

G.I.-30 SEPT. 1976

GEOCRES No. 30 317-101DIST. 9 REGION W.P. No. 69-76-01CONT. No. 80-41W. O. No. STR. SITE No. HWY. No. 60LOCATION Embankment Failure
West of RenfrewNo. of PAGES - =====OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:



Ministry of
Transportation and
Communications

FILE No. _____ DATE _____

REMARKS _____

Site Visit with Ron Graham
Fri. Sept. 4/81.

memorandum



To: Mr. W.E. Blum
Head, Geotechnical Section
Eastern (Kingston) Region

Date: 82 04 26

Attn: Ron Graham

From: Pavement & Foundation Design Section
Room 315, Central Bldg.
Downsview

Re: 127 Metre Waite Property Entrance Road
Sta. 20 + 608, Hwy. 60
W.P. 69-76-01, District 9, Ottawa

We have reviewed the site plans and hand auger data provided for the above-mentioned site and provide the following comments regarding the entrance road construction:

- 1) The profile grade for the entrance road should be designed to as minimum a fill height as possible. This will minimize settlements and post-construction distress, particularly in the area of the previous embankment failure.
- 2) The shallow roadway should be founded on a suitable geotextile which would act as a separator, preventing mixing of the organics and fill material, and provide some subgrade reinforcement, thereby reducing the required thickness of the roadway embankment.
- 3) Prior to placement of the geotextile, the roadway area should be prepared by close cutting of all vegetation to a maximum height of 0.15 metres without disturbance to the existing root mat.
- 4) The geotextile should consist of a nonwoven fabric of minimum 2.0 mm thickness such as:

Penroad	150
Fibertex	300
Texel	7607
Terrafix	270R

or their equivalent, depending on availability.

- 5) The geotextiles should be placed with a 1.0 metre overlap between adjacent panels and then earth fill placed directly on the geotextiles.

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- 6) Fill should be end dumped with a minimum 300 mm being kept between the truck wheels and geotextile. The aggregate can then be spread out over the geotextile and compacted in 300 mm lifts.

We trust the information provided is sufficient for your requirements, however, if further discussion is warranted, please feel free to contact this section.

A handwritten signature in dark ink, appearing to read 'Tom Kazmierowski', is written over a light blue horizontal line.

Tom Kazmierowski, P. Eng.
Foundations Engineer

TK:syc

memorandum



To: Mr. B. Blum,
Head, Geotechnical Section,
Eastern Region

Date: 81 09 30

ATTENTION: Mr. L. Ball

From: Pavement & Foundation Design Section
Room 315, Central Building

Re: Embankment Failure
Sta. 20+620 to Sta. 20+690
Highway 60, Contract No. 80-41
District 9, Ottawa

In response to your telephone request on 81 09 03, the above-mentioned site was inspected by Messrs. R. Graham and T. Kazmierowski with Messrs. L. Ball and J. Noonah in attendance on 81 09 04.

The following observations were made during the site visit:

- (i) the distressed area to the right of centreline had been regraded to elevation 118.5, approximately the same grade as the original embankment height some 1.2 metres below the proposed profile grade.
- (ii) a major tension crack, 2-5 cm in width, was visible immediately right of centreline between stations 20+630 to 20+670 with some intermittent cracks running parallel.
- (iii) a seven metre wide granular berm, approximately 1 metre high, in place only across the failed area, showed no apparent signs of distress.
- (iv) hydro poles along the toe of the berm indicated some 0.9 metres of horizontal displacement. A buried 20 cm diameter gas main immediately in front of the berm exhibited similar lateral movement.
- (v) minimal ground heave was apparent in front of the berm.
- (vi) the left portion of the embankment as constructed to profile grade, exhibited no obvious signs of distress and was carrying single lane traffic.

- (vii) no appreciable distress had occurred over the site since the last vertical movement of 80 09 02.

Background

Personal communications with Mr. J. Noonah, Project Supervisor, provided the following background information.

