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December 4, 2015

Summit Powder Mountain
c/o Ms. Andrea Milner
3632 North Wolf Creek Drive
Eden, Utah 84310

IGES Project No. 01628-008

Subject: Response to Review Comments – Geotechnical Engineering
Geotechnical Investigation
The Ridge Nests Development
Powder Mountain Resort
Weber and Cache Counties, Utah

Ms. Milner:

As requested, IGES has prepared the following response to a review comment regarding the referenced geotechnical report for the Ridge Nests development, part of the larger Powder Mountain Resort expansion project in Weber County, Utah. The review comments to be addressed were prepared by Taylor Geotechnical (TG) in notes uploaded on Miradi (Weber County on-line application) on October 15, 2015.

The review comments by TG was intended to address Lot 13; however, in consideration that the comments by TG could also be applicable to several other lots, it is the intention of IGES to address the comments with respect to the entire Ridge Nests development. For convenience, the review comments will be presented first, followed by our response.

Comment No. 1

"*Respond to geological comments in the Simon Associates, LLC (SA) "Geologic Review, Lot 13, The Ridge Crest Subdivision, 7914 East Heartwood Drive, Eden, Utah," (SA Project No 15-160), dated October 14, 2015.*"

Response to Comment No. 1

IGES has submitted a response to the referenced comments on November 4. IGES has subsequently received additional review comments by SA in a letter dated November 29, 2015; IGES is currently preparing a response to the new review comments, which will be responded to in a separate submittal.

Comment No. 2

"*Substantiate the 42 degrees friction angle for the shear strength of dolomite bedding planes, undifferentiated colluvium, and slope wash. The physical characteristics of bedding planes can affect bedding plane shear strength depending on degree of fracturing (generally controlled by the number of joints in a given direction), persistence of jointing, spacing of jointing, roughness of joint surface, open and/or closed joints, joint coatings and infillings, etc. Similarly, the shear* *strength of the undifferentiated colluvium and slope wash could vary depending on its gradation and clay content. "*

Response to Comment No. 2

IGES concurs with the Review's comment that the "*…physical characteristics of bedding planes can affect bedding plane shear strength depending on degree of fracturing (generally controlled by the number of joints in a given direction), persistence of jointing, spacing of jointing, roughness of joint surface, open and/or closed joints, joint coatings and infillings, etc."*. The following paragraphs are intended to provide a rational basis for selection of a friction angle of 42 degrees to model the strength along bedding/jointing planes in the dolomite.

The shear strength along a planar feature is often described using the familiar Coulomb's linear relation,

$$\tau = C + \sigma_n \tan\phi \qquad (1)$$

Where,

C = cohesion, or cohesion intercept

σ_n = normal stress on the sliding plane

ϕ = friction angle

τ = Peak Shear Strength

The friction angle for unconsolidated sediments can generally be determined by direct methods (e.g., direct shear test) or estimated based on index properties, insitu testing, or other suitable data. For rock joints, bedding, e.g. planes of weakness in rock, the Reviewer correctly points out that a representative friction angle will be dependent on a number of variables (e.g., physical rock properties) that should be assessed to determine a reasonable friction angle for analysis. An empirical relationship that is often utilized in rock mechanics to predict the mean peak strength along rock joints is taken as (after Barton and Choubey, 1977):

$$\tau = \sigma_n \tan[JRC\ log_{10}\left(\frac{JCS}{\sigma_n}\right) + \phi_b] \qquad (2)$$

Where,

τ = Peak shear strength

σ_n = effective normal stress

JRC = joint roughness coefficient

JCS = joint wall compressive strength

ϕ_b = basic friction angle (obtained from residual shear tests on flat, unweathered rock surfaces)

The Joint Roughness Coefficient (JRC) is a function of the texture along the rock joint or bedding. This value can be estimated a number of ways, including back-calculation, or estimating based on visual assessment using a typical roughness profile. Based on Figure 8 in Barton and Choubey (1977), a lower-bound estimate for JRC for the dolomite can reasonably be assessed as 5.

The Joint Wall Compressive Strength (JCS) is a function of the deformation properties of the rock. Where formation of the joint is within intact, unweathered rock, the JCS value is the same as the uniaxial compressive strength of the rock (σ_c). If the joint walls are weathered, the JCS may be a fraction of σ_c. The uniaxial compressive strength of the rock can be obtained using insitu means (Schmidt hammer) or conventional laboratory means. Empirical data is not available for this particular rock unit; however, the uniaxial strength of limestone (has very similar mechanical properties to dolomite) ranges from 5,120 psi to 54,100 psi (Johnson & Degraff, 1988). The exposed dolomite generally has a moderate degree of weathering, and the observed joints are close with openings generally less than 5mm, with little or no in-filling. Therefore, a conservative estimate of the JCS can be taken as 5,000 psi.

The basic friction angle (ϕ_b) for limestone ranges from 31-37 degrees (dry surface) to 27-35 degrees (wet surface) (Table 1 from Barton and Choubey, 1977). This friction angle is based on a diamond-saw cut smooth surface. For demonstrative purposes, we have estimated a representative basic friction angle of 31 degrees for this dolomite.

