

#60-F-47

CONT # 55-274

Hwy # 81

AU SABLE R.

BRIDGE

Mr. A. M. Toye,
Bridge Engineer.

Materials & Research Section.

July 12, 1960.

STABILITY ANALYSIS REPORT --

by- D.H.O. - W.J. 60-F-47.

Attention: Mr. S. McCombie.

Re: Au Sable River Bridge, Hwy. 81,
District 2, London, Ontario,
Cont. 55-274.

Attached to this memo, we are sending you the above mentioned report prepared and completed in our Section. The report contains an elaborate analysis of the stability of the existing structure, and also the proposals for the increase of the present factor of safety.

Since the whole problem is of quite a delicate nature, we would appreciate it if you would discuss it with us in due course. In the meantime, if there is any additional information that you require, please feel free to call on our Office.

L. G. Soderman,
PRINCIPAL FOUNDATIONS ENGR.

Per:

Attorney

(A. Stermac,
FOUNDATIONS OFFICE ENGR.)

AS/MdeF
Attach.

cc: Messrs. A. M. Toye (2)
H. A. Tregaskes
D. G. Ramsay
A. Cater
W. L. Fraser
J. Roy
Foundations Office
Gen. Files.

REPORT ON
STABILITY ANALYSIS

For

Au Sable River Bridge, Highway 81,
District 2, London, Ontario.

W.J. 60-F-47.

GENERAL:

The bridge under consideration, is located approximately 10 miles North of Strathroy and carries Highway 81 over the Au Sable River. It was constructed during the period January, 1956 to October, 1957, and is a three-span, continuous plate girder with a concrete deck. The piers and abutments are founded on 12-inch diameter Monotube piles which penetrate to a dense silt layer about 40 ft. below water level.

The soil at the site is a stiff, grey and brown, varved silty clay 40 to 60 ft. in thickness, underlain by a layer of about 3 ft. of dense silt which, in turn, is underlain by a 40-ft. layer of very dense, grey, silty fine sand. More detailed soil data are contained in the report on the site, by Geocan, Limited, dated November 20th, 1959.

Trouble was encountered in placing the structural steelwork in June, 1957, and it appeared at that time, that the South abutment had moved forward 4-1/2 to 7 inches, the exact amount being unknown. After the main girders were placed, there was apparently little or no further horizontal movement of the top of the abutment, but it was noticed that the back ends of the abutment wingwalls were settling. Between August, 1957, and March, 1958, these corners settled about 7-1/2 inches, and in March, 1958, it was found that the batter on the front of the South abutment was 11 inches greater than that designed. The batter on the front of the North abutment is 1 inch greater than designed, but no larger movements were observed at this abutment.

cont'd. /2 ...

GENERAL: (cont'd.) ...

Observations of the settlement of the wingwalls of the South abutment and the abutment, and of the distance between the South abutment and South pier, show that there has been negligible movement of the abutments and wingwalls since mid 1958. It is probable that the present stability of the bridge is maintained by compression in the girders and deck. There are concrete skirtings hiding the ends of the outside girders where they meet the abutments, so that it is not possible to determine if the end of the girder is in contact with the abutments; however, compression in the concrete beam supporting the West railing is indicated by a spalling and cracking of the concrete, resulting in exposed reinforcing where the beam meets the South abutment.

The nature of the movement of the South abutment and its wingwalls, indicate a rotational type of failure; however, there is a possibility that the rotation may be partially caused by the bridge girders being in compression and preventing movement of the top of the abutment. The rotational type of failure is further evidenced by a step in the soil on the West side of the approach embankment about 30 ft. behind the wingwall. This step, which indicates a relative movement between parts of the embankment, is not noticeable on the other side of the embankment nor on the road, but in the latter case, it would have been removed by road maintenance.

The original investigation of the site was made by the Department of Highways, in March 1955; at that time, an artesian head of about 19 feet above ground level was noted in Borehole 4, under the South pier.

Geocon, Ltd., was retained to investigate the bridge movement and they put down two boreholes in February, 1959. Details of the site and the investigation are given in their report dated November 20th, 1959. At the time of the investigation, artesian water pressures were noted in the boreholes which were through the approach fill to the abutment. Piezometers installed in these two boreholes indicated a water level from 5 to 10 feet below the surface or 30 to 35 ft. above normal river level.

cont'd. /3 ...

