

G.I.-30 SEPT. 1976

GEOCRES No. 31C-132DIST. 8 REGION _____

W.P. No. _____

CONT. No. _____

W. O. No. 76-16003

STR. SITE No. _____

HWY. No. _____

LOCATION WOLFE ISLAND FERRY
BARRACK ST. FENDERS REPLACEMENTNO OF PAGES -=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. _____

REMARKS: _____

FOUNDATION
INVESTIGATION & DESIGN
REPORT

SOIL MECHANICS SECTION

ENGINEERING SERVICES BRANCH
GEOTECHNICAL OFFICE



Ontario

Ministry of
Transportation and
Communications

31 C -132
GEOCRES No.

FOUNDATION INVESTIGATION & DESIGN REPORT

W. O. 76-16003

DIST. 8

HWY. N/A

STR. SITE N/A

Wolfe Island Ferry Service
Barrack St. Fenders Replacement

DISTRIBUTION

T.C. Kingsland (2)
R.S. Pillar
C.S. Grebski
B.J. Giroux
G.A. Wrong
S. Radbone
E.R. Saint
V.A. Snell

R. Hore

J. Anderson)
R. Forest) cover only
G. Sloan)
Files J

SAMPLE DISPOSITION NOTICE		
TYPE	DISCARD AFTER	RECOMM. BY
JARS	Feb 26 1977	MD-20
TUBES	"	"
ROCK CORES	"	"

31 C -132
GEOCRES No.

GEOCRES

DATE

NOV 1977

INTRODUCTION

The five existing fender structures on the north side of the Barrack Street dock are in a deteriorated condition. The Ministry is considering to replace them.

At the request of the Structural Planning Office of the Eastern Region the Soil Mechanics Section has carried out a foundation investigation to determine the subsurface conditions at the fender locations, and to provide design recommendations.

This report contains the factual and interpreted data obtained from the recent investigation together with recommendations pertaining to the design and construction of the new fender structures. Results of two boreholes (BH 4 & 5) from our previous investigation (W.O. 72-11164) are also included here. They are denoted as BH 4A & 5A in this report.

SITE & GEOLOGY

The site is located at the mouth of the Cataraqui River, opposite the intersection of Ontario Street (Hwy. #2) and Barrack Street, in the City of Kingston.

Geologically, the site is in a physiographic region known as the Napanee Plain. Bedrock in the Kingston area is a limestone of the Trenton-Black River formation. The overburden generally consists of a post-glacial silty clay deposit overlying a thin veneer of glacial till.

EXISTING DOCK FACILITIES

The dock, measured approximately 560 ft. by 100 ft. in plan, has an asphalt deck and is enclosed by interlocking steel sheet piling of BZ 350 Section.

According to a memorandum of March 22, 1973 from the Regional Structural Planning Office, (which is included in the Appendix), the internal

structures of the dock consist of earth-rock filled timber cribs and timber pile groups. The timber cribs, each measured 25 ft. long and 20 ft. wide, are founded on the silty clay layer and located 2½ ft. behind the steel sheet piling. Condition of the cribs is not known. The 2½ ft. space between the timber cribs and the sheeting is filled with rockfill. The timber pile groups are located behind the cribs in the remainder of the dock area, and are spaced at 10-12 ft. centers. Each pile group is composed of nine 10-12 inch diameter timber piles with poor quality concrete or mortar pile cap.

The five fenders in concern are on the north side of the dock. Each fender system initially consisted of a timber block mounted on two 10 X 42 steel H sections. The steel H piles were driven into the silty clay deposit and braced against the sheeting at approximately 3.5 ft. below the dock surface. As far as foundation of the piles is concerned, it is believed there is no bearing capacity failure in the silty clay. Structurally, the fenders were in a very poor condition. Some timber members of the fenders were badly shattered and the H-piles being overstressed, deflected substantially when subjected to docking impacts. At places, warpings of the flanges were noticeable. As a remedial measure, the H-piles have been bolstered in the upper portions by means of steel buttresses supported on the dock surface and the timber blocks have been replaced by rubber tires. At present, this temporary set-up is operating satisfactorily mainly because great care has been exercised during docking operations. However, concern has been expressed that this temporary set-up may not withstand the impacts under normal docking operations.

DESCRIPTION OF FIELDWORK

A total of five boreholes were put down, one at each fender location. The borings were advanced using wash-boring techniques with NX and BX casings. Disturbed soil samples were recovered by means of a 2 inch O.D. split-spoon sampler driven in accordance with specification of Standard Penetration Test. Rockfill samples were recovered by obtaining BX size rock cores whenever possible. Locations and elevations of the boreholes were determined by personnel from this Section who supervised the field work. All samples were visually examined and identified in

the field and again in the laboratory. Subsoil conditions encountered at the boring locations are presented in the Record of Borehole Sheets and the inferred subsoil stratigraphy is shown in Dwg. No. 7616003-A. Both the log sheets and the drawing are appended to this report.

SUBSURFACE CONDITIONS

General

The recent investigation revealed that the material immediately beneath the dock surface consists of 14 to 18 ft. of fill material (upper portion: earth fill; lower portion: rockfill). This fill material is underlain by organic clay followed by silty clay to clay.

Investigation carried out in the past (ref. W.O. 72-11164) indicated that the silty clay to clay stratum is underlain by a thin layer of glacial till followed by limestone bedrock.

A description of the various soil types, from dock surface downwards, is given below:

Fill Material

Mixed Earth Fill (Upper Portion) This is the uppermost material encountered inside the dock, extending to a depth of 8 to 14 ft. below the dock surface. This material is very heterogeneous in composition, consisting of sand, gravel and ashes mixed with silty clay. Occasional timber fragments and oil contaminated material were also encountered. The 'N' values of this material vary randomly from 1 blow per foot to as high as 26 blows per foot, suggesting the earth fill may have been end dumped and not uniformly compacted.

Rockfill (Lower Portion) Under the mixed earthfill is rockfill, the thickness of which is estimated to be in the order of 2 to 7 ft. The boundary between the rockfill and the underlying organic clay is not very well defined due to displacement of the organic clay by the rockfill in the interface zone. Rock core samples revealed that the rockfill is composed of limestone boulders, but it was difficult to deter-

mine the size of the boulders. In places, timber pieces were encountered in the lower portion of the rockfill. The timber may have been used as a mat to prevent the rockfill from puncturing into the organic clay.

In order to penetrate through the rockfill portion, diamond drilling techniques using BX casing was required in our field operations.

Organic Clay

This deposit underlies the rockfill and extends to elev. 233 ± for a thickness of about 2 to 4 ft.

During the sampling operations, the split-spoon sampler sometimes sank under its own weight. In view of this, together with the very low 'N' values (less than 1 blow per foot), it can be concluded that the organic clay is very soft and highly compressible.

