GEOQUEST, LLC
6825 Silver Ponds Heights #101
Colorado Springs, CO 80908
(719) 481-4560

24 September 2021

Palace Homes
1216 W. Colorado Ave. #110
Colorado Springs, Colorado 80904

RE: Response to Colorado Geological Survey Comments, 5050 Neeper Valley Road, Geoquest #17-1043

Reference: Geologic Hazard Report, Geoquest #17-1043, 21 June 2021
Comments from Colorado Geological Survey, 10 September 2021

To Whom it may Concern,

We were provided the above referenced comments obtained from the Colorado Geological Survey (CGS) in regard to our above referenced Geologic Hazard Report. CGS has request further information from Geoquest regarding the slope analysis.

First, CGS requested shear strength values should be determined from site-specific samples and lab testing. Our analysis was performed using published values. We disagree that this additional testing is necessary. This would require a Direct Shear or Tri-Axial test on an undisturbed soil sample. This is beyond the standards of practice for residential construction. Unfortunately, Geoquest does not have the ability to perform either of these tests.

Second, CGS requested further explanation regarding the results of the slope stability analysis. We found the existing site to have a factor of safety of 1.07 in the current state. This is a result of the steep loose decomposed granite overlying the solid bedrock. The failure modes are very shallow slip surfaces.

During construction we proposed cuts of the native granite to not be steeper than 1/4H:1V. There is evidence of steep cuts through bedrock on and adjacent to the property that have remain intact for extended periods of time. Therefore, we believe the granite bedrock to be acceptable to be cut to near vertical for the short period of time between excavation and backfill. This is more conservative than OSHA requirement for stable rock which allow vertical cuts. The native decomposed granite is recommended to have a slope of 1-1/2H:1V (Type C soil per OSHA). This results in a factor of safety of 1.05. This is nearly identical to the existing slope factor of safety and should not pose high risk to workers following OSHA guidelines.

Regarding the final slope stability, CGS indicated the upper wall stability was inadequate. This is correct, based on the given topography and proposed wall heights, the slope stability is inadequate at the upper wall. This can easily be corrected by extending the top of wall up two feet and properly reinforcing or including shear keys. This wall should be designed by a licensed Colorado Professional Engineer, either a MSE wall or reinforced concrete is recommended. The wall design should include analysis of slope stability. We believe a properly designed wall will be able to achieve a slope stability of greater than 1.50.

The native downslope stability has a factor of safety of 1.13 which matches the preconstruction stability downslope of the proposed structure. The proposed construction has no impact on the native slope stability past the area of disturbance. Therefore, we believe no additional constraints should be placed upon stabilizing the native slopes.

The slope stability analysis has also been updated with seismic analysis as requested by CGS. Seismic effects have been applied to "Stage of Construction 7". A Horizontal Seismic Coefficient (K_h) of 0.08 was applied based on a PGA of 8%g. A Vertical Seismic Coefficient (K_v) of 0.04 was applied based on an assumption that $K_v = 1/2*K_h$. The final global slope stability is 1.66. Please see the attached "Revised Slope Stability Analysis".

In conclusion, we believe the estimate shear values obtained from published data is sufficient for the proposed construction. The slopes during construction meet or exceed the requirements of OSHA regarding slopes and benches. The final slope stability analysis including seismic factors is adequate. However, the retaining walls should be design by a licensed engineer and should include slope stability analysis. We believe properly designed retaining walls will meet the minimum factor of safety of 1.50. The proposed construction will not impact the slope stability past the areas of disturbance and therefore we believe no additional constraints should be placed upon stabilizing these slopes. If you have any questions or would like more assistance, feel free to contact us at (719) 481-4560.

Sincerely,

Charles E. Milligan, P.E.

Attachment: Revised Slope Stability Analysis

Slope stability analysis

Input data

Project

Date : 6/18/2021

Settings

(input for current task)

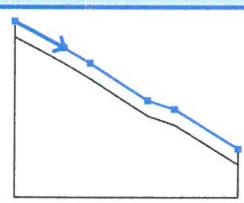
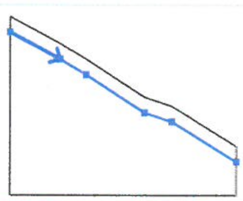
Stability analysis

Earthquake analysis : Standard
Verification methodology : Safety factors (ASD)

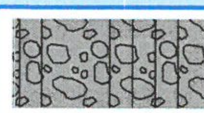
Safety factors Permanent design situation		
Safety factor :	SF_s =	1.50 [–]

