCE and 0.3 g for the CLE), superimposed live load (a surcharge live load of 200 psf immediately behind the face of the OCSP structure), groundwater elevation on the land side (El. 20 ft), tide level (El. 7.5 ft), inclusion of a hydrodynamic loading on the front face of the OCSP structure, and estuarine deposit present.

Therefore, even when adopting the PND design parameters, including a PGA for MCE conditions that is 65% of the value used by CH2MHILL and for the CLE conditions that is 60% of the value used by CH2MHILL (we have not yet independently verified the PGA), our work substantiates the conclusions of CH2MHILL that the as-designed OCSP structures of NE1 and NE2 do not satisfy the required design criteria with respect to pseudo-static seismic global stability. As stated above, the factors of safety are higher for the design parameters used by PND than for those used by CH2MHILL; however, they still are lower than the factors of safety in the design criteria.

[10] Including peak ground acceleration (PGA), superimposed live load, groundwater elevation on the land side, tide level, and hydrodynamic loading on the front face of the structure.
[11] National Cooperative Highway Research Program (NCHRP) Report 611 – Seismic Analysis and Design of Retaining Walls, Buried Structures, Slopes, and Embankments, Transportation Research Board, 2008.

## 3. CONCLUSIONS

This portion of our peer review concludes as follows[12]:

- The existing OCSP structures at NE1 and NE2 have factors of safety for static global stability under long-term undrained loading conditions at minimum low-water level that do not satisfy the design criteria set for this project with respect to static global stability, without considering the impact of potential construction defects related to the installation of the steel sheeting.
- The existing OCSP structures at NE1 and NE2 have factors of safety for pseudo-static seismic global stability under MCE (at NE1) and CLE (at NE2) conditions, that do not satisfy the design criteria set for this project with respect to pseudo-static seismic global stability, without considering the impact of potential construction defects related to the installation of the steel sheeting.
- The conclusions of CH2MHILL regarding long-term undrained static and pseudo-static seismic global stability are reasonable. The inadequate global stability of the OCSP structures at NE1 and NE2 results from PND's failure in two respects:
    - PND considered only two shear strength zones rather than three shear strength zones, which are necessary to fully consider anisotropic properties for the BCF clay stratum.
    - PND considered only circular failure surfaces rather than both circular and noncircular failure surfaces in their global stability analyses, which are necessary to obtain the minimum factor of safety.

Sincerely yours,

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[12] Refer to the body of this Executive Summary which contains several qualifications related to work we have not yet performed.