Silty Clay to Clay

This is the predominant deposit at the site. An earlier investigation (W.O. 72-11164) revealed that this deposit has a thickness of about 13 ft. at the fender locations and is underlain by a thin veneer of clayey silt (glacial till). The glacial till in turn is followed by limestone bedrock.

Engineering properties of this material were summarized in our foundation report (W.O. 72-11164), which indicate that this material is inorganic, has a medium to high plasticity, and contains traces of sand. Undrained shear strength of this material can be assumed as 1500 psf and adhesion with steel as 800 psf, for design purposes.

Clayey Silt with Sand & Gravel (Glacial Till)

This deposit is about 2.5 ft. thick and is of a glacial origin. It is composed of a cohesive heterogeneous mixture of clayey silt, sand and gravel. Based on the 'N' values, it can be assessed as very stiff.

Bedrock

Bedrock is a medium to thick bedded grey limestone. Bedrock surface at the fender locations varies from elev. 213 to elev. 209 approximately, dipping in an easterly direction.

Groundwater Conditions

For construction purposes, groundwater surface inside the dock can be assumed equal to the prevailing lake water level.

DISCUSSION & RECOMMENDATIONS

The Ministry is planning to replace the existing fender systems. In order to come up with an economical design, a fender scheme involving a rubber bumper mounted on an 'L' shaped concrete abutment is being considered.

As mentioned before, subsoil behind the steel bulkheads consist of 14 to 18 ft. of fill material (upper portion: earthfill, lower portion: rockfill), followed by 2 to 4 ft. of organic clay, which in turn is underlain by a deposit of silty clay to clay about 13 ft. thick. The silty clay to clay is underlain by a thin layer (2.5 ft. thick) of clayey silt with sand and gravel (glacial till), followed by limestone bedrock.

Our comments and recommendations for the supports of the abutments are as follows:

Gravity Abutments

This is the support scheme initially considered, in which the abutment is supported on a concrete block embedded in a granular fill with its base below the frost penetration zone. In this scheme, the resistance to lateral forces is derived primarily from passive earth pressure and sliding friction along the base. For design purposes, the following parameters are recommended:

Soil Bulk Density	$\gamma = 120 \text{ pcf}$
Soil Submerged Density	$\gamma' = 58 \text{ pcf}$

Coefficient of Passive earth pressure	$k_p = 3.0$
Friction between Soil & Concrete Base	$\tan \delta = 0.5$

Dimensions of the abutment and the concrete block will have to be proportioned in such a manner that the factor of safety will have a minimum of 1.5 against sliding and a minimum of 2.0 against overturning, and that the maximum bearing pressure at the underside of the concrete block resulted from dead load together with impact forces will not exceed 1.5 ksf. If necessary, a key should be used in order to have a sufficient resistance against sliding and overturning.

For this scheme to be effective, it is necessary that the concrete block be in tight contact with the surrounding granular fill so that passive earth pressure and sliding friction can be fully mobilized and that there is no excessive bending in the abutment. It is therefore important that neither washout of material nor excessive settlement should take place underneath the concrete block. To prevent washing out of material, we recommend that the backfill be composed of screened granular 'A' or crushed stones, placed to at least 2 ft. below the low water level. Longterm settlement caused by compression of the organic clay and silty clay is estimated to be in the order of 2 inches, assuming the retaining structure is purely gravity. If settlement of such magnitude is not acceptable, consideration should be given to modify the existing system incorporating the concrete block. In this case, the present steel 'H' piles and steel sheet pile wall will offer some lateral resistance and as a result of this the resistance required on the concrete block can be minimized. This will result in a reduction of dead load on the concrete block and consequently the settlement could be reduced to a tolerable limit. The suggested alternative fender system incorporating the existing H piles is illustrated in Fig. 1.

Fender System Supported on Piled Foundations

As an alternative, the concrete block can be supported on batter H piles driven to bedrock. However, the presence of rockfill within the timber cribs will pose difficulties in pile driving. This problem can be resolved by means of churn drilling techniques through the rockfill.

In our opinion, this will be a very expensive and laborious type of operation.

In order to key the piles into bedrock to provide sufficient lateral resistance, pile tips should be fitted with Oslo points. Such piles with Oslo points should be driven in a controlled manner as described in MTC Supplementary Specification Section 903 S.

Caisson Foundation

Consideration should also be given to supporting the fenders on steel piles embedded in concrete filled augered caissons. In this scheme, the caissons should be located in front of the sheet pile cofferdam and extended into bedrock of a sufficient depth. It is understood in the lake bottom where caissons are to be constructed rockfill was dumped during the renovation of the docking facilities. It is therefore essential that this rockfill be completely removed prior to the respective caisson installation.

For design purposes, the following recommendations are given.

Passive earth pressure in the silty clay

$$P_h \text{ (psf)} = 60z + 3000 \text{ (psf)}$$

z = distance below dredge line in feet

Safe compressive stress in limestone

$$P_h \text{ (ksf)} = 30 \text{ ksf}$$

Depth of the caisson should be determined from its safety with respect to overturning, for which a factor of safety of at least 2 is required. Diameter of the caisson should be 36 in. or greater so that the steel piles can be accommodated. The caisson should be reinforced in the upper portion and have a permanent liner the thickness of which should be determined from the structural strength requirement of the caisson. Caisson cutoff should be sufficiently below the keel of the ferry boat. For installation of the caisson under water, tremie concrete technique will be required.

MISCELLANEOUS

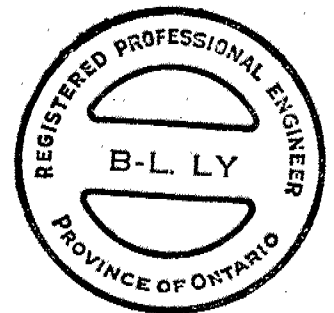
The recent fieldwork was carried out from August 4 to August 9, 1976 under the supervision of Mr. S. Maloney, Student Technician.

The drilling equipment was owned and operated by F.E. Johnston Drilling Company, Ottawa.

This report was prepared by Mr. B. Ly and reviewed by Mr. M. Devata, Supervising Engineer.

