Control of Slide by Vertical Sand Drains

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●OF the many adverse agents of nature, to the engineer and geologist, a slide is not the least. Many preventative and remedial measures have been tried, but no one method is applicable to all cases, and the remedy must be custom-tailored to suit the situation. The paper does not discuss a new method, but is a case history of a slide which was brought under control by the use of vertical sand drains.

In 1947, the Virginia Department of Highways began the relocation and widening of US 220 between Clifton Forge and Iron Gate in Alleghany County, Virginia. It was realized from the beginning that the probability of slides was imminent due to the following factors:

The location of this road is in the Valley and Ridge Province which embraces the major portion of the Appalachian Valley. The terrain is extremely rough and mountainous, with the mountains being cut by numerous streams forming a number of water gaps.

The immediate site of this road is near the famed Iron Gate Gorge where the Jackson River cuts through Rich Patch Mountain, revealing one of the best known of all anticlines in the Appalachian Valley. This anticline rises 700 feet above the grade of the new road and is composed of interbedded sandstones, limestones, and shales of Silurian and Devonian ages. Joint planes set up by the forces of folding have developed in the sandstone at right angles to the bedding, giving rise to large rectangular blocks of rock, which came in handy in building the retaining walls which will be mentioned later.

The new location runs parallel to the axis of the anticline and is sandwiched between the Jackson River and the mountain side. Excavation showed that through this entire section the road passed through a thick mantle of talus, mostly sandy soil, and the heretofore-mentioned boulders. An analysis of this soil gave the following results: a liquid limit of 21 percent; nonplastic; shrinkage limit of 16 percent; optimum moisture, 10.5 percent; and a density of 123 pcf.; 49.3 percent of the material passed a No. 10 sieve. Of this, 20 percent was coarse sand, 52 percent fine sand, 15 percent silt, and 13 percent clay. This soil was classified as A-2 sand silt. It was in this talus material that the slides first showed evidence of developing.

As in 99 percent of all cases of slides, water was the chief offender. It could percolate through the beds of sandy soil and badly fractured rock and break out in the slope above the new grade.

To further complicate matters, the old road (which was still carrying traffic) was perched on a narrow shelf-like indentation. It was under this that the slide first showed signs of starting.

The engineering staff believed that a massive retaining wall would have a tendency to check the slide. For once nature was on our side, for the large sandstone blocks which normally would have been waste material were used to construct the wall. This wall was approximately 4 feet through and 3 feet high. No mortar was used.

Owing to the character of the material, the excavation for the footing of the wall was only carried forward about 5 feet ahead of the actual construction of the wall. This wall was quite effective in checking any large earth movements at the base of the slide, but further creep and seepage caused the bank to slough off and break back into the pavement of the then-existing road.

A detailed study disclosed the presence of a horizontal bed of plastic varved impervious clay about 35 feet above the grade. The water draining through the loose sand would reach this bed of clay, then follow it and break out on the slope.

The geological staff of the highway, in consultation with the Engineering Geology Branch of the United States Geological Survey, considered several possibilities as remedies, among them being benching, grouting, and a flatter slope. However, it was finally decided to try vertical sand drains, even though there was some question as to whether they would be effective. It was known that these drains had performed with excellent results in the marsh lands of New Jersey and California, but as far as was then known this was a pioneering attempt to use them to drain a slide.

It must be borne in the mind that this method is different from the normal sand drains, wherein a layer of sand is placed upon a marshy section and the water forced upward through the sand drain. In our case the sand drains were installed in hopes that the water would be carried down and discharged in the porous material at the bottom of the hole.

A well-drilling company contracted to do the work. An ordinary churn drill was used. An 8-inch hole was drilled and cased with 6-inch casing. Ten of these holes, each 80 feet deep, were drilled in the ditch line of the old road. This placed the bottom of the hole 10 feet below the grade of the new one. It was anticipated that the water would drain through the sand and gravel in the old flood plain of the river and hence find its way into the river itself. When the first hole was finished, it was found that contrary to expectations, the water would not drain through the tightly compacted gravel and clay. Five sticks of dynamite were exploded at the bottom of each hole, which allowed the water to drain freely out to the river. No other drainage was necessary. The hole was then filled with well-graded concrete sand. The casing was pulled and sealed with a bituminous cap.

It had been estimated that this work would cost in the neighborhood of $8,000, whereas the actual cost was a little over $500 per hole or approximately $6.25 per foot. The total cost was a little over $5,000.

This area has been carefully watched for the past 7 years, and with the exception of the normal sloughing of any new cut, no slides have occurred. It is therefore concluded that these drains are operating efficiently and that their use may have a more-widespread application to the control of various drainage problems than those confined to marshes and tidal sections.

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