Foundation Design Using Common Sense

By James R. Cagley, P.E., S.E.

In my practice over the last forty plus years, I have had the opportunity to be involved with many different foundation conditions and situations. In this article I have attempted to relate some of those experiences. Some have been good. Some have not.

Variable Thickness Post-tensioned Mats

One of our clients, a contractor/developer, had spent one whole winter trying to drive piling for a new building project on a site that they were developing. This particular piece of property had been an old junkyard or dump (no organics). The decision had been made to use piling because of the limited available bearing capacity and the potential for soft pockets.

After discussions with the geotechnical consultant, we came up with the idea of using a mat. This was appealing but also demanded excavation of a large amount of material, which was also an issue in the old dumpsite.

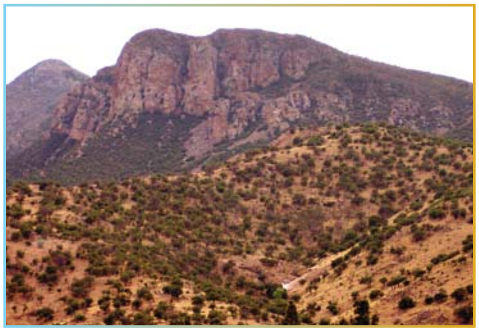
The buildings to be designed and built were three to five story office buildings with parking under them at grade. Since this was a flood plain area, no inhabited space would be below approximately eight feet above grade. This also was a plus for some type of mat, since the top surface could be used as parking.

Washington is a concrete town; post-tensioned concrete is a normal material to use for construction of office buildings. If one could come up with a post-tensioned mat that was not too thick, we would have a practical solution if it was also economical. Several ideas were thrown out on the table, but the one with the most promise was something that looked like a flat slab. It had drop panels around the column locations to give shear capacity and enough thickness in the balance of the area to provide for flexural capacity. Considering that a flat slab is designed to carry a vertical load on the upper or flat surface, we had to develop a method of designing this system like an upside down flat slab or a flat slab with the applied vertical load on the bottom. This meant that the flexural reinforcing, in this case unbonded tendons, were at their high points at mid span and at the bottom of the drop panels at the column locations.

We subsequently designed three office buildings using this system for this owner on this site. They have all performed quite well for over ten years.

Post-Tensioned Mats

Since the variable thickness post-tensioned mats had worked so well, in lieu of using a post-tensioned uniform thickness mat on a project at a nearby site that also appeared to require a mat, or at least a uniform distribution of the load to the soil in order to lighten the unit load placed on the soil. This particular project was a 12-story apartment building with two levels of parking below grade. The unit load was such that a uniform thickness seemed to be a better answer than varying the thickness. The post-tensioned mat was priced out against a typical mild reinforced mat. The post-tensioned mat was slightly less expensive, so the owner/contractor/developer elected to go ahead with it since the balance of the building was cast-in-place post-tensioned concrete.



The structural solution was successful, but the practical side of this decision suffered. Since the load was relatively high, we had to stage stress the tendons in the mat. That meant that we had to first hold back the sheeting and shoring on the exterior of the excavation on two sides for stressing, and then leave it open for approximately three or four extra months until we could stress the second half of the tendons.

This particular client strongly suggested that we never use this type of a solution for one of his projects again. We listened, and are still working for him after ten years and probably ten major apartment projects later.

Swelling Soils

Early in my career, I spent seven years in Texas. One of the interesting phenomena's in Texas and the Southwest are the soils, which have a tendency to swell with the addition of water.

On most projects, a geotechnical consultant will give the structural engineer three criteria for selecting bearing capacity. Sometimes it is difficult to meet all of them at the same time, although that is the intention. Those criteria are typically as follows:

1. A maximum dead load plus live load pressure.
2. A minimum dead load pressure.
3. A minimum size such as the width of a wall footing, an area of a spread footing or a diameter of a caisson.

It is also normal practice to use carton forms to form a void under a grade beam connecting to caissons or under a ribbed slab on grade. The consequences of allowing the pressure of the swelling soil to develop under a grade beam, for example, can be disastrous. I personally saw a 24- x 36-inch grade beam broken in two by this pressure.

The three criteria above usually shake out so that the first two can be met. That is the maximum DL + LL pressure and the minimum DL pressure. The problem usually is coordinating this with the minimum size. For instance, this requirement on a low-rise structure with drilled piers could cause a spacing which is not easily translated into a reasonable bay size for framing. The solutions sometimes involve various methods of controlling the introduction of moisture to the foundation soils, as well as using uneconomical framing to minimize future movements which would in turn cause potential damage to the structure.

Conclusion

These thoughts are some of the ramblings of a structural engineer who has practiced for sometime and wanted to pass on some ideas from experience to the profession.▪

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