GENERAL: (cont'd.) ...

The conclusion from the Geoccon investigation was that the cause of the movements was: "EITHER, by overload and consequent tip deformation of the back piles at the abutment accompanied by possible movements of structurally imperfect piles at the western corner, OR: instability of the South slope of the river by high piezometric pressures within the slope." It was recommended in the report that further piezometers be installed in order to determine the water conditions within the slope more accurately.

Inspection of the piles under the South abutment by D.H.O. personnel, showed that there were no unusual features. It was therefore decided to put down further borsholes and install piezometers for a more accurate determination of water levels within the slope. Four piezometers were installed in May, 1960, in the area between the South abutment and South pier. Observations of the piezometric levels since then, indicate that there is an artesian head of about 18 ft. in the silt layer at the tip of the abutment piles and that the head decreases nearer the surface. The exact readings of piezometric levels are given in Table I.

STABILITY ANALYSIS:

A study of the stability of the South slope and abutment was carried out using the measured piezometric levels. The study consisted of assuming a rotational type of failure (see Fig. I.) the circle of which was tangent to the silt layer containing the high piezometric level. Such a circle would pass almost under the piles supporting the abutment and the weights of the abutment, pier and their loads were assumed to be carried outside the slip surface.

Analyses of this type give the factors of safety shown in Fig. I. with a minimum factor of safety of 1.02. A factor of safety this close to unity is fortuitous but does indicate that the type of analysis is a reasonable one for the case.

cont'd. /3 ...

STABILITY ANALYSIS: (cont'd.) ...

The analysis indicates that the suspected rotational type failure is probable and therefore, remedial measures may consist of: (1) increasing the shearing strength of the soil by lowering the piezometric water level, or: (2) of reducing the weight tending to cause failure. The lowering of the water table could be accomplished by the installation of filter walls which would tap the artesian head in the silt and fine sand. However, it is not possible to estimate how many wells would be required for this as the supply of the water under the artesian head and the permeability of the aquifer is unknown. The installation of one or two wells could give some indication of the number which might be required, but as the permanence of filter wells is questionable, since they may become silted up, it is better to consider more permanent methods of increasing stability. In the case of this bridge, the instability was apparently caused by the addition of the weight of the approach fill to a natural slope which had reached its stable state by geologic processes. The most logical, as well as the most practical method of stabilizing the slope, therefore, is to remove the fill which started the movement.

Calculations indicate that the lengthening of the span by 80 ft., as shown in Figure 2, and the removal of the approach fill over this length, would increase the factor of safety of the slope to a rotational type of failure by 15 to 20 percent. The increase in the factor of safety would be of the same order whether or not an intermediate pier were used between the proposed new abutment and the existing abutment. These calculations are based on the proposed abutment and pier being supported on spread footings in the stiff, grey, varved silty clay. A further increase of about 10 percent in the factor of safety of the slope would be obtained if the abutment were supported by friction piles in the clay or on longer piles penetrating to the dense, silt layer.

If two spans are used to extend this bridge, it is recommended that they be simply supported in order to accommodate any settlements which may take place.

STABILITY ANALYSIS: (cont'd.) ...

No borings have been made at the locations of the proposed abutment and possible pier in order to determine the precise soil and foundation conditions at each location. Shallow borings at each of these locations will be necessary before a final footing elevation and bearing pressure is decided. For preliminary considerations only, a bearing pressure for spread footings for both the abutment and pier of 2 tons/sq.ft. and base elevations of 688' and 683', respectively, may be assumed.

CONCLUSIONS AND RECOMMENDATIONS:

The movement of the South abutment at this site was apparently brought about by the loading of a natural slope which had achieved stability by geologic processes. A contributing factor to the movement was the high piezometric level in the dense silt and dense, fine sand underlying the abutment at a depth of approximately 50 ft.

It is recommended that the approach fill to the present South abutment be removed for a distance of at least 80 ft. and the span be lengthened the same amount. The additional span could be supported by a new South abutment and an intermediate pier, or an abutment alone. Spread footings could probably be used for the pier and abutment, but the foundation conditions would have to be determined more exactly when the proposed type of structure is known.

It is recommended that shallow borings be carried out at the location of the proposed abutment and pier in order to definitely establish foundation conditions and recommend definite elevations before final design of these foundations.

