

Memo to Mr. H. A. Tregaskes
Construction Engineer

Date : April 21, 1961

From : Materials & Research Section
(Foundations Office)

Subject : A stability Analyses Study
by D.H.O. for - W.J. 59-F-95
Cont. 59-177

Re: Embankment Failure at Earlton
District 14

We are forwarding to you our stability analyses report for the above mentioned project.

This report contains the history, description of soil conditions, details of failure, summary and conclusions, as well as drawings and photos.

We believe you will find this accumulated information self-explanatory.

L. G. Soderman,
PRINCIPAL FOUNDATION ENGR.

per:

AGS/MdeF
Attach.

c.c. : Messrs. A. M. Toye
H. D. McMillan
A. Mantle
G. K. Hunter
R. S. Chapman
E. R. Saint
A. Watt

Foundations Office
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(A. G. Stermac,
SUPERVISING FOUNDATION ENGR.)

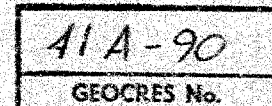


TABLE OF CONTENTS

1. INTRODUCTION
2. HISTORY :
 - 2.1) Previous Embankment Construction.
 - 2.2) 1959 Embankment Construction.
3. DESCRIPTION OF SOIL CONDITIONS:
 - 3.1) Soil Conditions at the Site.
 - 3.2) Soil Conditions in the Embankment.
4. DETAILS OF FAILURE :
 - 4.1) Mechanism of Failure.
 - 4.2) Stability Calculations.
 - 4.3) Remedial Section.
 - 4.4) Movement Check Points.
5. SUMMARY & CONCLUSIONS

FIGURES IN THE APPENDIX :

Grain Size distribution of varved clay.

Grain Size distribution of Gravel's Borrow & Fill.

DRAWINGS IN THE FOLDER :

59-F-95A -- Plan & Sections showing fill before and after failure.

59-F-95B -- Section at centre of failure and section used in Analyses.

59-F-95C -- Summary of Stability Analyses.

59-F-95D -- Revised section of fill and results of stability analyses.

59-F-95E -- Plan showing locations of movement check points

EMBANKMENT FAILURE

At

C.N.R. OVERHEAD AT EARLTON
W.J. 59-F-95 - CONTRACT 59-177
DISTRICT NO. 14.

1. INTRODUCTION :

During the night of September 9 - 10, 1959, the east approach embankment to the proposed C.N.R. overhead at Earlton failed. It had been constructed to earth grade at the time of failure and had been completed approximately one day. Failure took place over a period of about 12 hours. Prior to the failure there had been a period of heavy rain.

2. HISTORY :

2.1) Previous Embankment Construction :

An account of previous work at this site is given in the report, "Foundation Investigation, Ontario Northland Railway Overpass and Embankments, Highway 11, Earlton, Ontario", by Trow, Soderman and Associates. For convenience, this will be summarized here: About 30 years ago, an attempt was made to construct an embankment at this site. This attempt was unsuccessful and the embankment failed. This early embankment was constructed to a reported height of 26 feet using well graded granular material placed by end-dumping. After the embankment failed, the attempt was abandoned and some redistribution of the fill was carried out.

As a result of the operations at this time, a pile of material existed at the site at the time the new construction started. It was not considered necessary to remove this material and fill and operations were started on top of it.

2.2) 1959 Embankment Construction:

Embankment construction was carried out using conventional Department of Highways's practice. Compaction of the embankment materials was by means of a 15-ton grid roller. An average number of about 4 passes was made over each lift. The consensus of opinion at the site was that the embankment had been satisfactorily constructed, and this was supported by the results of the field compaction

checks which were made. The only matter which there had been any confusion over, was the compaction of the berms. No compaction of the berms was carried out at Earleton because the personnel at the site were not aware that it was necessary. Lack of compaction in the berms was not the cause of the embankment failure.

3. DESCRIPTION OF SOIL CONDITIONS:

3.1) Soil Conditions at the Site :

Soil conditions at the site are described in the report which was prepared by Trow, Soderman & Associates, and which has been mentioned above.

Three borings were put down to try and find whether it was possible to locate the slip surface. At the same time, shelly tube samples and in-situ vane shear tests were made to check the strength-depth profile. The results of in-situ vane shear tests gave confirmation of the strength-depth profile already established by Trow, Soderman. However, the results of undrained triaxial tests seemed to indicate the possibility of a lower strength in the upper layers of the varved clay than had been indicated previously. Because of this, it was decided to take a figure of 400 lb./sq. ft. for the shear strength in terms of total stress in this material. Other properties for this material were established as follows:- Unit Weight, 110 lb./cu.ft.; Average Water Content, 73%. Liquid and Plastic Limit determinations were carried out, but no average values could be used: the results are recorded in the "Summary of Field and Laboratory Tests". Examination of the samples from the shelly tubes seemed to indicate a possible location for the slip surface. This was established as being in Sample 2-14, in which much evidence of shear failures was seen. Also, the varves above this sample were seen to be dipping and those below it, to be sensibly horizontal. Logs of the three borings which were carried out, are included in the Appendix. Photograph No. 4 in the Appendix shows a section of the varved clay.