Safety factors Transient design situation		
Safety factor :	SF_s =	1.25 [–]

Interface

No.	Interface location	Coordinates of interface points [ft]					
		x	z	x	z	x	z
1		0.00	65.00	22.33	53.00	34.00	46.00
		60.00	29.00	72.25	25.00	101.25	7.00
2		0.00	58.00	22.33	46.00	34.00	39.00
		60.00	22.00	72.25	18.00	101.25	0.00

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [psf]	γ [pcf]
1	DG		35.00	0.0	110.0
2	Gx		45.00	0.0	120.0

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [psf]	γ [pcf]
3	Fill		30.00	0.0	105.0

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [pcf]	γ_s [pcf]	n [–]
1	DG		130.0		
2	Gx		140.0		
3	Fill		125.0		

Soil parameters

DG

Unit weight : γ = 110.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 35.00 °
Cohesion of soil : c_{ef} = 0.0 psf
Saturated unit weight : γ_{sat} = 130.0 pcf

Gx

Unit weight : γ = 120.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 45.00 °
Cohesion of soil : c_{ef} = 0.0 psf
Saturated unit weight : γ_{sat} = 140.0 pcf

Fill

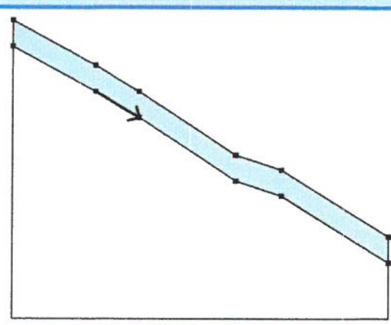
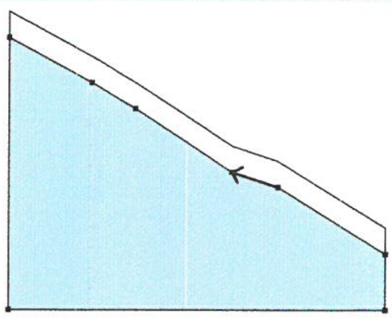
Unit weight : γ = 105.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 0.0 psf
Saturated unit weight : γ_{sat} = 125.0 pcf

Rigid Bodies

No.	Name	Sample	γ [pcf]
1	Concrete		150.0

No.	Name	Sample	γ [pcf]
2	Boulder		125.0

Assigning and surfaces

No.	Surface position	Coordinates of surface points [ft] x	z	x	z	Assigned soil
1		22.33	46.00	34.00	39.00	DG 
		60.00	22.00	72.25	18.00	
		101.25	0.00	101.25	7.00	
		72.25	25.00	60.00	29.00	
		34.00	46.00	22.33	53.00	
		0.00	65.00	0.00	58.00	
2		72.25	18.00	60.00	22.00	Gx 
		34.00	39.00	22.33	46.00	
		0.00	58.00	0.00	-15.00	
		101.25	-15.00	101.25	0.00	

Water
Water type : No water

Tensile crack
Tensile crack not input.

Earthquake
Earthquake not included.

Settings of the stage of construction
Design situation : permanent

Results (Stage of construction 1)

Analysis 1 (stage 1)
Circular slip surface

Slip surface parameters							
Center :	x =	64.06	[ft]	Angles :	α_1 =	-36.95	[°]
	z =	89.76	[ft]		α_2 =	-28.16	[°]
Radius :	R =	53.28	[ft]				
Slip surface after grid search.							

Slope stability verification (Bishop)

