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Status Report on Landslide Area on I-75, Covington, Kentucky [August 1963]

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A Slide Area Being Studied as Part of Research Project KYHPR-63-16

DEVELOPMENT OF A PRACTICAL METHOD OF LOCATING AND TRACING SEEPAGE WATER IN UNSTABLE SLOPES

KHS-HPR-l(25), Part II

by

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INTRODUCTION

This report has been prepared to describe the conditions of
the landslide area on Interstate Route I-75 in Covington, Kentucky,
since May 15, 1963, the date of an earlier status report. Subsurface
data which has been collected and assembled during the past three
months is also included. Possible corrective considerations have
also been included in this report.

The rainfall data included in this report, as well as the
previous status report (May 15, 1963), are the official 24-hour
precipitation recorded by the U. S. Weather Bureau at the Greater
Cincinnati Airport in Boone County, Kentucky. The airport is
located approximately nine miles west of the site of the landslide.
HISTORY OF LANDSLIDE AREA

MAY 14, 1963 --- 0.13 inches of rainfall

Conditions (see Figures 1 and 2) in the landslide area were very much the same on this date as they were on May 10. Personnel from the telephone company were on the site realigning their poles near the toe of the embankment.

MAY 15, 1963 --- 0.04 inches of rainfall
MAY 17, 1963 --- 0.49 inches of rainfall
MAY 19, 1963 --- 0.11 inches of rainfall
MAY 20, 1963 --- 0.44 inches of rainfall

MAY 22, 1963 --- The slopes in the landslide area were dressed in attempt to close some of the larger cracks and thus reduce infiltration of rainfall and increase runoff. The unstable mass of soil was still moving slowly, as evidenced by tilted telephone poles at the toe of the embankment (see Figure 3). Figure 4 shows the extent to which the pavement had dropped in the two outside, northbound lanes near Station 490.

MAY 23, 1963 --- The dressing of the slopes was completed. A bituminous patch was placed in the center, northbound driving lane near Station 490.
Fig. 1.

Main Scarp of Landslide, May 14, 1963.

Fig. 2.

Area of Seepage Water at Toe of Embankment, May 14, 1963 (Looking North).
Fig. 3. Telephone Poles Near Toe of Embankment, May 22, 1963 (Looking South).

Fig. 4. Main Scarp of Landslide Showing Pavement Slab Settlement, May 22, 1963 (Looking North).
MAY 26, 1963 --- Trace of rainfall
MAY 27, 1963 --- 0.08 inches of rainfall
MAY 28, 1963 --- 0.14 inches of rainfall

JUNE 3, 1963 --- 0.08 inches of rainfall
The unstable soil mass was still moving slowly as evidenced by the appearance of transverse cracks in slope that had been dressed (see Figures 5 and 6).

JUNE 4, 1963 --- 0.06 inches of rainfall
JUNE 5, 1963 --- Trace of rainfall
JUNE 6, 1963 --- 0.20 inches of rainfall
JUNE 7, 1963 --- 0.15 inches of rainfall
JUNE 10, 1963 --- 0.22 inches of rainfall
JUNE 13, 1963 --- 0.01 inches of rainfall
JUNE 16, 1963 --- Trace of rainfall
JUNE 20, 1963 --- 0.75 inches of rainfall

JUNE 21, 1963 --- The rate of movement of the unstable soil mass has been much slower since mid-May. Movement is still occurring, however, as evidenced by the appearance of transverse cracks in the slope (see Figures 5 and 6), tilting of telephone poles (see Figures 3 and 7), and the appearance of a crack in the bituminous patch placed near Station 490 (see Figure 8).
Fig. 5. Transverse Cracks, June 3, 1963 (Looking North).

Fig. 6. Close-up of Transverse Cracks, June 3, 1963.
Fig. 7. General View of Landslide Area, June 21, 1963 (Looking South).

Fig. 8.
Close-up of Crack in Bituminous Patch Near Station 490, June 21, 1963.
JUNE 24 - JULY 31, 1963 --- Subsurface exploration (augering)

JUNE 28, 1963 --- 0.02 inches of rainfall

JUNE 30, 1963 --- 0.10 inches of rainfall

JULY 1, 1963 --- 0.09 inches of rainfall

JULY 6, 1963 --- 0.26 inches of rainfall

JULY 11, 1963 --- Conditions were much the same as on June 21 with transverse cracks open to a somewhat greater extent (Figure 9).

JULY 14, 1963 --- 0.45 inches of rainfall

JULY 19, 1963 --- Trace of rainfall

JULY 20, 1963 --- 1.72 inches of rainfall

JULY 22, 1963 --- 0.42 inches of rainfall

JULY 23, 1963 --- 0.36 inches of rainfall

JULY 26, 1963 --- Trace of rainfall

JULY 27, 1963 --- 0.10 inches of rainfall

JULY 28, 1963 --- Trace of rainfall

JULY 29, 1963 --- 0.16 inches of rainfall

JULY 30, 1963 --- Trace of rainfall
Fig. 9.  Condition of Slope, July 11, 1963 (Looking North).
SUBSURFACE EXPLORATION

Evaluation of Previous Exploration Data

In late April and early May, 1962, and again in late March and April, 1963, several drill holes were sunk in the median strip and along the shoulders of the highway in the vicinity of the landslide. These holes were made with a drill rig using large quantities of water to remove the cuttings. This, of course, made identification and assignment of depths somewhat difficult. Three soil profiles -- one 56 feet left of centerline (west shoulder), one 45 to 56 feet right (east shoulder), and one at the centerline -- have been prepared and are presented in Figures 10 through 14.