- Reconstruction of Highway 60 through this swamp section necessitated muskeg excavation and back-filling with native earth for widths up to +3 metres beneath the embankment widening portion on either side of the existing embankment to a maximum depth of 4 metres.

During subexcavation operations, the excavation sides for the right widening sloughed in up to the existing concrete pavement edge resulting in excavation widths up to 6 metres.

- Excavations were continuously being backfilled during this operation.
- Final granular placement was completed by 81 08 06 to a height of approximately 1 metre above original profile grade.
- The area in question exhibited an initial vertical movement immediately right of centreline in the order of 0.3 metres on 81 08 28, some three weeks after embankment reconstruction.
- On 81 08 31, the distressed area was brought back to grade.
- A second movement occurred, similar in depth and extent, on 81 09 01.
- On 81 09 02, the distressed area was again rebuilt incorporating a 7 metre wide midheight earth borrow berm.
- On the same day, a third vertical movement, in the order of 1 metre, occurred. At this time, the lateral shift of the hydro poles was noticed.

At the time of the site visit, it was recommended that the distressed area be slightly regraded to insure the integrity of the N. B. L. In addition, it was decided a detailed subsurface investigation by the Foundation Unit be carried out to ascertain soil conditions in order to provide recommendations regarding embankment redesign. Cross-sections showing original, proposed and post-failure embankment geometries plus all available soils information were requested.

Scope of Field Investigation

The fieldwork consisted of five boreholes across Sta. 20+660; 2 in the failure zone of the embankment, 1 through the bermed area, and one hole on either side of the reconstructed area beyond the limits of the failure zone. The work progressed from 81 09 09 to 81 09 16, utilizing a continuous flight auger machine mounted on a muskeg vehicle. Extensive insitu shear strength testing utilizing a field vane and collar were carried out in each borehole in addition to retrieval of disturbed and undisturbed samples.

Subsurface Conditions

In general, three distinct soil types were encountered across the site. The following brief description of these soils should be read in conjunction with the attached Record of Borehole sheets.

Beneath the embankment and berm area, fill material ranging in depth from 4.0 to 4.6 metres (elevations 115.3 to 113.8 respectively) was encountered. This fill consisted of a very loose to loose sand to silty sand with varying amounts of gravel. In addition, some zones of silty clay with sand and trace of organics were encountered under the old embankment area. In B H 1, a 20 cm layer of concrete was encountered at elevation 116.8, some 1.8 metres below the previous concrete pavement location. The limits of this fill material indicates that sloughing of muskeg excavation slopes occurred to a much greater extent (+10 metres in width) than reported.

Underlying the fill material and surficial beyond the embankment and berm limits is an extensive amorphous organic deposit containing shells and is described as a calcareous marl. The thickness of this organic deposit varies from 3.8 to 4.3 metres beneath the fill and extends for depths of 5.2 on the east side and 7.5 on the west side beyond the embankment. The depth of organics decreased from west to east across the site. Upper portions of the non-surcharged organic stratum contains fibrous peat and organic silty sands.

The consistency of the non-surcharged organic material based on insitu shear strengths measurements ranging from 15 to 25 kPa but averaging 20 kPa, is described as soft. Higher strengths as a result of long term consolidation of the organic stratum underlying the fill indicate a consistency ranging from soft to firm.

Underlying the calcareous organic stratum, and encountered at depths ranging from 5.2 to 8.8 metres (elevations 113.3 to 109.6), is a sensitive brittle marine clay (CI - CH) with occasional sand seams. The upper one metre of this deposit consists of a very soft transitional silty clay (CL - CI) with some sand. Shear strengths values were generally in excess of 40kPa for the remainder of this fissured marine clay indicating a generally firm to stiff consistency.

Groundwater levels were observed to reflect the original ground surface across the site, i. e., elevation 117.5.

Discussion and Recommendations

In consideration of the expressed urgency of providing recommendations for remedial measures and to avoid any delay to the contractor in his workings, this section has analysed for the stability of the embankment based on total stresses utilizing strength parameters obtained from insitu measurements.

