Geotechnical Design Method Quantifying Risk—An Owner's Perspective

Owners want a safe and economical geotechnical design. Unlike other engineering disciplines that design using "man-made" products that have well known properties, the geotechnical engineer designs based on soil/rock properties that may have significant variability. A "bell" shaped probability distribution best models these properties with its average value at the center of the bell.

By definition, the area under the probability distribution curve must equal 1.00. If one flips a coin, it will land as either a head or tail. While one does not know whether it will land as a head or tail, it will have one of those two outcomes. Similarly, if the weather prediction calls for 30% of rain, then the corollary prediction for not raining equals 70%. But there is a 100% chance that it will either rain or not rain. With engineering, the desirable outcome will have a certain percentage or probability of success and one minus that percentage results in an undesirable outcome or probability of failure.

The success zone equals the area under the probability curve on the good side of the threshold value. For example, a slope's success area equals the area under the probability curve more than a factor of safety of 1.0. A settlement's success area equals the area under curve that is less than the desired maximum amount of settlement. Generally, the success area should exceed 90% and typically averages 95%.

Figure 1 presents an example of the high and low variability cases. If the engineer performs a detailed subsurface investigation and accurately defines and acquires knowledge of the soil properties, then he/she designs based on the low uncertainty (blue) curve, resulting in an economical solution. On the other hand, if the engineer only performs a basic investigation and only generally knows the soil properties, then he/she designs based on the high uncertainty (red) curve, resulting in a costly design solution. The area where the high uncertainty curve exceeds the low uncertainty curve computes as the probability of financial failure.

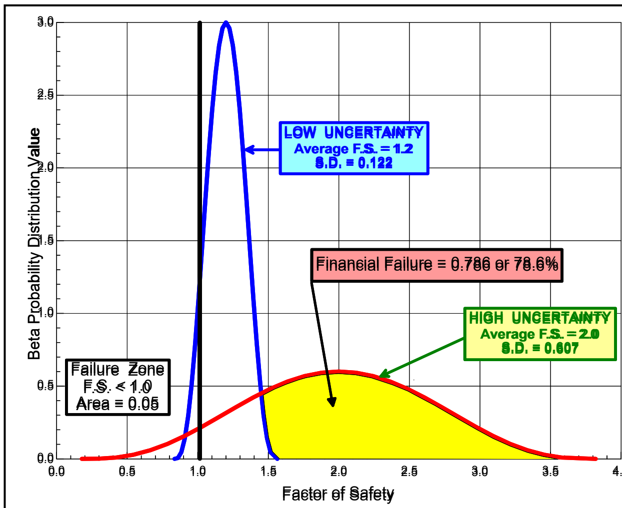

Figure 1: Financial Failure from Poor Quality

If the subsurface conditions at the site have significant variability, how does the engineer best design for them? The engineer first identifies, maps and accurately measures the soil properties at the site. He/she then designs the weaker areas more robustly than the stronger areas, accounting for and minimizing the effects of the spatial subsurface variability at the site. In the ideal foundation design, each column will settle exactly the same amount, minimizing the risk of cracking or distress to the structure.

The owner should choose the probability of success balancing the risk of potential undesired outcome with the cost of construction. The engineer should design for the owner's desired probability of success. For example, if the engineer designs for a threshold settlement of 1.0 inch but a column settles 1.1 inches (undesired outcome or failure), then the owner should determine how important and costly this consequence is. If he/she is building a warehouse, the repair may only have minor costs and not disruptive to the operations of the building. On the other hand, if he/she is building a hospital, the repair could be quite costly and disruptive to building's operations. Table 1 presents a guide for the owner to choose his/her desired probability of success:

Risk Level	Design Probability of Success	Construction Type
Low	90%	Warehouse—Repair, if made, not costly or disruptive
Average	95%	
High	99%	Hospital, Manufacturing Building with Sensitive Alignment—Repair costly with significant loss of production and use

In summary with the geotechnical design method quantifying risk, the owner benefits from:

1. An accurate design solution that matches his/her desired risk rather than a risk that protects the engineer's liability,
2. Columns that settle the same predicted amount, which reduces the potential for cracking by minimizing differential settlement or angular distortion, and
3. Reduction in potential legal disputes.

We hope that you will request your geotechnical engineer to use this method for your project, saving you money for unnecessary costs and designs that match your risk requirements. You can find the link to the technical detailed design method quantifying risk at Design Method Quantifying Risk – In-Situ Soil Testing.