B. Ly

B. Ly, P. Eng.
Senior Engineer



M. Devata

M. Devata, P. Eng.
Supervising Engineer

BL/bp
October, 1976

APPENDIX

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 1

WO 76-16003 LOCATION Sta. 2+11.5 ; 6.5' Rt. of Edge of Dock ORIGINATED BY SM
DIST 8 HWY N/A BORING DATE August 4, 1976 COMPILED BY SM
DATUM Geodetic BOREHOLE TYPE Washboring BX Rock Coring CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES		20	40	60	80	100	W_P	W	W_L		
250.1	Dock Surface					250										GR SA SI CL
0.0	6" Asphalt															
	Fill - gravel & sand, some silty clay.		1	SS	7											
			2	SS	7											
	Firm to Very Stiff		3	SS	26											
243.1			4	SS	8											
7.0	Timbers, some gravel, sand & silty clay. Cavities throughout.		5	SS	10											
			6	SS	9	240										
237.6	Loose		7	SS	6	10"										
12.5	Rock Fill															
	some silt		8	SS	54											
233.3			9	BX-RC	-											
16.8	Organic clay															
231.3	Very Soft		10	SS	3	26"										
18.8	Silty Clay		11	SS	16	230										
	Very Stiff to Hard															
227.1			12	SS	37											
23.0	End of Borehole															

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 2

WO 76-16003 LOCATION Sta. 1 + 73.5, 5' Rt. of Edge of Dock ORIGINATED BY SM
DIST 8 HWY N/A BORING DATE August 5, 1976 COMPILED BY SM
DATUM Geodetic BOREHOLE TYPE Washboring, BX Rock Coring CHECKED BY *JP*

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	W_P	W	W_L		
250.1	Dock Surface					250										GR SA SI CL
0.0	6" Asphalt															
	Fill - gravel & sand, some silty clay.		1	SS	5											
	Firm to Very Stiff		2	SS	29											
243.1			3	SS	11											
7.0	Sand, silt, silt and some burnt wood chips				1											
	Cavities throughout		4	SS	5	240										
	Loose		5	SS	7											
235.3			6	SS	8	4"										
14.8	Rock Fill		7	RC	-											
234.0	Organic Clay															
16.1	Very Soft															
230.1	Silty clay		8	SS	13	230										
20.0	Stiff to Very Stiff		9	SS	21											
226.6																
23.5	End of Borehole															

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 3

WO 76-16003 LOCATION Sta. 1 + 36.5; 5' Rt. of Edge of Dock ORIGINATED BY SM
DIST 8 HWY n/a BORING DATE August 5 & 6, 1976 COMPILED BY SM
DATUM Geodetic BOREHOLE TYPE Washboring CHECKED BY GP

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	w_p	w	w_L		
250.1	Dock Surface					250										
0.0	6" Asphalt		1	SS	6											
	Fill - gravel & sand, some silty clay.		2	SS	3											
			3	SS	13											
241.4	Soft to Hard		4	SS	33	3"										
8.7	Rock fill		5	SS	40	4"										
	some sand & gravel															
232.6	some timber		6	SS	6											
17.5	Organic clay				1											
230.1	Very Soft		7	SS	1											
20.0	Silty Clay					230										
	Stiff to Hard		8	SS	31											
224.7			9	SS	14											
25.4	End of Borehole															

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 4

WO 76-16003 LOCATION Sta. 1 + 00.5; 5' Rt. of Edge of Dock ORIGINATED BY SM
 DIST 8 HWY N/A BORING DATE August 6 & 9, 1976 COMPILED BY SM
 DATUM Geodetic BOREHOLE TYPE Washboring CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20 40 60 80 100					w_p w w_L				
							SHEAR STRENGTH					WATER CONTENT %				
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE									
250.1	Dock Surface					250										
0.0	6" Asphalt		1	SS	6											
	Fill - gravel & sand, some silty clay.		2	SS	20											
			3	SS	12											
	Firm to Stiff		4	SS	13	240										
240.1			5	SS	8											
10.0	Rock Fill - some gravel and sand.		6	SS	33											
	Timber at bottom.															
235.4																
14.7	Organic Clay															
	Very Soft															
231.3			7	SS	25	230										
18.8																
	Silty Clay		8	SS	39											
	Very Stiff to Hard		9	SS	17											
220.1			10	SS	17											
30.0	End of Borehole															

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 5

WO 76-16003 LOCATION Sta. 0 + 68.5; 6.5' Rt. of Edge of Dock ORIGINATED BY SM
DIST 8 HWY N/A BORING DATE August 9, 1976 COMPILED BY SM
DATUM Geodetic BOREHOLE TYPE Washboring CHECKED BY *EP*

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W			UNIT WEIGHT γ	REMARKS % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	W_P	W	W_L		
250.1	Dock Surface					250										
0.0	6" Asphalt															
	Fill - gravel & sand, some silty clay.															
	Firm to Stiff		1	SS	8											
			2	SS	15											
			3	SS	9	240										
238.1																
12.0	Rock Fill - some sand trace of gravel.															
236.1	Timber at bottom		4	SS	53											
14.0	Organic Clay															
	Very Soft		5	SS	1											
232.1																
18.0	Silty Clay		6	SS	22	230										
	Very Stiff															
227.1			7	SS	19											
23.0	End of Borehole															

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 4 A (Formerly BH#4 W.O.72-11164)

WO 76-16003 LOCATION Sta. 2 + 45 o/s 2.0' Lt. of Edge of Dock ORIGINATED BY CP
DIST 8 HWY N/A BORING DATE February 15 & 16, 1973 COMPILED BY JB
DATUM Geodetic BOREHOLE TYPE Washboring and Cone Test CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W			UNIT WEIGHT γ PCF	REMARKS % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	W_P	W	W_L		
248.7	River Level															
0.0																
	WATER					240										
						230										
225.7																
23.0	Silty clay to clay with traces of sand.		1	SS	15											
	Grey		2	TW	PH	220										
	Stiff to Hard		3	TW	PH											
210.7																
38.0	Clayey silt with traces of sand & gravel (Glacial Fill)		4	TW	PH	210										
208.2	Limestone Bedrock															
40.5	End of Borehole															