The effective normal stress varies along the failure plane; to estimate a reasonable, representative value for this demonstration, IGES has assessed the slope stability analysis for Section B-B'. By observation, the average depth from the ground surface to the shear surface is approximately 15 feet. The unit weight of dolomite is likely on the order of 180 pcf (Deer et al., 1966). Therefore, a representative effective normal stress can be estimated as 2,700 psf.

Inserting the foregoing estimated values into the referenced equation,

$$\phi_r = JRC\ log_{10}\left(\frac{JCS}{\sigma_n}\right) + \phi_b \qquad (3)$$

$$\phi_r = 5\ log_{10}\left(\frac{720\ ksi}{2700\ psf}\right) + 31$$

$$\phi_r = 43.1\ degrees$$

Where ϕ_r is the representative equivalent friction angle to be used in a conventional limit-equilibrium slope stability analysis to model the friction angle along rock bedding or jointing.

Based on this assessment, the estimate of 42 degrees is considered reasonable and conservative for use in a limit-equilibrium slope stability program. The estimated values of JRC and JCS are considered fairly conservative – it is likely that actual measured JCS and JRC values would be higher, but barring new empirical data IGES considers the lower-bound estimates based on published data reasonable, particularly in light of the fact that the static factor-of-safety determined in our slope stability analysis is greater than 5. It is interesting to note that Barton and Choubey (1977) recommends that the equivalent friction angle along rock joints should be limited to no more than 70 degrees in practice.

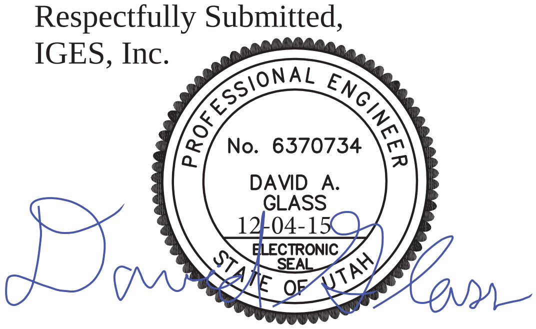
With respect to the strength of undifferentiated colluvium, the value of 42 degrees is considered a conservative and reasonable estimate based on soil types typically encountered in the vicinity, e.g., typically clast-supported gravel and cobbles, often with angular to sub-angular constituents. Quantifying the strength of particularly coarse, angular earth materials is often difficult or impractical. Nevertheless, in our slope stability analysis, the colluvium appears to have little or no bearing on the results of the slope stability analysis, as the strength and anisotropic properties (apparent dip of jointing/bedding) of the dolomite controls the analysis.

Although the strength of the colluvium has little or no bearing on this particular slope stability analysis, IGES concedes that assessing the strength of the colluvium may be critical for other nearby lots outside of the Ridge Nests project area. To that end, IGES has recently acquired a large-diameter shear box, which will allow testing of remolded soil samples with material up to 1 inch diameter. IGES anticipates testing representative samples of the prevailing coarse colluvium at selected locations in the spring, as the need arises. As this data is developed, at the Reviewer's request IGES will share this information with the Reviewer and discuss the implications for future slope stability analysis for upcoming Powder Mountain projects, or past projects if re-assessment is warranted based on this new data.

Closure

We appreciate the opportunity to provide you with our services. If you have any questions please contact the undersigned at your convenience (801) 748-4044.

Respectfully Submitted,
IGES, Inc.



David A. Glass, P.E.
Senior Geotechnical Engineer

Attachments:

References

References

Barton, N., and Choubey, V., 1977, The Shear Strength of Rock Joints in Theory and Practice, in Rock Mechanics, December 1977, Volume 10, Issue 1, pp 1-54.

Deer, W.A., Howie, R.A., and Zussman, J., 1966, An Introduction to The Rock-forming Minerals, 2nd Ed. 1992), Addison Wesley Longman Limited (pub.).

IGES, Inc., 2014, Geotechnical Investigation, The Ridge Nests Development, Powder Mountain Resort, Weber and Cache Counties, Utah Project No. 01628-008, dated September 16, 2014.

IGES, Inc., 2015a, Response to Review Comments, Geotechnical Investigation, The Ridge Nests Development, Powder Mountain Resort, Weber and Cache Counties, Utah Project No. 01628-008, dated April 7, 2015.

IGES, Inc., 2015b, Addendum to Geotechnical Report, The Ridge Nests Development, Powder Mountain Resort, Weber and Cache Counties, Utah Project No. 01628-008, dated August 18, 2015.

IGES, Inc., 2015c, Response to Additional Review Comments – Geology, Geotechnical Investigation, The Ridge Nests Development, Powder Mountain Resort, Weber and Cache Counties, Utah, Project No. 01628-008, dated September 23, 2015.

Johnson, R.B., and DeGraff, J.V., 1988, Principals of Engineering Geology, Wiley.