3.2) Soil Conditions in the Embankment :

A number of auger holes were made through the embankment to establish as far as possible, the distribution of fill and the depth below original ground to which the 1930 [±] fill had penetrated. The results of these borings are shown in Drawing 59-F-95B. A number of samples were taken during this investigation and particle size distributions of the 1930 [±] fill were drawn. These are shown in the Appendix.

A Proctor density test was carried out on the 1930 [±] fill and it was found that the Proctor density was 136 lb./cu.ft. This corresponded to a water content of 11%. A number of water content determinations carried out on samples taken from the fill, gave an average water content of 15.6%. This corresponds to a unit weight of 131 lb./cu.ft. The unit weight of the 1959 fill has been established by field density checks to be at least 140 lb./cu.ft.

4. DETAILS OF FAILURE :

4.1) Mechanism of Failure:

Drawing 59-F-95A shows a plan and sections of the embankment before and after failure. Photographs 1, 2 & 3, show the embankment after failure. Drawing 59-F-95B is a reconstruction of conditions at the section at the centre of the failure. Also shown on this drawing is the idealized section which was used in the analyses. Failure is thought to have occurred by the familiar cylindrical rotation, and the shape of the failure area in plan, is characteristic. Movement occurred on both sides of the fill at the same time, and the shape after failure as before, was approximately symmetrical about the centre line.

4.2) Stability Calculations:

A summary of the analyses which were carried out on the section thought to have existed at failure, is given in Drawing 59-F-95C. As will be seen, the factors of safety are around and

below one. These calculations were based on the fill having no strength and the clay in the base having a strength of 400 lb./sq. ft. As far as possible, trial circles were arranged so as to pass through the centre of the fill and the area which was found in the borings to have indications of a slip surface. Circles which did not pass through the centre line of the embankment top were discontinued at centre line and a vertical crack was assumed to the surface.

4.3) Remedial Section:

A remedial section was designed arbitrarily at the time of the failure. This section along with some of the stability calculations to check it, is shown in Drawing 59-F-95D. The section was chosen on the basis of a maximum ten-foot difference in elevation between grade and berm. This gave a section with two berms. The section was checked with a number of stability calculations, all of which gave fairly large factors of safety. As the design was obviously safe and as it had already been transmitted to the field, no refinements were made to it.

4.4) Movement Check Points:

In order to guard against a failure due to some unanticipated cause, it was decided to install a number of movement check points in the berms and in the original ground below the toe of the fill. Drawing 59-F-95E shows a detail of a check point and also the installation pattern which was proposed. As the check points were to be installed in the fall, it was thought necessary to seat them below the frost line.

Readings were taken of the positions of the movement check points during the reconstruction of the fill. No movements of significance were observed.

5. SUMMARY AND CONCLUSIONS:

Although a section had been designed for this site which would have been satisfactory under the original construction conditions, these conditions did not prevail at the time of

the new construction. Failure occurred partly because the distribution of the fill caused the base to be loaded much more severely than had been anticipated, partly because the berm design called for a berm to an elevation to which varved clay had been forced by the previous failure. There may have been other contributing causes, among them, the development of pore water pressure with an unknown distribution in silt layers below the toe of the fill.

The question of compaction in the berm has been discussed on this job. Some confusion exists as to whether material in a berm should be compacted. In fact, the material in the berm merely adds a dead weight reaction which opposes the anticipated movement. A particular stress is required. This may be produced by a compacted layer of a certain thickness or an uncompacted layer of a slightly greater thickness. It should be specified whether the designated height of berm is based on a compacted or an uncompacted density.

The lack of compaction in the berm at this site did not have a significant effect on the failure.

January 1961

REPORT PREPARED BY John Brown
Project Foundation
Engr.

REPORT APPROVED BY A.G. Stermac,
Supervising Foundation
Engr.

TELETYPE

Toronto H 0 November 3/59

12.30 p.m.

R. S. Chapman
New Liskeard

Contract 59-177, Approach Fills, Earlton Overhead

Mr. Titus and Mr. Sedgwick of Standard Paving visited the Chief Engineer's office yesterday and discussed with Mr. Clarke and myself the matter of building the above-mentioned approach fills. It was decided that the work would be discontinued this fall, but Standard Paving is to finish the work next spring and summer when the weather becomes favourable. There is the possibility that a better type of material will be used to finish the fills, but the Soils Section is to give us a recommendation on that. A. Rutka has advised me that the placing of the 4" diameter pipes could be done by his own men. Would you please advise if you would like this service performed by the soils staff.

H.M

H. A. Tregaskes

Const. Engr.

JB
CLR
DM
TS

Department of Highways
COPY
For the Information of
H. A. Tregaskes

New Liskeard

Mr. A. Rutka,
Materials & Research Section.

E. A. Fletcher,
Dist. Construction Engineer.

November 4, 1959
Contract 59-177, Approach Fill
Earlton Overhead.

During your conversation with Mr. H. Tregaskes you advised him that the installation of the 3 inch diameter pipes could be done by your forces. We would appreciate it if you would arrange to perform this service.