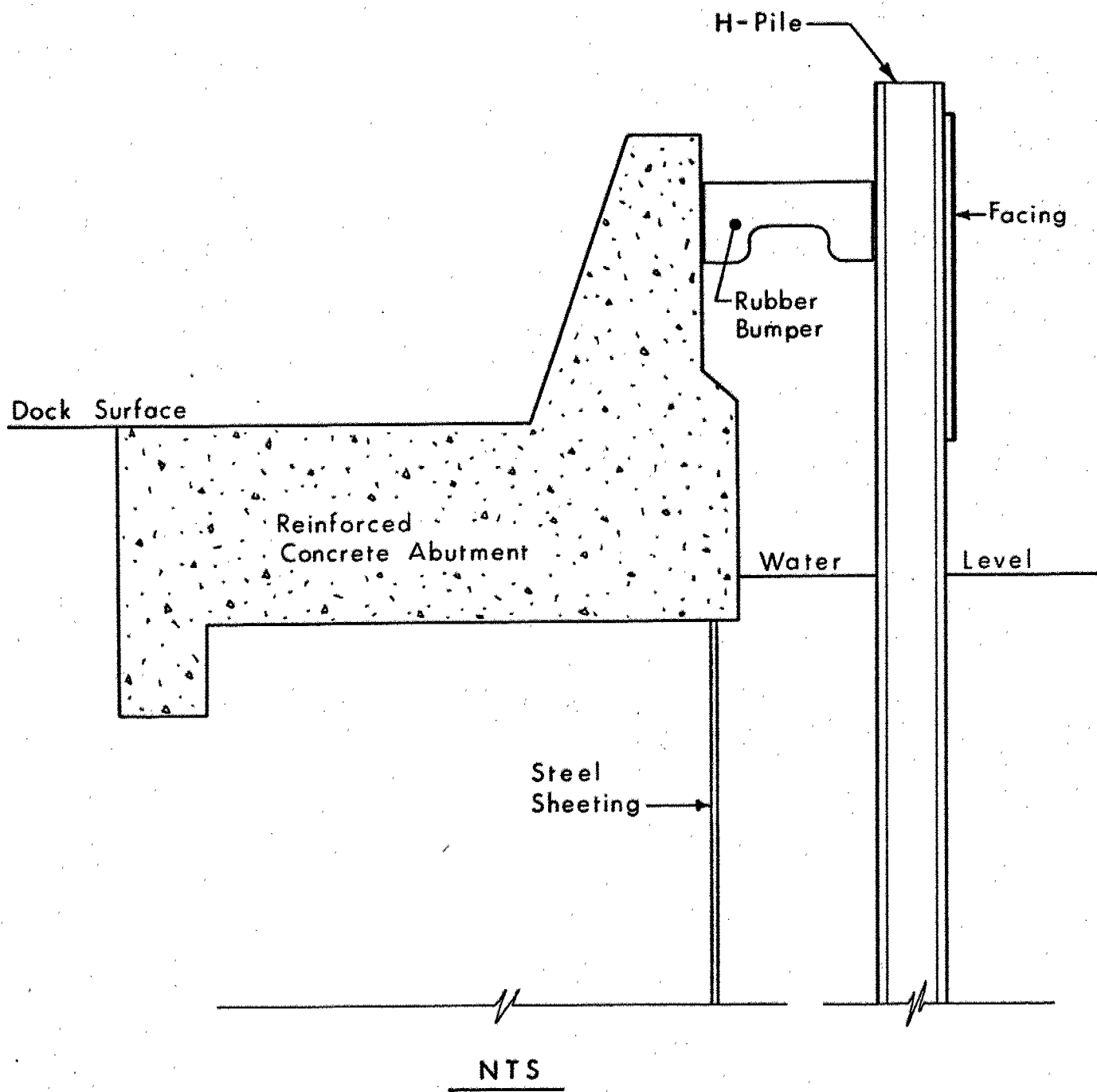
20
15 5 % STRAIN AT FAILURE
10

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 5A (formerly BH#5 W.O.72-11164)

WO 76-16003 LOCATION Sta. 0+07.0 o/s 2.0' Lt. of Edge of Dock ORIGINATED BY CP
DIST 8 HWY N/A BORING DATE February 13-14 & 16, 1973 COMPILED BY JB
DATUM Geodetic BOREHOLE TYPE Washboring, Cone Test and BXL Rock Core CHECKED BY *JP*

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES		20	40	60	80	100	w_p	w	w_L		
248.7	River Level															
0.0																
	WATER															
						240										
						230										
226.7	Silty clay to clay with traces of sand. Grey		1	SS	4											
22.0	Stiff to Very Stiff		2	SS	33											0 1 65 34
			3	SS	23	220										
215.7																
33.0	Clayey silt with traces of sand & grav (Glacial Till)		4	SS	15/3"											3 12 62 23
213.1																
35.6	Bedrock Limestone Grey		5	RC BXL	80%											
	Sound		6	RC BXL	95%	210										
207.1																
41.6	End of Borehole															



PROPOSED FENDER SUPPORT SYSTEM

22 March 1973

EX C.S.L. DOCK - KINGSTON

DETAILS OF CONSTRUCTION

- From the end face of the dock to approximately 2-1/2 ft. behind the sheet piles forming the face there is a layer of rock fill.
- From 2'-6" behind the face of the dock for approximately 25 ft. rock filled crib (plan dimensions 25' x 20').
- For the next 25 ft. 10"-12" dia. timber piles in groups of 9 with poor quality concrete or mortar pile caps 5 ft. square. The groups of piles are at 10'-12' centres.
- From approximately 35 ft. from the northwest end of the building there would appear to be more groups of piles similarly spaced.
- Tops of the pile heads carry beams of concrete or steel, or perhaps timber in places. A few feet below the tops of the piles transverse timbers or walings carry deck timbers spanning between the pile groups, and these decking timbers carry fill. Thus, below the surface of the dock it can be assumed that there are a few feet of fill supported by timber of unknown condition, with voids and water beneath. It is understood that there is a longitudinal drainage system contained within the fill extending from the dock building to a storm sewer in Ontario Street. There are also electrical and possibly other services following the same route.

.....2

- The dock building is supported on a solid concrete plinth or a concrete edge beam. The plinth possibly forms a capping to groups of piles supporting the structure so that if the entire building were removed to top of dock elevation, this may expose the piles and the entire area may have to be resurfaced in some way, e.g., with a reinforced concrete slab. It is thought that the dozen or so groups of piles near the southeast end of the dock building were used originally to support an elevator structure.