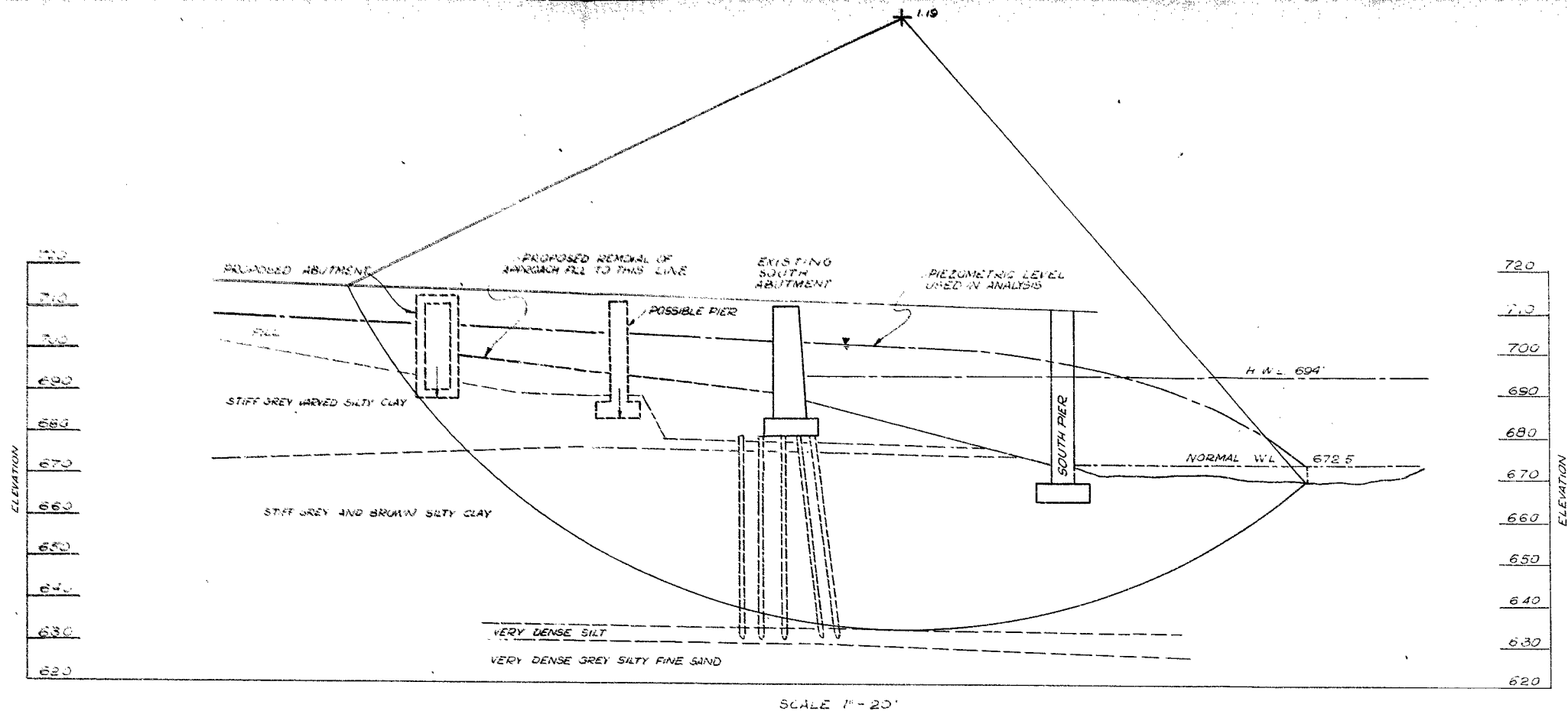
July, 1960.