Sum of active forces : F_a = 65.2 lbf/ft

Sum of passive forces : F_p = 71.4 lbf/ft

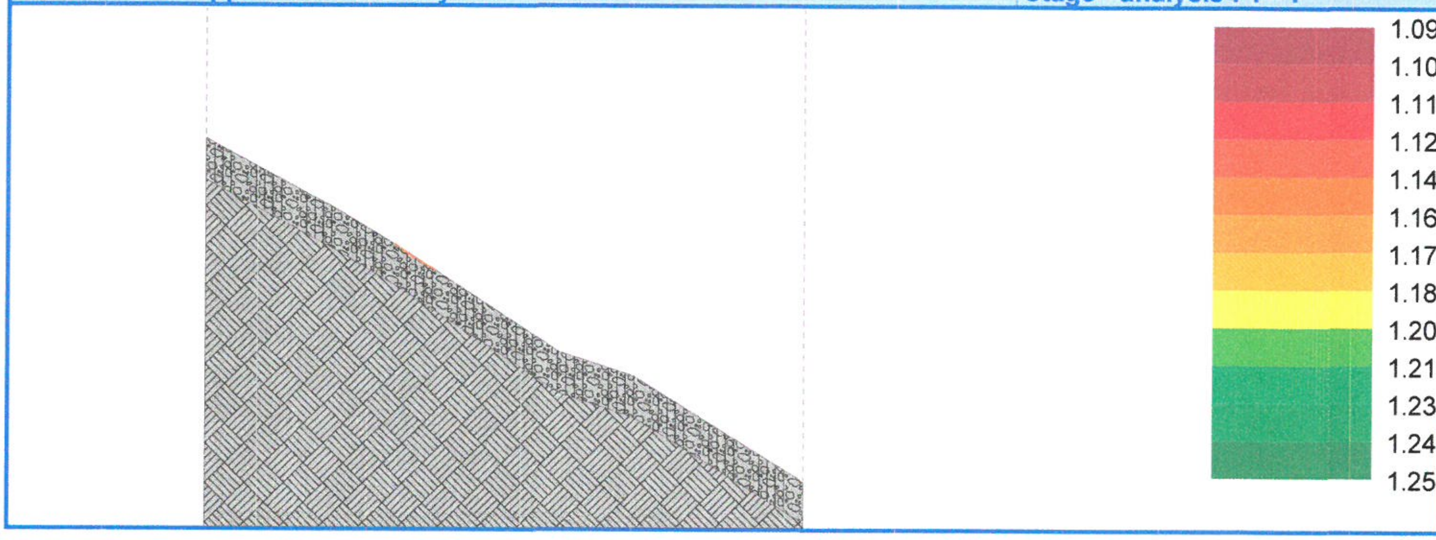
Sliding moment : M_a = 3475.5 lbfft/ft

Resisting moment : M_p = 3804.2 lbfft/ft

Factor of safety = 1.09 < 1.50

Slope stability NOT ACCEPTABLE

Name : Initial Upper Level Stability **Stage - analysis : 1 - 1**



Results (Stage of construction 6)

Analysis 1 (stage 6)

Circular slip surface

Slip surface parameters									
Center :	x =	32.34	[ft]	Angles :	α_1 =	-80.26	[°]
	z =	58.06	[ft]		α_2 =	3.66	[°]
Radius :	R =	14.94	[ft]				
Slip surface after grid search.							

Reinforcement bearing capacity

Reinforcement	Bearing capacity [lbf/ft]
1	0.0
2	0.0
3	224.0
4	2000.0
5	0.0

Slope stability verification (Bishop)

Sum of active forces : F_a = 4125.7 lbf/ft

Sum of passive forces : F_p = 7686.6 lbf/ft

Sliding moment : M_a = 61652.2 lbfft/ft

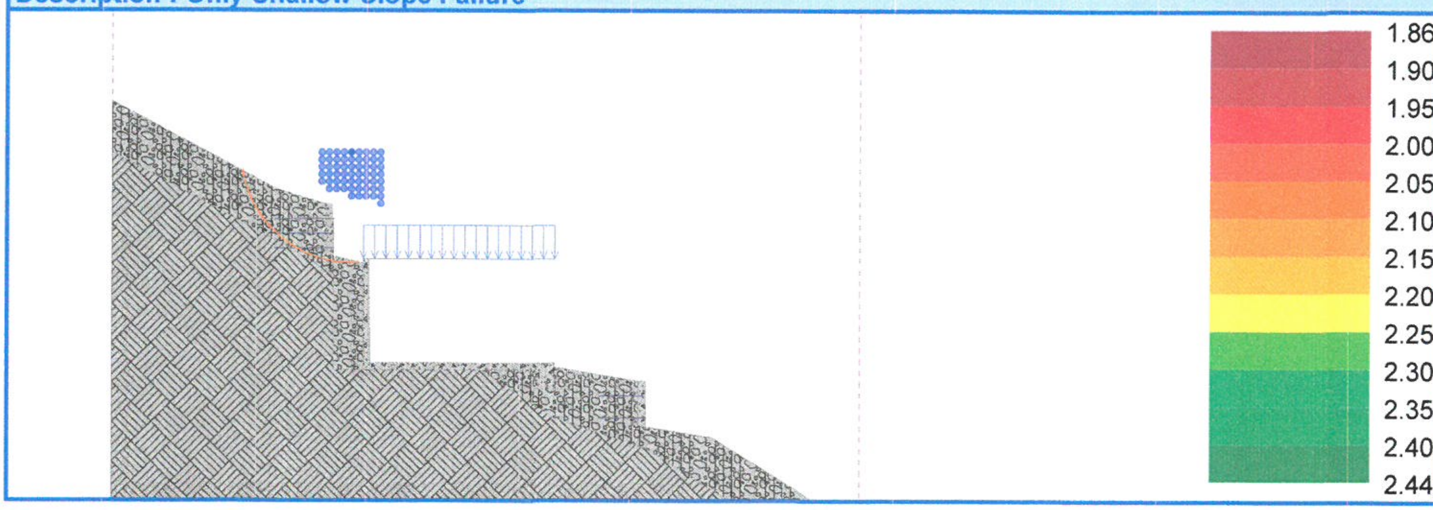
Resisting moment : M_p = 114862.5 lbfft/ft