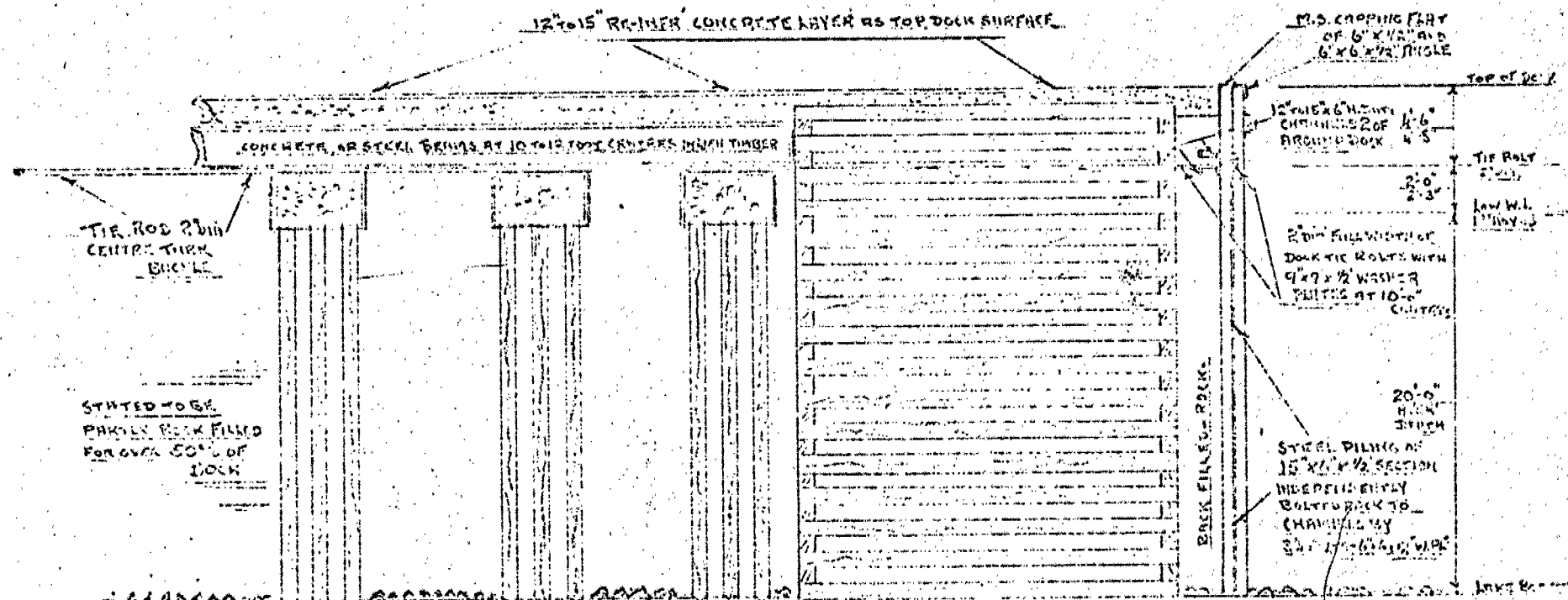
In summary, it would appear that the dock consists of several different forms of construction, built at different times.

The report by McNamara suggests that the dock surface is capable of carrying vehicles up to light trucks in loading. Presumably the portion of the dock required for off-loading and storage will have to be further investigated to assess its capability for carrying the heavy truck traffic which will make up part of the ferry loading.

T. C. Kingsland

TCK/hl

EX. C.S.L. DOCK-KINGSTON, ONT.



CLUSTERS OF NINE 10x12 TIMBER PILES WITH
CONCRETE 5'x5' HEADS AT 10'-0" TO 12'-0" CENTRES

SUNK ON LAKE BOTTOM ROCK FILLED

CRS 25'-0" X 20'-0" WIDTH

HALF SECTION OF EX. C.S.L. DOCK, KINGSTON, ONTARIO - 50'-0"
BASED ON INFORMATION MADE AVAILABLE

PREPARED FOR -
VICKI WILSON CONSTRUCTION
LIMITED

BY -
G.L. BRADY, P.E.
MAY 1978
S.M. 1016-2/78

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

PENETRATION RESISTANCE

'N' STANDARD PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES

DYNAMIC PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

<u>CONSISTENCY</u>	<u>c LB./SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 250	VERY LOOSE	0 - 4
SOFT	250 - 500	LOOSE	4 - 10
FIRM	500 - 1000	COMPACT	10 - 30
STIFF	1000 - 2000	DENSE	30 - 50
VERY STIFF	2000 - 4000	VERY DENSE	> 50
HARD	> 4000		

TERMS TO BE USED IN DESCRIBING SOILS:-

TRACE < 10 % , SOME 10-25 % , WITH 25-40 % , > 40 % SILTY, SANDY, GRAVELLY, CLAYEY ETC

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.T.	SLOTTED TUBE SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

U	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL	F.V.	FIELD VANE
CIU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
CID	" " DRAINED "	S	SENSITIVITY
CAU	" ANISOTROPIC UNDRAINED "		
CAD	" " DRAINED "		

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_p	PLASTIC LIMIT
I_p	PLASTICITY INDEX
w_s	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_c	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \log_{10} \sigma}$
T_v	TIME FACTOR = $\frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e \sigma$ OR $\ln \sigma$	NATURAL LOGARITHM OF σ
$\log_{10} \sigma$ OR $\log \sigma$	LOGARITHM OF σ TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
$\bar{\sigma}$	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

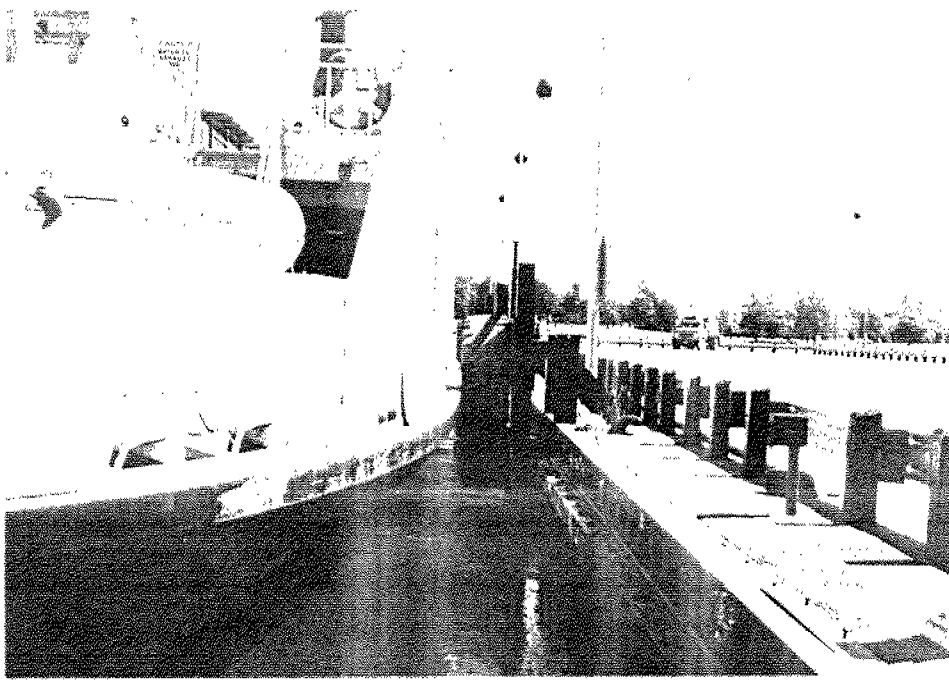
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