F. A. DeLory,
PROJECT FOUNDATION ENGR.

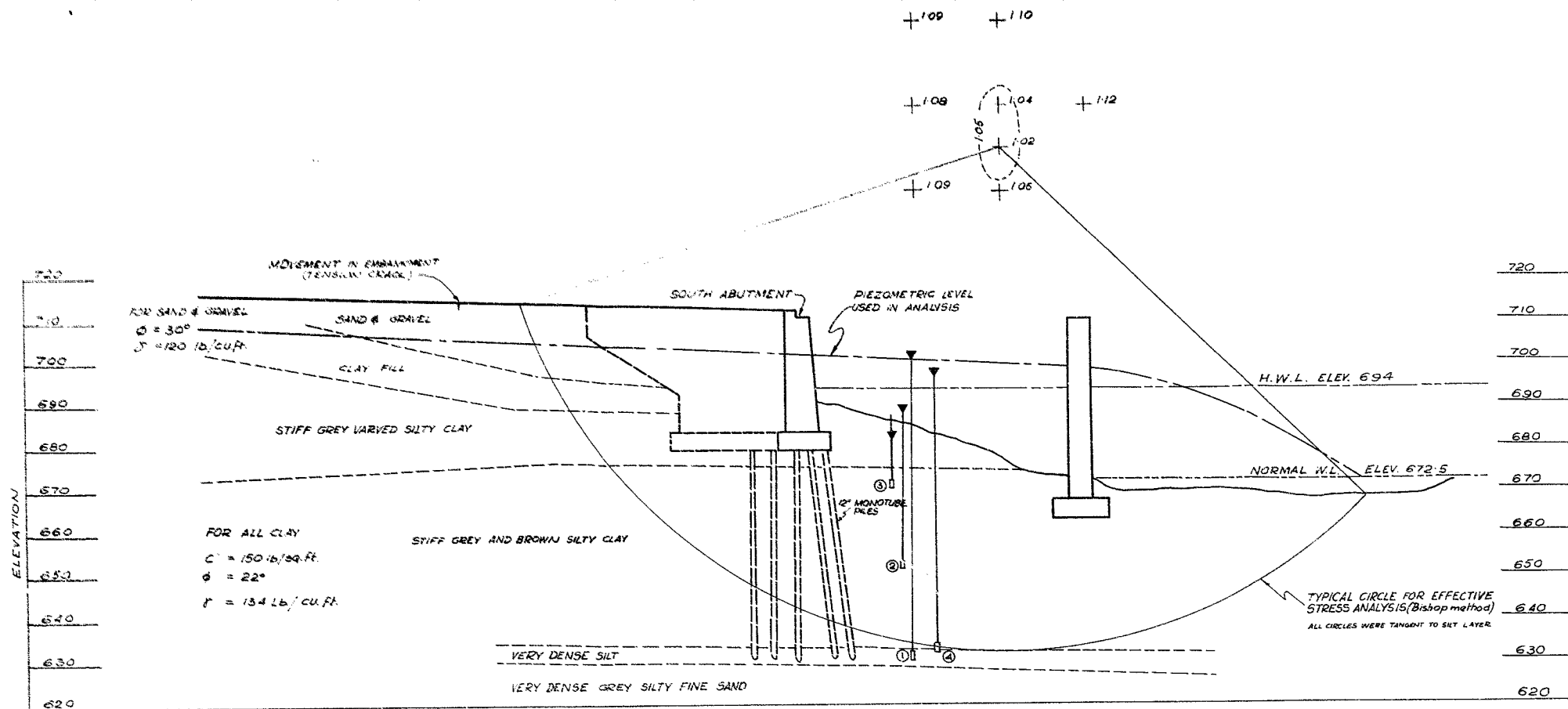
TABLE 1.

PIEZOMETER READINGS

Piezometer No.	Ground Elev. at Piez.	Piezometer Depth Ft.	PIEZOMETRIC HEAD ABOVE GROUND ELEV., FT.			
			22 May '60	27 May '60 Manometers Installed.	6 June '60	25 June '60
1	682.5	50 - 52	17.2	17.8	18.6	18.7
2	682.5	29 - 31	2.0	Over- Flowing	5.0	5.1
3	682.5	10 - 12	- 0.5	- 0.7	- 1.0	- 1.5
4	681.5	50 - 52	Not Set	9.0	12.0	15.0



FOR ANALYSIS, LOAD AT BASE OF PROPOSED
NEW ABUTMENT WAS ASSUMED TO BE 25 K/FT
OF LENGTH WHEN ADDITIONAL PIER WAS USED,
40 K/FT. WITHOUT PIER, LOAD AT BASE OF
PROPOSED PIER WAS ASSUMED TO BE 40 K/FT.



RESULTS OF
STABILITY CALCULATIONS
AUX SABLES RIVER BRIDGE
HIGHWAY 81 STA 53+00 - STA. 55+00
JOB NO 60-F-47 FIG 1.