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AND

A MOOSE HUNT

A CASE HISTORY OF A COMEDY OF MISTAKES

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A Case History of a Comedy of Mistakes

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An upgrading and straightening of a highway included building a bridge across a small river. A routine site investigation was initiated to determine the conditions for designing the foundation of the bridge. The proposed bridge was a two-lane highway bridge in one span with a total length of 30 m (100 ft), as indicated in Fig. 1. It was to be placed about 20 m (66 ft) upstream of a bridge for the existing highway.

The site investigation included one boring at each abutment with soil sampling and in-situ vane testing and placed about halfway up the slope from the small river at ground surface elevation +54 m. Within the investigated maximum depth of 40 m (130 ft), the soils at both borehole locations consisted of a thin clay crust over a thick deposit of soft sensitive clay with a natural water content of about 70% and a liquid limit of about 60. The undrained shear strength below the crust was about 20 KPa (400 psf) and increased slightly with depth. The sensitivity was high, about 40.

It was clear from the outset that the bridge abutments had to be supported on driven, precast concrete piles - shaft bearing piles "floating" in the clay. A preliminary analysis indicated that the necessary pile length would be about 30 m (100 ft). To verify the design, two 31 m (102 ft) long test piles were installed and subjected to a static loading test. The results of the two tests showed that the pile capacity was too small for the intended allowable load. An extrapolation of the test data indicated that if the pile embedment length was increased to 40 m (131 ft) the capacity would be adequate. This length became the design length for the project.

As shown in Fig. 1, the foundation elevation of the abutments was about 4 m (13 ft) below the ground elevation at the boring locations necessitating excavation prior to the piling work. There was some concern as the stability of the excavations and the slopes. To address this problem, it was specified that the excavation should be made about twice the width necessary for access and that all soil above an elevation 5 m (16 ft) higher than the excavation bottom be removed within a distance of 15 m (50 ft).

The design was completed and a contract was let for the work. No one expected anything out of the ordinary to happen and no one realized that a mistake had been made that would have serious implications on the construction work.

The construction started and the excavations were made as specified. Now the second mistake was made: the excavated soil was placed on the slope above and immediately next to the excavations! However, nothing happened that could have alerted someone to this potentially unstable situation.

Upon completing the excavations, the contractor proceeded with the installation of the piles. In both abutments and for most of the depth, the piles penetrated the clay under the weight of the hammer alone or met a very light penetration resistance. However, at a depth of about 38 m (125 ft), the resistance increased markedly, and a refusal condition occurred leaving the piles with a 2 m (6 ft) stick-up.

There was some consternation as to why the "floating" piles would stop. After all, the borings indicated that the soil at the pile toes, depth 38 m (125 ft), consisted of sensitive clay. No one realized that the elevation of the reference ground surfaces were different.

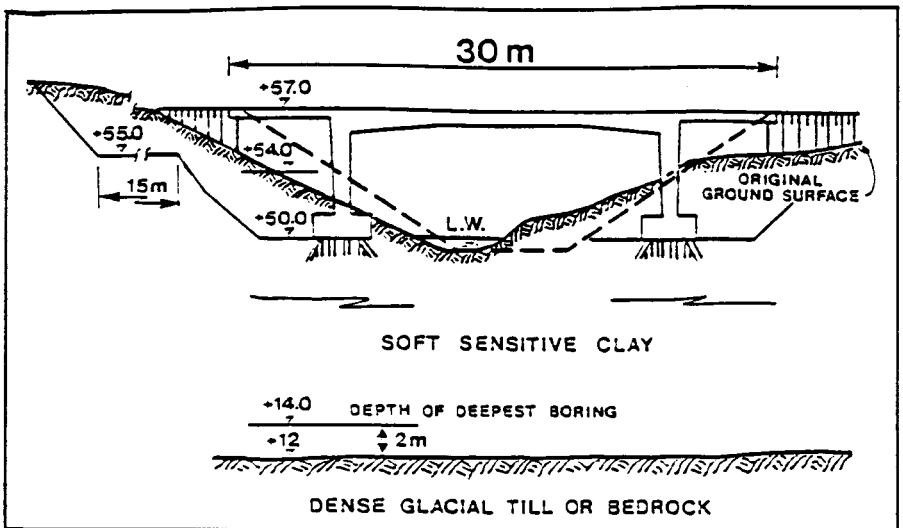
There was also a contractual concern: the piling contractor was paid to drive 40 m long piles and had now driven only 38 m. In addition to not accepting that the payment would be reduced on account of the piles being shorter, he mentioned something about his desiring payment for cut-off. The engineers recognized and had a solution to this problem, however, and directed the contractor to continue driving with increased hammer height-of-fall. Thus, the third mistake was committed.

The contract specifications limited the hammer height-of-fall in easy driving, but not in hard driving. The hammer height was doubled and tripled after a few blows, only, the pile penetration increased and the full length of the piles were easily driven down. Of course, it is highly unlikely that the pile toes went any deeper!

Theoretically, the excavation with the stockpiled soil up above had an inadequate stability. Driving displacement piles into sensitive clay in a sloping ground is at best risky. Under the circumstances it is very surprising that there was no slope failure. However, Mother Nature is often forgiving and up to the final hard driving, which induced considerable shaking of the ground, nothing happened. But now, she had had enough. The soil slope above the excavation moved down, broke the piles in the process, and partially filled the river bed.

Due to the narrowing of the river bed, the water rose and its velocity increased considerably and started to erode the slope on the other side. If this erosion was unchecked, the slope would be undermined and a second landslide would occur. If so, the existing bridge downstream of the site would become endangered. It was clear that until the river could be widened, the slope had to be protected. To serve as erosion protection, loads of sand and gravel were ordered to the site. The intent was to push this coarse material down the endangered slope to protect it from further erosion.

The fourth mistake was to pile the erosion protection material up on the



Longitudinal section of bridge and foundations

slope instead of moving it down the slope as fast as it arrived.

The sand and gravel arrived and was dumped on top of the slope. A bulldozer arrived to push the material down the slope and into the water. There was a real urgency in the activities. Alas, the urgency was not because of the importance of stopping the second slide. It was simply the excitement at the imminent start of the moose hunting season.

The next day was the first day of the hunting season. The construction site lay deserted and Mother Nature had a free hand. A couple of days later, the second slide occurred. The clay soil was swept away, but some of the sand and gravel ended up around the abutments of the existing bridge effectively protecting them from damage due to further erosion! When the crew returned from the hunt, there was mopping-up work to do, new piles to drive, but very few questions asked, and, eventually the bridge got built without any further incidents.

Four separate mistakes were made. Actually, there was a fifth one, the first, really: that of not having a person in charge with some common sense, experience, and overall authority for the work.

The mistakes presented in this case history are common, although they do not often combine into such a spectacular series of events. The lesson to learn from the case is obvious and does not require an in-depth analysis.

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