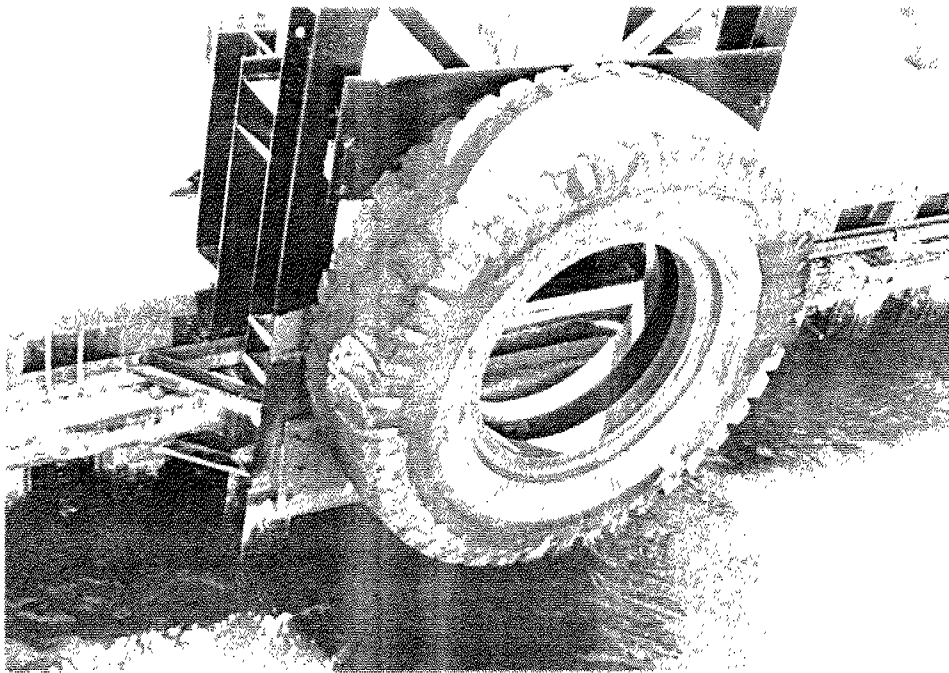
B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

SLOPES

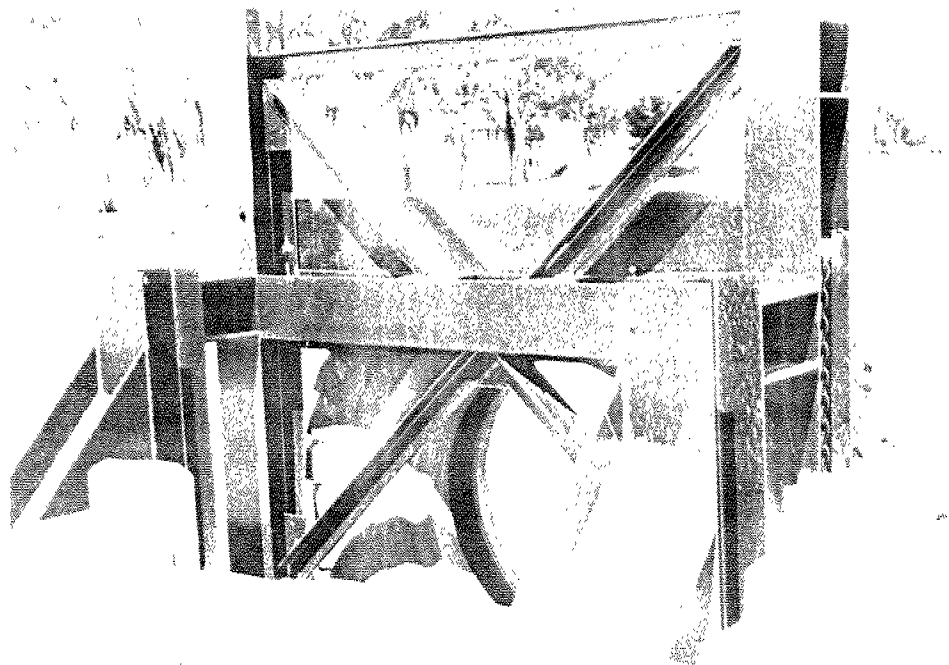
H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL



BARRACK ST
DOCK



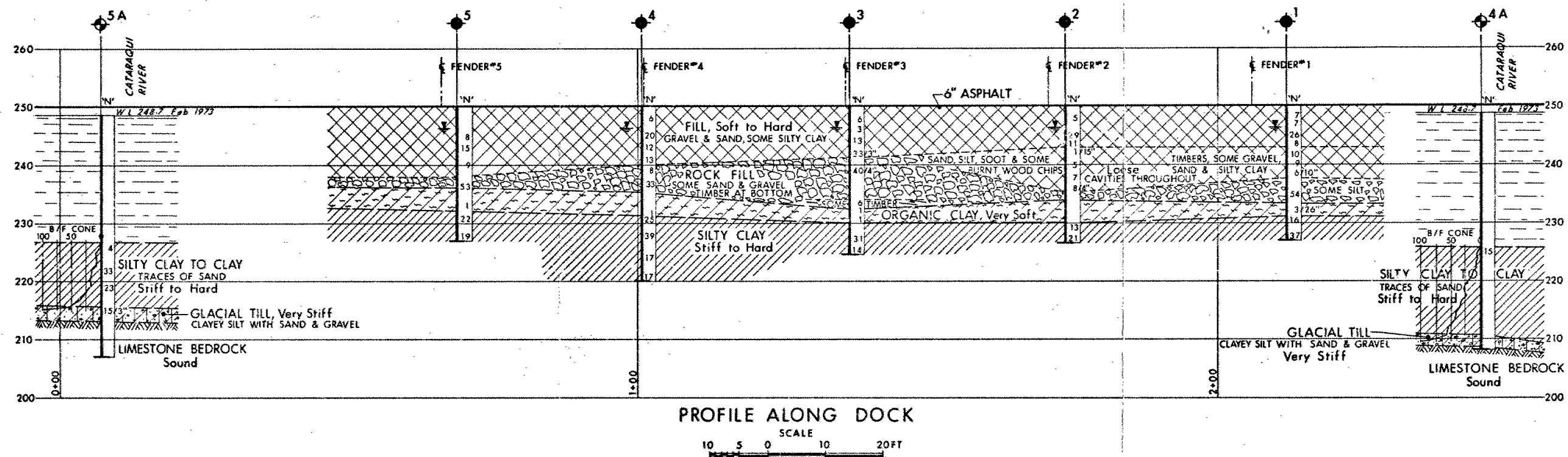
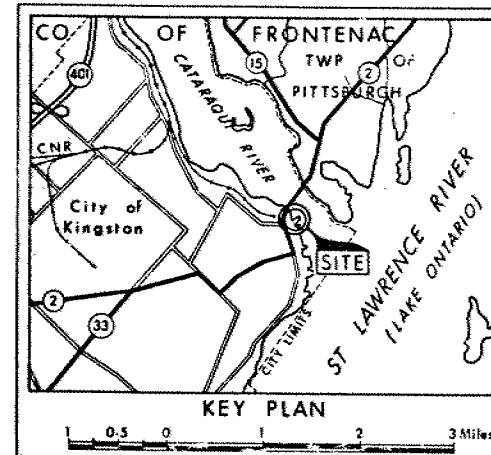
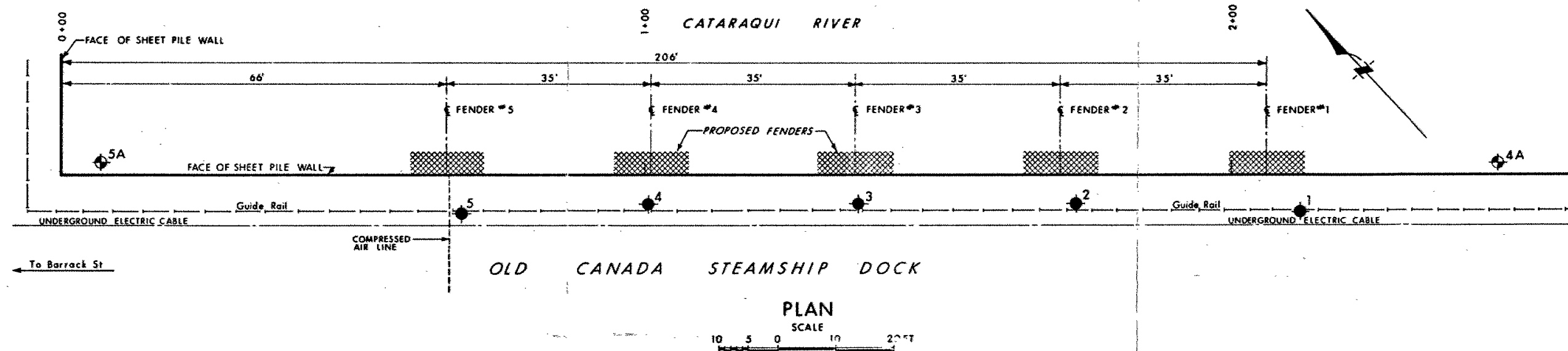
FRONT VIEW
OF FENDER




