Filed: 2021-04-19, EB-2020-0290
Exhibit L-D2-02-AMPCO-137
Attachment 114
Page 1 of 6

Ontario Hydro

OFFICIAL RECORD

NK38-CORR-21440-0445218

Memorandum To MR. M.S. HO
Supervising Design Engineer
Civil Design Department

Date March 8, 1983

Location or Dept H15-D24

File 992-NK38-21440 P

Subject Darlington G.S.
Fuelling Facilities Area Structure West
Foundation Structural Analysis

Further to your request for foundation subgrade reaction data for the above work and discussions with your Mr. W. Pratt, the accompanying note describes the subgrade conditions and contains the data from which appropriate values can be derived for the subgrade reaction.

The two-layer subgrade concept was reviewed with Mr. B. Lukajic and a thickness of 0.5 m for the surficial layer is considered reasonable. From the influence values for deflection under a unit load of 1 kN/m^2, the equivalent spring for any foundation element and load can be readily determined.

If necessary, the data can be discussed with your staff for further clarification.

F. Debidin

V357

F. Debidin
Supervising Engineer - Geotechnical Design
Geotechnical Engineering Department

FD:OJ

Attach.

cc. Messrs. J.J. Godawa/E.M. Taylor H13
J.J. Deans H15
B. Lukajic H13

COURIER TERMINAL 186D
SERIAL No. 19773

DARLINGTON G.S. - FUELLING FACILITIES AREA STRUCTURE - WEST FOUNDATION - SUBGRADE REACTION

Data on the subgrade reaction is required for the design of the foundations for the Fuelling Facilities Area Structure - West.

Civil Design advises that the maximum total load on the subgrade is about 370 kN/m^2 while the average value is around 150 kN/m^2. Also, the effects of dynamic loads are taken into account by a pseudo-static method in the analyses. The structure covers an area about 66 m by 36 m. The west side of the structure is near line 9,880 E and the south side is near line 9,992 N.

Subsurface Conditions

Excavations for the structure have removed the upper 3 to 5 m of bedrock and the foundations will be located at around elevation 83-85 m. Data on the rock subgrade is contained in the general site geology Report No. 81406 and details of the rock mass characteristics after site excavations are given in Report No. 81179.

Below the foundation grade the rock mass consists of a 3 to 4 m thick, shaly limestone zone covering an extensive stratum of limestone containing shaly interbeds. The rock is horizontally bedded and generally sound and intact. Inspection of the rock after the excavations has revealed some minor effects of the disturbance and exposure of the upper 0.5 m of the shaly limestone subgrade but the underlying material is intact and undisturbed. It may thus be assumed that the mechanical properties of the upper 0.5m of the subgrade differ from those of the strata below this zone.

Subgrade Characteristics

The stress deformation relationships are obtained from the results of plate bearing and other in-situ tests carried out in 1979 and 1980 described in detail in Research Report No. 80-484-H.

The stress level imposed by the structure is in the low range - 150 to 370 kN/m^2. The test data show the rock mass exhibits strain hardening behaviour in which the modulus of deformation increases as the level of stress increases.

The tangent modulus values at high stresses are most likely representative of the properties of the intact undisturbed rock and range between 9,000 MN/m^2 in 1979 and 6,800 to 8,100 MN/m^2 in 1980. The reduction in values is believed to have been caused by rebound or stress relief after site excavations. A value of 7,000 MN/m^2 is conservatively recommended as the modulus of deformation for application in design studies.

The data for the partly disturbed upper zone of about 0.5 m is derived from the results of plate-bearing tests with a 914 mm

diameter plate in June, 1980. The plate was subjected to loading-unloading cycles and the deflection for the loading range 0-800 kPa is given in Table 1 for the initial and three rebound loads. The modulus of deformation is estimated to range between 384 and 622 MN/m^2 with an average value of about 534 MN/m^2. It appears from these values that the Modulus of Deformation is not significantly changed by the level of previous stress on the mass. The modulus of the disturbed zone may thus be taken as 534 MN/m^2.

Application to Foundation Analysis

To summarize the above, the subgrade consists of a two-layer system as follows:

- upper layer, generally 0.5 m thick, $E = 534\ MN/m^2$
- lower layer, very thick, $E = 7{,}000\ MN/m^2$
- Poisson's ratio for both layers $= 0.3$

It is understood that the foundation will be divided into tributary areas or elements about 4 or 5 m square for the analysis. Under each element, the subgrade is considered as an equivalent spring with a stiffness K given by

$$K = \frac{Q_A}{\delta} = \frac{q_A \cdot A}{\delta}$$

where Q_A = total load on the element of size A

q_A = average unit load on the element

δ = deflection under load Q_A

The spring stiffness is thus dependent on the rigidity of the foundation, the size and shape of the loaded area, the stress distribution and elastic properties in the subgrade.
For a uniformly loaded rigid slab, the deflections will be uniform with a total value of 65×10^{-7} m for a loading of 1.0 kN/m^2 as shown in Appendix 1. This influence value can be used to determine the deflection under any element and corresponding load and hence the value of K for that element.