We have ordered these pipes made up as suggested by Mr. Brown and have so far received 20 of them from the supplier.

E. A. Fletcher,
Dist. Construction Engineer.

EAF/ds.
c.c. H. A. Tregaskes

Memo to Mr. H. Tregaskes
Construction Engineer
From A. Rutka

November 2nd, 1959

Re: Highway #11, Contract NO.
59-177
Earlton Overhead

Further to our discussion of November 2nd, 1959, I have discussed the fill material with Mr. Soderman and he agrees that it is quite suitable for embankment purposes. There is no doubt that granular type material would be preferable, although not essential.

The 4" diameter pipes which we intend to install for construction control purposes will not in any way affect the contractor's operations. One row of pipes will be installed on the original ground outside the toe of the fill slope. Another row will be installed on the first berm and still another row on the second berm. These pipes will be installed after the contractor has completed the berms and by our own forces. The contractor, therefore, need not worry about any delay resulting because of these pipe installations.

I had suspected that the failure might, in some way, cause the contractor to place a claim against the Department due to hold-ups. I therefore requested Mr. Soderman to prepare a report in this connection and I am sending you herewith a copy of this report, dated November 2nd, 1959.

You will note that the contractor had ample opportunity to work the west approach if he so desired. However, the weather was such that the contractor could not operate.

I thought you might be interested in this information for future purposes.

ar/zw
Enc.
c.c. L.G. Soderman
T.J. Kovich
E. R. Saint
File.

A. Rutka
A/Materials & Research Engr.

Memo to Mr. A. Rutka
Acting Materials and
Research Engineer.

November 2, 1959

Re: Hwy #11. Contract 59-177

From Mr. L. G. Soderman

Earlton Overhead

With reference to your memo dated Oct. 28/59, pertaining to the failure of the Earlton By-Pass East approach embankment, please find enumerated in the following paragraphs, a resume of the action carried out and recommendations made by the Foundation Section: -

1. Failure of the completed embankment section occurred during the night of Sept. 9/59 and was reported to Materials and Research Engineer, A. Rutka, Sept. 10/59.
2. Soils & Foundations Engineer, L. Soderman advised of failure Friday P.M., Sept. 11/59. K. Peaker and L. Soderman visited site Saturday and Sunday, Sept. 12th and 13th, respectively, to observe failure conditions.
3. On completion of field observations at the site, Peaker and Soderman met with R. S. Chapman, District Engineer, Sunday, Sept. 13/59. Mr. Chapman emphasized the point that any delay due to re-design of the fill section would be probable cause for claim by the contractor. Since this was to be avoided, the following instructions were given to Mr. Chapman for the express purpose of allowing the contractor to carry on with his grading operations:-
 - (a) Remedial design would involve additional fill quantities to construct heavier berm sections. A tentative minimum required berm elevation of 830.0' was suggested, for the portion of the embankment where the completed fill section was in excess of 20 feet above natural ground elevation. It was pointed out to Mr. Chapman that additional material placed within the berm section was to be spread in shallow lifts, typically 12" loose and compacted to 95% of Proctor max. dry density. This specification was not adhered to in material placed within the berms up to date of failure.
 - (b) Tension cracks, typically four feet in width and 8 feet deep developed within the berm sections in place. It was suggested to Mr. Chapman that the contractor be instructed to drain and backfill these cracks immediately.

Virtually no fill had been placed in the West approach embankment up to the time of failure of the East embankment. It was pointed out to Mr. Chapman that

3. (cont'd).....

the contractor could use his men and equipment to construct this section of the embankment if he chose to, rather than to carry on with the placement of the additional fill required for the East approach fill.

(d) Mr. Chapman was advised to keep an accurate record of weather conditions from the date of failure so that working days post failure suitable for fill placement would be recorded.

(e) Mr. Chapman was informed that a period of one week would be required for a revised safe fill section to be proven analytically.

4. Mr. K. Peaker visited the site Friday, Sept. 18 while enroute to Marathon. The revised fill section was discussed with Mr. Chapman and Mr. Fletcher, Construction Engineer. Mr. Peaker again suggested to these men that the contractor be instructed to fill the tension cracks. Mr. Peaker advised L. Soderman by 'phone' that the contractor had not carried out any fill placement in the area of the failure.

5. Project Engineer, J. Brown of the Foundation Section, arrived on site Sept. 23, and presented details of the re-designed fill section to the District personnel. Mr. Brown remained on site from Sept. 23 to Oct. 10 assisting the District forces in laying out the re-designed fill section. During this period, the contractor placed no fill on either the East or West approach embankment sections. The only work carried out by the contractor was in connection with the placement of a C.I.P. in the drainage ditch paralleling the railway centre line on the East side of the track.

Based upon the above facts, it is my conclusion that the contractor is justified in claiming delay only for the days of Sept. 12 and 13, and Saturday, Sept. 14, if this is considered to be a normal working day.

LGS/MdeF

c.c.: Files

L. G. Soderman,
PRINCIPAL SOILS & FOUNDATIONS ENGINEER.

CONT. 59-177

EARLTON

BY-PASS

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