GEOLABS, INC.
Geotechnical Engineering and Drilling Services

July 24, 2023
W.O. 7341-10

Mr. Calvin Miyahara
KSF, Inc.
615 Piikoi Street, Suite 300
Honolulu, HI 96814

Amendment to Geotechnical Report
Interstate Route H-1 and H-201
Destination Sign Upgrade/Replacement, Phase 3B
Federal-Aid Project No. NH-0300(205)
Island of Oahu, Hawaii

Dear **Mr. Miyahara:**

In accordance with the scope of services outlined in our fee proposal dated April 17, 2023, we performed the requested additional geotechnical engineering services for the proposed *Interstate Route H-1 and H-201 Destination Sign Upgrade/Replacement, Phase 3* project on the Island of Oahu, Hawaii.

This amendment report summaries findings from our geotechnical engineering services and amends recommendations presented in our previous report entitled "Geotechnical Engineering Exploration, Interstate Route H-1 and H-201, Destination Sign Upgrade/Replacement, Phase 3, Federal-Aid No. NH-0300(144), Island of Oahu, Hawaii," dated February 3, 2022, based on the updated information provided. The recommendations presented herein are intended for design input only and are subject to the limitations noted at the end of this report.

PROJECT CONSIDERATIONS

We understand that Sign H1WB-421 is changed from a cantilever structure to a two-post sign structure. We also understand that it is desired to use a smaller diameter drilled shaft foundation for Sign H1EB-104 from a 72-inch diameter to a 60-inch diameter drilled shaft foundation. In addition, the structural load information has been updated for the sign structures. Therefore, additional foundation analysis and recommendations are desired. The boring information in our previous report, dated February 3, 2022, was used to develop our foundation recommendations.

The following updated structural load information acting at the top of the foundation was provided by the project structural engineer for our analysis of the new sign structure foundation design.

FOUNDATION LOADING FOR REPLACEMENT DESTINATION SIGNS				
EXTREME EVENT I LIMIT STATE				
Destination Sign Identification	78WB-853	H1WB-421	H2NBR-722	H1EB-104
Vertical Load (kips)	20.5	17.1	18.5	23
Shear Parallel to Sign (kips)	0	0	0	0
Shear Perpendicular to Sign (kips)	46.15	40.11	33.71	52.13
Moment Parallel to Sign (ft.-kips)	0	0	0	350
Moment Perpendicular to Sign (ft.-kips)	1,040.23	850.17	764.53	1,104.72
Torsion (ft.-kips)	0	0	0	1,217.82

PURPOSE AND SCOPE

The purpose of our geotechnical engineering services was to review existing subsurface information to develop foundation recommendations for the revised sign structures of the proposed project. Our work was performed in general accordance with our fee proposal dated April 17, 2023. Our scope of work consisted of the following tasks and work efforts:

1. Review of available subsurface information and drawings.

2. Analyses of the existing field and laboratory data to formulate geotechnical recommendations for the foundation design of the revised sign structures.

3. Preparation of this amendment report summarizing our work on the project and presenting our findings and recommendations.

4. Coordination of our overall work on the project by our project engineer.

5. Quality assurance of our work and client/design team consultation by our principal engineer.

6. Miscellaneous work efforts such as drafting, word processing, and clerical support.

DISCUSSIONS AND RECOMMENDATIONS

Based on the updated structural loading information provided, the sign structure foundations will be subjected to relatively high ground line moments. In order to develop the

required bearing and lateral load resistances, the proposed new sign structures may be supported by a foundation system consisting of cast-in-place concrete drilled shafts. Our recommendations for the drilled shaft foundations at each sign site are presented in the following table:

DRILLED SHAFT FOUNDATION DESIGNS			
Destination Sign I.D.	**Number of Post Supports**	**Minimum Shaft Diameter** (inches)	**Minimum Shaft Embedment Length** (feet)
H1WB-421	2*	60	16
78WB-853	2	60	28
H1NBR-722	2	60	28
H1EB-104	1	60	18
*The left side post will be supported by the concrete median barrier structure.			

The cast-in-place concrete drilled shafts would derive vertical support principally from skin friction between the shafts and the surrounding soils. The end-bearing component of the drilled shafts has been discounted in our analysis. Discussion and recommendations for the drilled shaft construction presented in our previous report entitled "Geotechnical Engineering Exploration, Interstate Route H-1 and H-201, Destination Sign Upgrade/Replacement, Phase 3, Federal-Aid No. NH-0300(144), Island of Oahu, Hawaii," dated February 3, 2022, should be consulted.

Lateral Load Resistance

The lateral load resistance of each drilled shaft is a function of the stiffness of the surrounding soil, the stiffness of the drilled shaft, allowable deflection at the top of the drilled shaft, and the induced moment in the drilled shaft. The lateral load analyses were performed using the program LPILE for Windows, which is a microcomputer adaptation of a finite difference, laterally loaded deep foundation program originally developed at the University of Texas at Austin. The program solves for deflection and bending moment along a deep foundation under lateral loads as a function of depth. The analysis was carried out with the use of non-linear "p-y" curves to represent soil moduli. The lateral deflection was then computed using the appropriate soil moduli at various depths.

Based on the updated structural loads provided and the subsurface soil conditions anticipated at each destination sign location, the results of our analyses are summarized in the following table. The project structural engineer should verify the drilled shaft structural capacity for the calculated induced stresses.