From Figures 10-12 it is seen that the top 8 to 10 feet of the material in the median strip is a fine, silty sand which is highly permeable. Much of the precipitation which falls on the median will thus infiltrate into the soil, and very little will run off on the surface. The logs of the drill holes and the profiles (Figures 13 and 14) indicate the presence of an extremely wet and soft material at depths between Stations 477 and 482. The top of this soft layer ranged between 5 and 10 feet with the bottom 20 to 35 feet below the pavement. This zone appeared to exist only under the southbound lanes.

Near the west shoulder, it appears that hard shale
Fig. 10. Soil Profile, Centerline, Station 448 to Station 460 (Taken from Logs of Core Drilling, 1962-63).
Fig. 11. Soil Profile, Centerline, Station 460 to Station 477  
(Taken from Logs of Core Drilling, 1962-63).
Fig. 12. Soil Profile, Centerline, Station 477 to Station 494 (Taken from Logs of Core Drilling, 1962-63).
Fig. 13. Soil Profile, West Shoulder (56 Feet Left of Centerline) (Taken from Logs of Core Drilling, 1962-63).
Fig. 14. Soil Profile, East Shoulder (45 to 56 Feet Right of Centerline) (Taken from Logs of Core Drilling, 1962-63).
(probably undisturbed) is encountered a few feet below the pavement between Stations 483 and 487 (see Figure 13). At the centerline, this undisturbed material is again found between Stations 483 and 487 (see Figure 12) and at the east shoulder between Stations 483+50 and 486+50 (see Figure 14). This undisturbed material and that fill material on the east slope between Stations 477 and 483 may be acting as a dam and holding water in the resulting basin beneath the south-bound lanes between Stations 477 and 482.

In Figure 14, a zone of wet clay is shown at an elevation of 690 to 700 feet at Station 486+50. In Figure 12, a similar material is shown at Station 485+00 at an elevation of 700 to 710 feet. This could represent a zone of material connecting the basin to the landslide area -- which would permit the passage of water into the landslide area as the basin filled and overflowed. An additional drainage path between the basin and the slide zone may have been created in the summer of 1962 when a perforated pipe (backfilled with sand) was placed at a depth of 15 to 20 feet in the west ditch line.

The pavement was cored late in March, 1963, at several locations in the outside driving lane of the northbound lanes between Stations 485 and 490. The holes were cored dry, using no water, and reached to depths of approximately 18 inches -- just into the subgrade. The dense graded aggregate and subgrade soil removed from these holes appeared to be wet; and the next day after coring,
free water was found to be standing in these holes within 6 to 12 inches of the top of the slab. Many of the drill holes placed in the median strip in March, 1963, were also noted to have free water standing in them at depths of 2 to 9 feet below the surface on the day after drilling.

Research Explorations

Auger Methods Additional subsurface data were obtained during June and July of 1963. This information was obtained by vertical augering methods; and, since no water was used during the augering, identification of the soil material and depths to water-bearing layers was much more definite. Sufficient data were obtained to plot five soil profiles:

Line A -- 65 feet right of centerline
Line B -- 145 feet right of centerline
Line B' -- 112 feet right of centerline
Line C -- 222 feet right of centerline
Line D -- 105 feet left of centerline.

These profiles are shown in Figures 15 through 18.

It is noted in Figure 17, for example, that two extremely wet, soft layers of clay were detected. These layers are thought to be rather extensive in the vicinity of the slide. Both layers dip to the east on about 10 percent grade, and there may be a direct connection between these layers and the lower portion of the deep mucky
Fig. 15. Soil Profile, Line A (65 Feet Right of Centerline) (Taken from Logs of Auger Holes, 1963).
Fig. 16. Soil Profile, Lines B and B' (145 and 112 Feet Right of Centerline) (Taken from Logs of Auger Holes, 1963).
LANDSLIDE AREA
1-75, COVINGTON, KY.
1-75-8(6)81
RESEARCH PROJECT NO. KYHPR-63-16
SCALE: 50'-100'

Fig. 17. Soil Profile, Line C (222 Feet Right of Centerline)
(Taken from Logs of Auger Holes, 1963).
Fig. 18. Soil Profile, Line D (105 Feet Left of Centerline) (Taken from Logs of Auger Holes, 1963).
clay in the bottom of the lake which lies to the west of the highway at Station 478.

Near Station 490, in Figure 17, a 4-foot by 4-foot box culvert is located at an elevation of approximately 585 feet, just below the upper water-bearing layer. Visual inspection indicates that the culvert has sustained no structural damage, and it has been concluded, therefore, that the culvert is located in stable material. The upper wet layer shown in Figure 17 is thought to be very weak and is the zone in which movement and slippage is occurring.