Factor of safety = 1.86 > 1.50

Slope stability ACCEPTABLE

Name : Final Construction - Upper Wall Stability — Stage - analysis : 6 - 1

Description : Only Shallow Slope Failure



Analysis 2 (stage 6)

Circular slip surface

Slip surface parameters							
Center :	x =	76.22	[ft]	Angles :	α_1 =	-63.97	[°]
	z =	36.83	[ft]		α_2 =	15.35	[°]
Radius :	R =	18.03	[ft]				
Slip surface after grid search.							

Reinforcement bearing capacity

Reinforcement	Bearing capacity [lbf/ft]
1	0.0
2	0.0
3	0.0
4	0.0
5	0.0

Slope stability verification (Bishop)

Sum of active forces : F_a = 3492.9 lbf/ft

Sum of passive forces : F_p = 5483.0 lbf/ft

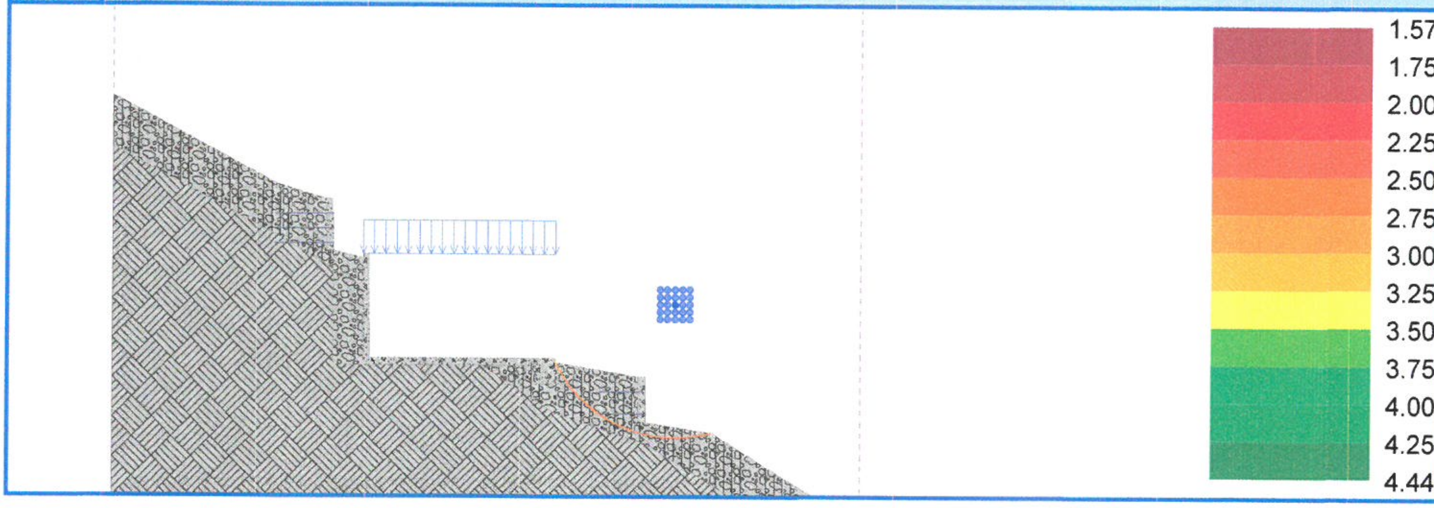
Sliding moment : M_a = 62976.6 lbft/ft

Resisting moment : M_p = 98858.9 lbft/ft

Factor of safety = 1.57 > 1.50

Slope stability ACCEPTABLE

Name : Final Construction - Lower Wall Stability	Stage - analysis : 6 - 2
Description : Pass	



Analysis 3 (stage 6)

Circular slip surface

Slip surface parameters							
Center :	x =	112.26	[ft]	Angles :	α_1 =	-33.48	[°]
	z =	58.29	[ft]		α_2 =	-30.15	[°]
Radius :	R =	49.41	[ft]				
Slip surface after grid search.							