LATERAL DEFLECTION AND MAXIMUM INDUCED MOMENT & SHEAR IN THE DRILLED SHAFTS					
Destination Sign I.D.	**Limit State**	**Lateral Head Deflection** (inches)	**Maximum Induced Shear** (kips)	**Maximum Induced Moment** (kip-feet)	**Depth to Maximum Moment** (feet)
H1WB-421	Extreme Event I	0.2	291	967	5.5
78WB-853	Extreme Event I	0.5	104	1,283	7.5
H1NBR-722	Extreme Event I	0.3	81	933	8.0
H1EB-104	Extreme Event I	0.7	416	1,467	8.0

Torsional Resistance

In general, the cantilever sign structures may be subjected to torsional moments resulting in torsion on the drilled shaft foundations. Torsion may be resisted by the side shear along the drilled shaft surface and adjacent soils. Based on our analyses, we believe that the recommended diameter of drilled shafts extending to the depths recommended should be capable of resisting the torsional moment without significant movement of the foundations. It is our understanding that frequency analyses for modeling the foundation along with the structure for the large cantilever sign structure under high torsional loads will be performed for Sign H1EB104. For the required analyses, “p-y” curves for the pile cap and the drilled shaft were estimated using the LPILE program for a composite pile with an upper pile section consisting of 6.5 feet by 6.5 feet by 4 feet thick with the top of the pile at 6 inches above the finish ground surface. The second pile section from the 4 feet below the top of the pile to the design bottom consists of a 60-inch diameter drilled shaft. Results of the generated non-linear “p-y” curves are summarized and present on Plates 1 and 2.

Design Review

Final drawings and specification for the proposed construction should be forwarded to Geolabs for review and written comments prior to bid advertisement. This review is needed to evaluate the conformance of the plans and specifications with the intent of the foundation recommendations provided herein. If this review is not made, Geolabs cannot be responsible for misinterpretation of our recommendations.

CLOSURE

We appreciate the opportunity to provide our services to you on this project. If you have questions or need additional information, please contact our office.

Respectfully submitted,

GEOLABS, INC.

By _____
Herbert Y.F. Chu, P.E.
Associate/Senior Project Engineer

By _____
Gerald Y. Seki, P.E.
Vice-President

GERALD Y. SEKI
LICENSED PROFESSIONAL ENGINEER
No. 5635-C
HAWAII, U.S.A.

THIS WORK WAS PREPARED BY
ME OR UNDER MY SUPERVISION.

_____ 4-30-24
SIGNATURE EXPIRATION DATE
OF THE LICENSE

GS:HC:cj

Attachments: P-Y Curves, Plates 1 and 2

h:\7300 Series\7341-10.hc1

SIGN H1EB-104 LATERAL LOAD ANALYSIS

Interstate Route H-1 and H-201
Destination Sign Upgrade/Replacement, Phase 3B
Federal-Aid Project No. NH-0300(205)
Island of Oahu, Hawaii

2 feet		4 feet		6 feet		10 feet		12 feet	
y	p	y	p	y	p	y	p	y	p
(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)
0.000	0	0.000	0	0.000	0	0.000	0	0	0
0.047	76	0.001	115	0.114	940	0.160	2278	0.168	2891
0.161	107	0.022	230	0.195	1064	0.236	2469	0.243	3133
0.275	124	0.110	345	0.275	1154	0.313	2615	0.319	3322
0.389	137	0.347	461	0.356	1224	0.389	2735	0.395	3478
0.503	147	0.847	576	0.436	1284	0.465	2837	0.470	3613
0.616	156	1.757	691	0.517	1335	0.542	2927	0.546	3731
0.730	163	3.255	806	0.597	1381	0.618	3008	0.622	3837
0.844	170	5.554	921	0.678	1422	0.694	3081	0.697	3934
0.958	176	8.896	1036	0.758	1459	0.771	3147	0.773	4022
1.072	182	13.559	1152	0.839	1494	0.847	3209	0.849	4104
1.186	187	19.851	1267	0.919	1526	0.924	3267	0.924	4181
1.300	192	28.115	1382	1.000	1556	1.000	3320	1.000	4252
2.113	225	38.724	1497	1.625	1782	1.625	3747	1.625	4826
2.925	259	52.086	1612	2.250	2007	2.250	4173	2.250	5400
3.510	259	68.640	1727	2.700	2007	2.700	4173	2.700	5400
4.095	259	85.800	1727	3.150	2007	3.150	4173	3.150	5400

14 feet		16 feet	
y	p	y	p
(inch)	(pounds/inch)	(inch)	(pounds/inch)
0.000	0	0.000	0
0.024	24000	0.024	24000
0.032	24400	0.032	24400
0.040	24800	0.040	24800
0.048	25200	0.048	25200
0.056	25600	0.056	25600
0.064	26000	0.064	26000
0.072	26400	0.072	26400
0.080	26800	0.080	26800
0.088	27200	0.088	27200
0.096	27600	0.096	27600
0.104	28000	0.104	28000
0.112	28400	0.112	28400
0.120	28800	0.120	28800
0.128	29200	0.128	29200
0.136	29600	0.136	29600
0.144	30000	0.144	30000

Soil Profile at Sign H1EB-104 (B-9)

Fill	0-3 feet
Residual Soil	3-5 feet
Saprolite	5-13 feet
Basalt Formation	13-31 feet

SIGN H1EB-104 LATERAL LOAD ANALYSIS

Interstate Route H-1 and H-201
Destination Sign Upgrade/Replacement, Phase 3B
Federal-Aid Project No. NH-0300(205)
Island of Oahu, Hawaii