BACK VIEW
OF FENDER

WO 76-16003


08-MT-308 10-75
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO




LEGEND



Bore Hole



Dynamic Cone Penetration Test (Cone)



Bore Hole & Cone

N' Blows/ft (Std Pen Test 350ft lbs energy)

CONE Blows/ft (60° Cone, 350ft lbs energy)

↓ WL at time of investigation Aug 1976

Bore Holes 4A & 5A were done
Feb 1973 (WO 72-11164)

No	ELEVATION	STATION	OFFSET EDGE OF DOCK
1	250.1	2+11.5	6.5' RT
2	250.1	1+73.5	5.0' RT
3	250.1	1+36.5	5.0' RT
4	250.1	1+00.5	5.0' RT
5	250.1	0+68.5	5.5' RT
4A	248.7	2+45.0	2.0' LT
5A	248.7	0+07.0	2.0' LT

NOTE:
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.



REVISIONS	DATE	BY	DESCRIPTION

HWY No

SLM/D/BL

DRAWN

CHECKED

DATE

Oct 29, 1976

APPROVED

DWG 7616003-A

DIST 8

SITE



Memorandum

To: Mr. M. Devata,
Supervising Engineer,
Soils Mechanics Office,
Downsview, Ont.

From: Structural Planning Office,
Kingston, Ont.

Attention:

Date: July 9th, 1976.

Our File Ref.

In Reply to

Subject: RE: Wolfe Island Ferry Service,
W.O. 76-16-003,
Barrack St. Fenders Replacement,
DISTRICT # 8-KINGSTON

Further to our previous discussions, I confirm our request for your opinion as to the allowable bearing pressures, etc. at the locations of the abutments for the revised dock fenders at the above site. The design of these is being prepared by Mr. K. Bassi, Structural Office.

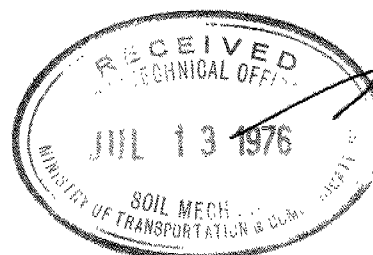
The new fender abutments will be located as shown on the enclosed copy of a drawing, showing the Structural Office Preliminary Proposals. I am enclosing also copies of three old Dock Drawings and a Report by the writer, dated March 22nd, 1973. These give an indication of the various types of construction which make up the dock. However, other types of construction may be encountered during your investigation. It is known for example, that when parts of the internal structure have collapsed in the past, the resulting voids have been filled with various materials.

It will evidently be necessary to investigate each fender location separately by whatever methods you consider to be appropriate.

TCK/pab
Att'd.

T.C. Kingsland
Regional Structural Planning Engineer.

c.c. C.S. Grebski-Att; K. Bassi
V.A. Snell- Att: J. Reid



22 March 1973

EX C.S.L. DOCK - KINGSTON

DETAILS OF CONSTRUCTION

- From the end face of the dock to approximately 2-1/2 ft. behind the sheet piles forming the face there is a layer of rock fill.
- From 2'-6" behind the face of the dock for approximately 25 ft. rock filled crib (plan dimensions 25' x 20').
- For the next 25 ft. 10"-12" dia. timber piles in groups of 9 with poor quality concrete or mortar pile caps 5 ft. square. The groups of piles are at 10'-12' centres.
- From approximately 35 ft. from the northwest end of the building there would appear to be more groups of piles similarly spaced.
- Tops of the pile heads carry beams of concrete or steel, or perhaps timber in places. A few feet below the tops of the piles transverse timbers or walings carry deck timbers spanning between the pile groups, and these decking timbers carry fill. Thus, below the surface of the dock it can be assumed that there are a few feet of fill supported by timber of unknown condition, with voids and water beneath. It is understood that there is a longitudinal drainage system contained within the fill extending from the dock building to a storm sewer in Ontario Street. There are also electrical and possibly other services following the same route.

- The dock building is supported on a solid concrete plinth or a concrete edge beam. The plinth possibly forms a capping to groups of piles supporting the structure so that if the entire building were removed to top of dock elevation, this may expose the piles and the entire area may have to be resurfaced in some way, e.g., with a reinforced concrete slab. It is thought that the dozen or so groups of piles near the southeast end of the dock building were used originally to support an elevator structure.

In summary, it would appear that the dock consists of several different forms of construction, built at different times.

The report by McNamara suggests that the dock surface is capable of carrying vehicles up to light trucks in loading. Presumably the portion of the dock required for off-loading and storage will have to be further investigated to assess its capability for carrying the heavy truck traffic which will make up part of the ferry loading.

T. C. Kingsland

TCK/hl

TO BARRACK ST.