Reinforcement bearing capacity

Reinforcement	Bearing capacity [lbf/ft]
1	0.0
2	0.0
3	0.0
4	0.0
5	0.0

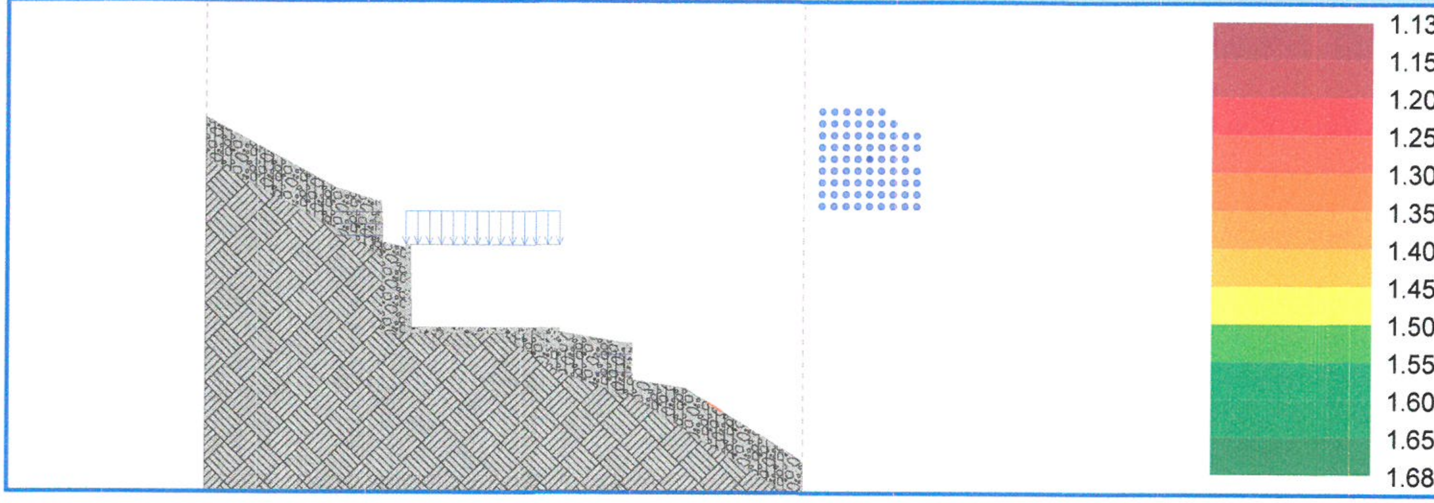
Slope stability verification (Bishop)

Sum of active forces : F_a = 2.1 lbf/ft

Sum of passive forces : F_p = 2.4 lbf/ft

Sliding moment : M_a = 104.1 lbfft/ft
Resisting moment : M_p = 117.6 lbfft/ft
Factor of safety = 1.13 < 1.50
Slope stability NOT ACCEPTABLE

Name : Final Construction - Downslope Stability	Stage - analysis : 6 - 3
Description : Only Shallow Slope Failure	



Results (Stage of construction 7)

Analysis 4 (stage 7)

Circular slip surface

Slip surface parameters							
Center :	x =	69.40	[ft]	Angles :	α_1 =	-67.23	[°]
	z =	92.91	[ft]		α_2 =	7.75	[°]
Radius :	R =	73.88	[ft]				
Slip surface after grid search.							

Reinforcement bearing capacity

Reinforcement	Bearing capacity [lbf/ft]
1	0.0
2	0.0
3	0.0
4	0.0
5	0.0

Slope stability verification (Bishop)

Sum of active forces : F_a = 44053.5 lbf/ft
Sum of passive forces : F_p = 73000.7 lbf/ft

Sliding moment : M_a = 3254670.8 lbfft/ft
Resisting moment : M_p = 5393289.5 lbfft/ft

Factor of safety = 1.66 > 1.50

Slope stability ACCEPTABLE

Name : Final Global Slope Stability | **Stage - analysis : 7 - 4**