The mode of failure in this case is not one of basal rotational movement but that of vertical settlement of the very loose to loose fill material and consolidation of the underlying organic stratum coupled with lateral displacement in a westerly direction of the same soft confining organic stratum.

Due to the shallow fill heights, insufficient vertical stresses are imposed on the underlying subsoils to create a rotational-type of failure resulting in the large lateral movements exhibited by the hydro line.

However, the large scale sloughing of excavation slopes resulted in severe disturbance of the soft organic stratum and probable localized undermining of the concrete pavement. Time dependent consolidation of the underlying organic material further undermined the pavement, causing it to crack and exhibit the first sudden vertical movement. Regrading of the embankment brought about the second movement as a result of immediate elastic settlements and increased lateral displacement of the organics. Pushing of the granular berm westerly out from the embankment created high horizontal stresses in the virgin organic material resulting in large lateral movements away from the embankments which were exhibited by westerly movements of both the hydro line and the gas main. The increased loading as a result of regrading of the embankment in combination with this sudden loss of confining pressure as a result of disturbance/movement of the organic stratum triggered off the third and final vertical movement.

Considering the highly disturbed nature of the underlying subsoil as a result of three previous failures and muskeg excavation operations, it is recommended that the profile grade of Highway 60 through the swampy area (Sta. 20+590 to Sta. 20+720) be lowered at least to the original profile grade (i. e., elevation 118.5 at Sta. 20+660). In addition, to prevent continuing maintenance problems and poor ride performance on the S. B. L. over the distressed area, it is recommended that the alignment be shifted easterly a minimum distance so that the edge of pavement of the S. B. L. coincides with centreline of the existing. In this manner, only shoulder maintenance will be required for continuing differential settlements expected through this area.

Alternatively, selective subexcavation and replacement with lightweight fill material (i. e., air dried slag or bottom ash) can be used to reduce the magnitude of long term consolidation settlements, however, this is a costly alternative depending on the availability of lightweight fill and will require specialized excavation techniques.

The granular berm should be removed prior to any relocation of utilities and these utilities should be relocated beyond the limits of the disturbed area. In addition, every effort should be made to minimize soil disturbance (i. e., minimum excavation widths and lengths) during relocation of the utilities.

We trust this letter summarizes the recommendations telephoned to you on 81 09 24. Should further discussion be warranted, please feel free to contact this office.



T. J. Kazmierowski, P. Eng.,
Foundations Engineer

for

M. Devata,
Senior Foundations Engineer

cc: J. W. Reid
R. W. Oddson
J. A. Noonah

SEP 22 11 18 AM '81

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KIN787

DNA

TOM KAZMIEROWSKY PAVT. AND DESIGN OFFICE 81-09-22 11:00AM

RE: CONT. 80-41 HWY 60 RENFREW W'LY

4 BOREOLES TAKEN 81-06-08 ARE AS FOLLOWS:

20 PLUS 640 4.1 RT

0-270 BR CR GR

270-530 CONC. PAVT

530-900 BR SI SA WITH GR

900-1.80 GRY SA SI

1.80-4.80 GRY SI CL (WET AND SOFT) (TR OF ORG)

20 PLUS 669 4.1 RT

0-270 BR CR GR

270-900 BR SI SA

900-2.35 GRY SI CL

2.35-4.80 BLK ORG (COMP) (TR OF MARL)

20 PLUS 695 4.0 RT

0-280 BR CR GR

280-1.20 BR SI SA (WITH GR)

1.20-2.25 GRY SI CL

2.25-4.80 BLK ORG (COMP) (TR OF MARL)

20 PLUS 718 4.0 RT

0-270 BR CR GR

270-1.05 BR SI SA

1.05-2.10 GRY SI CL (MOIST AND FIRM)

2.10-4.80 BLK ORG (COMP)

4.80-8.40 GRY SI CL (WET AND SOFT)

W.LLBALL GEOTECHNICAL SECTION KINGSTON

MM