For a uniformly loaded flexible foundation-subgrade system, the total deflection will vary under the mat increasing from the edges towards the centre as shown in Appendix 1. A linear interpolation of the deflection for tributary areas may be sufficiently accurate. From these influence values of deflections for a unit load of 1 kN/m^2, the appropriate value of K can be derived.

The initial values of K obtained in the above methods will be the first approximation to the foundation subgrade reaction or equivalent spring. As indicated in Reference 3, the values of δ and K can be refined for the desired degree of accuracy by a sufficient number of iterative cycles.

References

Sovinc, I. - Displacement and inclinations of rigid footing resting on a limited elastic layer of uniform thickness. 7 1CSMFE - Vol. 1, pp 385

British Geotechnical Society - Settlement of structures: No. 624-15-5495

Zeevaert - Foundation Engineering on Difficult Soil, pp 234-242, 593-615

TABLE 1

(Abstract from Appendix C, Report No. 80-484-H)
Plate Diameter 0.914 m

Maximum Applied Stress Before Rebound (MPa)	Loading Range (MPa)	Deflection (mm)	Modulus of Deformation, E (MPa)
Initial, 0	0 - 0.8	0.91	574
1.7	0 - 0.8	0.94	556
3.4	0 - 0.8	1.36	384
5.1	0 - 0.8	0.84	622
	AVERAGE	1.0125	534

APPENDIX 1

Deflection under unit load 1 kN/m^2.

Rigid Foundation

1. Deflection = upper layer (one dimensional strain)

$$\partial_u = \frac{\sigma \times H}{E}$$

$\sigma = 1.0$ kN/m^2, $H = 0.5$ m, $E = 534$ MN/m^2

$$\partial_u = 9.4 \times 10^{-7} \text{ m}$$

2. Deflection - lower layer

$$\partial_L = \frac{\sigma \cdot B \cdot (1-\mu^2) \cdot (I)}{E}$$

$\sigma = 1.0$ kN/m^2, $B = 33$ m, $\mu = 0.3$, $E = 7{,}000$ MN/m^2

1 $\frac{L}{B} = 1.0$ $\frac{L}{B} = 2$, $I = 1.3$

$$\partial_L = 55.8 \times 10^{-7} \text{ m}$$

3. Total deflection per unit load of 1 kN/m^2

$$\partial = 65.2 \times 10^{-7} \text{ m}$$

Flexible Foundation

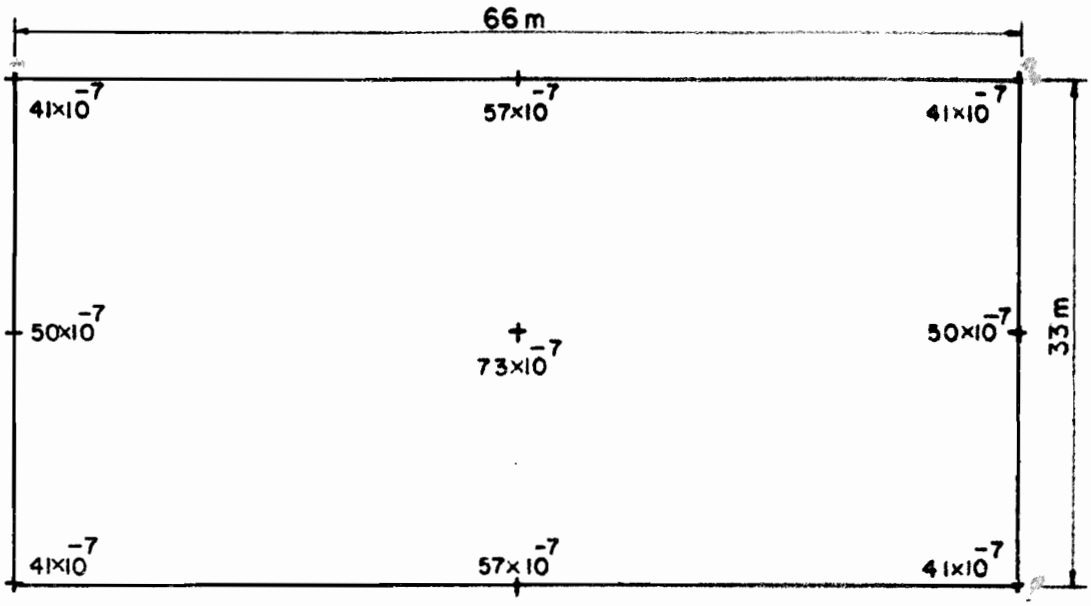
1. Deflection in upper layer = 9.4×10^{-7} m
   (as for rigid system)

2. Deflection in lower layer

$$\partial = \frac{q\ B\ (1-\mu^2)}{E}\ I$$

The value of I varies with location on the foundation.
(Terzaghi-Theoretical Soil Mechanics, pp 383)

Location	I	∂ (lower)	Total ∂
corner	0.75	32×10^{-7} m	41×10^{-7} m
mid width	0.95	41×10^{-7} m	50×10^{-7} m
mid length	1.12	48×10^{-7} m	57×10^{-7} m
centre	1.50	64×10^{-7} m	73×10^{-7} m



Influence values for deflections under load 1 kN/m^2