The water in the two wet layers was under considerable head. At the time the auger penetrated these layers, the water would raise very quickly to as much as 20 feet above the elevation of the water-bearing layer. It should also be noted that the water contained in these layers had a very pronounced odor and felt greasy to touch. This same type of water was encountered in the mucky clay in the bottom of the lake west of Station 478.

A water-bearing layer at a high elevation is noted between Stations 488+50 and 491+00 in Figure 16. This layer is located approximately 10 feet below the surface of the slope and could possibly be the weak material in which slippage has occurred in a secondary slide within the major slide area. It should also be noted that the water in this perched layer is different from that observed in the lower water-bearing layers. The water in the upper level is clear.
and clean.

**Electrical Resistivity Method**  The resistance which a soil mass offers to the flow of an electrical current is significantly influenced by the soil moisture content. It seems reasonable, then, that areas of low resistance might be associated with areas of high moisture content.

Work has been started to develop a technique of using an electrical resistivity method to locate and trace seepage water in a landslide. For this preliminary work, a two-probe resistivity method has been used; the probes were driven to a depth of approximately one foot. One electrode is left in a fixed position while the other is moved from point to point. Readings of both current and potential are obtained for each position of the movable probe.

Figures 19 and 20 delineate areas of low resistance (high moisture content) for two locations of the fixed probes. The division between high and low resistance has been made rather arbitrarily for purposes of these figures. It is interesting to note that areas of high moisture content for the two probe positions appear to be much the same.

This approach to the problem of locating and tracing seepage water seems to offer a great deal of promise. More work is planned to develop techniques of obtaining and analyzing the data.
Fig. 19. Areas of Low Resistivity by Two-Point Electrical Resistivity Method (Station 470 to Station 485).
Fig. 20. Areas of Low Resistivity by Two-Point Electrical Resistivity Method (Station 485 to Station 500).
POSSIBLE CORRECTIVE CONSIDERATIONS

Several measures (see Figures 21 and 22) have been considered as ways to improve the stability of the unstable soil mass. It is felt that excess seepage water in certain zones of the landslide is a significant factor causing the instability. An important consideration in correcting the landslide thus involves adequate control or cutoff of the several sources of water which are thought to exist.

The first considerations involve the control of these water sources.

1. Drain the lake which lies to the west of highway near Station 478. This lake is apparently the major source of water which is causing trouble in the landslide area. There is approximately 3 feet of water standing in the lake at this time (see Figures 23 and 24). This level is controlled by a 6-inch pipe through the base of the dam. According to the logs of auger holes in the lake area, a mucky clay exists to depths of 30 to 33 feet.

2. To reduce infiltration of precipitation into the base, subgrade, and embankment, the following are recommended:
   a. Pave the median strip between Station 430 and Station 495.
Fig. 21. Possible Corrective Considerations (Station 470 to Station 483).
Fig. 22. Possible Corrective Considerations (Station 485 to Station 500).
Fig. 23. Lake West of I-75 near Station 478, July 25, 1963
(Looking South).

Fig. 24. Lake West of I-75 near Station 478, July 25, 1963
(Looking West).
b. Check and reseal the joints between Station 430 and Station 495.

3. If an attempt is made to cutoff water which may get into and move through the base, subgrade, or embankment, the following may be considered:

a. Install full-width, transverse, drainage cutoffs (skewed approximately 15° left) at:
   1) Station 468+15,
   2) Station 482+27, and
   3) Station 486+25.

These cutoffs could be trenches about 20 feet deep with two perforated pipe -- one in bottom and one at mid-depth -- placed in each. The north side of each of these ditches should be positively sealed against seepage by backfilling the northern third of the ditch with a well compacted clay. The remainder of the trench could be backfilled with sand.

b. Install drains through the shoulders between Station 430 and Station 495. These should serve to drain the dense graded aggregate base.

c. Install a series of horizontal drains (6-inch perforated pipe) on the east slope of the highway between:
1) Station 480 and 483
2) Station 491 and 493.

A group of the drains should be installed near the toe of the embankment and another group midway up the slope.

Once the water sources are controlled, the landslide area could be repaired and restored to proper cross-section, as follows:

1. Excavate the bottom portion of the embankment between Station 486+50 and Station 491+50 (see Figures 22 and 25). The excavation should extend about 5 feet into dry, firm bedrock. The excavated zone should be immediately backfilled with quarry-run stone having a maximum dimension of 2 feet. Care should be taken so as not to excavate the embankment material over lengths greater than 25 to 40 feet parallel to the centerline before backfilling is accomplished. If excavation is done over too great a length, there is danger of an additional slope failure. The rock berm (lug) replacing the embankment material will serve to stabilize the slope by adding weight to the toe of the slope and by keying into firm material. Drainage (sand blanket and perforated pipe) should be provided in the bottom of the excavation.
Fig. 25. Typical Section Showing Possible Repairs of Landslide Area.
2. Repair top portion of slide by first placing a clay blanket to reduce infiltration of precipitation and then reshaping slope with a light-weight, backfill material.

3. Repair driving lanes and shoulder.