

SECTION 3. DISCUSSION AND RECOMMENDATIONS

In order to develop the required bearing and lateral load resistances for the new CCTV structures, we recommend supporting the CCTV structures on drilled shaft foundations. The CCTV structures should be supported on 42-inch diameter drilled shaft foundations. Based on the anticipated structural loads and the subsoil conditions encountered at each site, the length of the 42-inch diameter drilled shafts supporting the CCTV structures would range from about 6 to 13 feet.

The drilled shaft subcontractor will need to have the appropriate equipment and tools to drill through the cobbles, boulders, and basalt rock where encountered. Basalt rock was encountered at the Waikele CCTV and H-2 North CCTV sites. Residual and saprolitic soils were encountered at the H-1/Kamehameha CCTV and H-2 South CCTV site. It should be noted that there is a high potential for encountering basalt rock in the form of unweathered boulders and cobbles in the residual and saprolitic soils.

The performance of the drilled shafts depends significantly upon the contractor's method of construction, construction procedures, and workmanship. Therefore, the contractor should follow the recommendations and general guidelines presented in the "Drilled Shaft Construction Considerations" subsection of this report. Detailed discussion of these items and our geotechnical engineering design recommendations are presented in the following sections.

3.1 Drilled Shaft Foundations

In order to develop the required bearing and lateral load resistances, the proposed new CCTV camera 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 CCTV site are presented in the following table:

CCTV DRILLED SHAFT FOUNDATION				
<u>Site</u>	<u>Unfactored Compressive Load Shaft Capacity</u> (kips)	<u>Compressive Load Service Limit State</u> (kips)	<u>Shaft Diameter</u> (inches)	<u>Shaft Length</u> (feet)
Waikale CCTV	170	55	42	12
H-1/Kamehameha CCTV	125	40	42	13
H-2 North CCTV	130	43	42	6
H-2 South CCTV	80	25	42	10
Ko Olina CCTV	115	38	42	12

The drilled shaft foundation lengths provided in the above tables are measured from the design finished grades (ground level) to the tip of the drilled shaft. The cast-in-place concrete drilled shafts would derive vertical support principally from skin friction between the shafts and the surrounding soils.

3.1.1 Uplift Load Resistance

In general, uplift loads may be resisted by a combination of the dead weight of the drilled shaft and by shear along the shaft surface and the adjacent soils. Considering that the drilled shafts are designed based on adhesion between the shaft and the surrounding soils, we recommend using the following uplift load capacities for the extreme event and strength limit states. For the strength limit state, a resistance factor of 0.35 has been applied to the extreme event limit state uplift load capacities. In addition, the resistance factor was reduced by 20 percent for the single non-redundant drilled shaft. The project structural engineer should check the structural capacity of the shaft member in tension.

UPLIFT LOAD CAPACITIES FOR CCTV DRILLED SHAFT FOUNDATION			
<u>Site</u>	<u>Shaft Diameter</u> (feet)	<u>Uplift Load Capacity</u> (kips)	
		Extreme Event Limit State	Strength Limit State
Waikale CCTV	42	180	50
H-1/Kamehameha CCTV	42	136	38
H-2 North CCTV	42	140	39
H-2 South CCTV	42	84	24
Ko Olina CCTV	42	120	35

3.1.2 Lateral Load Resistance

The lateral load resistance of drilled shafts 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. Based on the loading conditions and the subsurface soil conditions, the results of our analyses are summarized in the following tables:

FOUNDATION ANALYSES RESULTS FOR CCTV 42-INCH DIAMETER DRILLED SHAFTS					
<u>Site</u>	<u>Loading Condition</u>	<u>Maximum Horizontal Deflection</u> (inch)	<u>Maximum Induced Shear</u> (kips)	<u>Maximum Induced Moment</u> (kip-feet)	<u>Depth to Maximum Moment</u> (feet)
Waikele CCTV	Extreme Event	0.1	91	152	5.5
H-1 / Kamehameha CCTV	Extreme Event	0.2	26	153	3.8
H-2 North CCTV	Extreme Event	0.2	194	141	1.7
H-2 South CCTV	Extreme Event	0.1	22	141	1.8
Ko Olina CCTV	Extreme Event	0.2	28	151	3.5

3.1.3 Torsional Resistance

In general, the CCTV 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. We wish to emphasize that the sides of the drilled holes should be relatively free of loose materials and that the concrete for the drilled shaft should have close contact with the in-situ soils after the drilled shaft has been constructed to provide the torsional resistance required.

3.1.4 Foundation Settlement

Settlement of the drilled shaft foundation will result from elastic compression of the shaft and subgrade response of the foundation embedded in the soils encountered at the site. We anticipate that the total settlements of the drilled shafts are estimated to be less than 0.5 inches. We believe that a significant portion of the settlement will be elastic and should occur as the loads are applied.

3.1.5 Drilled Shaft Construction Considerations

In general, the performance of drilled shafts depends significantly upon the contractor's method of installation and construction procedures. The following conditions would have a significant effect on the effectiveness and cost of the drilled shaft foundations.

The load-bearing capacities of drilled shafts depend, to a significant extent, on the friction between the shaft and the surrounding soils. Therefore, proper construction techniques, especially during the drilling operations, are important. The contractor should exercise care in drilling the shaft holes and in placing concrete into the drilled holes.

Basalt rock was encountered at the Waikele CCTV and H-2 North CCTV sites. Residual and saprolitic soils were encountered at the H-1/Kamehameha CCTV and H-2 South CCTV sites. There is a high potential for encountering basalt rock in the form of unweathered boulders and cobbles in the residual and saprolitic soils. In addition, cobbles and boulders may be encountered in the fill. The drilled shaft subcontractor will need to have the appropriate equipment and tools to drill through the basalt rock, boulders, and cobbles where encountered.

A Geolabs representative should be present to observe the drilling and installation of drilled shafts during construction. Although the drilled shafts are designed based primarily on skin friction, the bottom of the drilled hole should be relatively free of loose materials prior to placement of concrete. Therefore, Geolabs observation of the drilled shaft installation operations is necessary to confirm the assumed subsurface conditions and should be designated as a "Special Inspection" item.

3.2 Design Review

Drawings and specifications for the proposed construction should be forwarded to Geolabs for review and written comments prior to bid advertisement. This review is necessary to evaluate the conformance of the plans and specifications with the intent of the foundation and earthwork recommendations provided herein. If this review is not

made, Geolabs cannot assume responsibility for misinterpretation of the recommendations presented.

3.3 Construction Observation

Geolabs should be retained to provide geotechnical engineering services during construction of the proposed project. The critical item of construction monitoring that requires "Special Inspection" includes a review of the drilled shaft construction submittals and observation of the drilled shaft construction.

A Geolabs representative should monitor other aspects of earthwork construction to observe compliance with the intent of the design concepts, specifications, or recommendations and to expedite suggestions for design changes that may be required in the event that subsurface conditions differ from those anticipated at the time this report was prepared. The recommendations provided herein are contingent upon such observations. If the actual exposed subsurface conditions encountered during construction are different from those assumed or considered in this report, then appropriate modifications to the design should be made.

END OF DISCUSSION AND RECOMMENDATIONS