#5

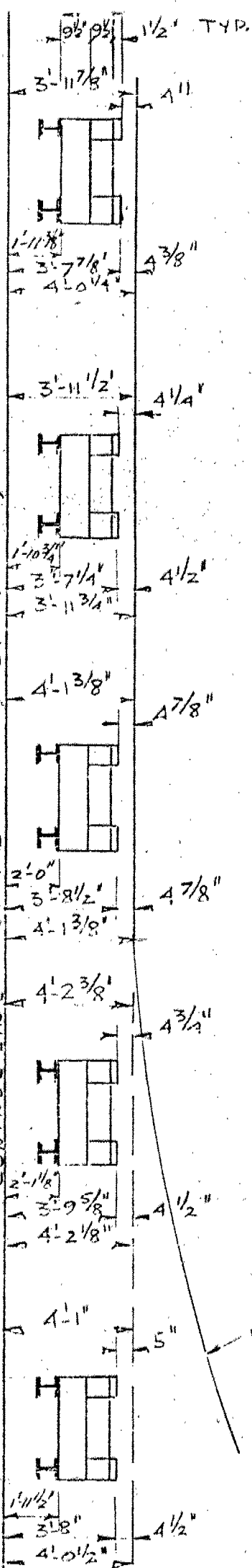
#4

#3

#2

#1

FACE OF SHEET PILES
CONTROL LINE



BARRACK STREET DOCKS

N. T. S.

END OF DOCK

EX: C.S.L. DOCK-KINGSTON, ONT.

12"x15" REINER CONCRETE LAYER AS TOP DOCK SURFACE

CONCRETE OR STEEL BEAMS AT 10' TO 12' CENTRES WHEN TIMBER

TIE ROD 2" dia
CENTRE TURN
BOLT

STARTED WORK
PARTIAL BEAM FILLED
FOR OVER 50% OF
DOCK

M.S. CAPPING PLATE
OF 6" x 12" AND
6" x 6" x 1/2" ANGLE

12" x 15" x 1/2" MASONRY
CHIMNEY 2 OF 4-6
AROUND DOCK

2" dia FULL VERTICAL
DOCK TIE BOLTS WITH
4" x 7" x 1/2" WASHERS
PLATES AT 10' - 12'
CENTRES

20'-0"
DEPTH

STEEL PILING OF
15" x 1/2" x 1/2" SECTION
UNDERLIES DOCK TO
BOLTS TO ROCK BY
CHARMILLAN BY
3/4" x 1/2" x 1/2" PLATE

BACK FILLER - ROCK

CLUSTERS OF NINE 10" x 12" TIMBER PILLS WITH

SUNDS ON LOSE BOTTOM ROCK FILLER

CONCRETE 5'0" SQUARES AT 10' TO 12' CENTRES - 12' x 12' x 12'

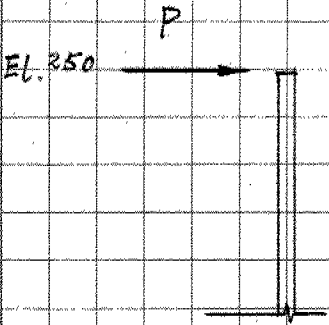
12' x 12' x 12'

HALE SECTION OF EX: C.S.L. DOCK, KINGSTON ONTARIO - 50'-0"
BASED ON INFORMATION FROM HYDROGRAPHIC

PREPARED FOR -
VICKI MASON, CONSTRUCTION
LIMITED

BY

G.L. GERRARD, O.E.
P.O. # 10-19-1967
SHELL, 10-19-1967



Design strength of Limestone

$$\sigma'_c = 0.45 \sigma_c$$

Crushing strength of Limestone

$$\sigma_c = 4.5 \text{ ksi}$$

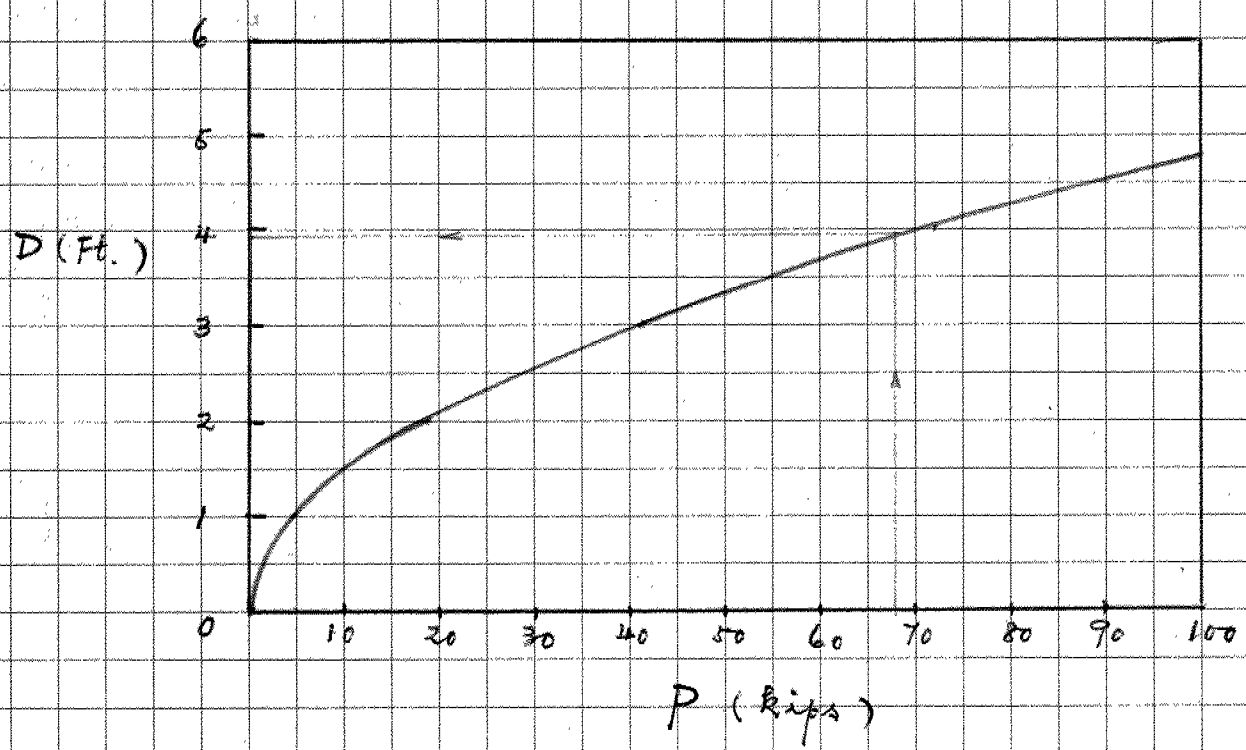
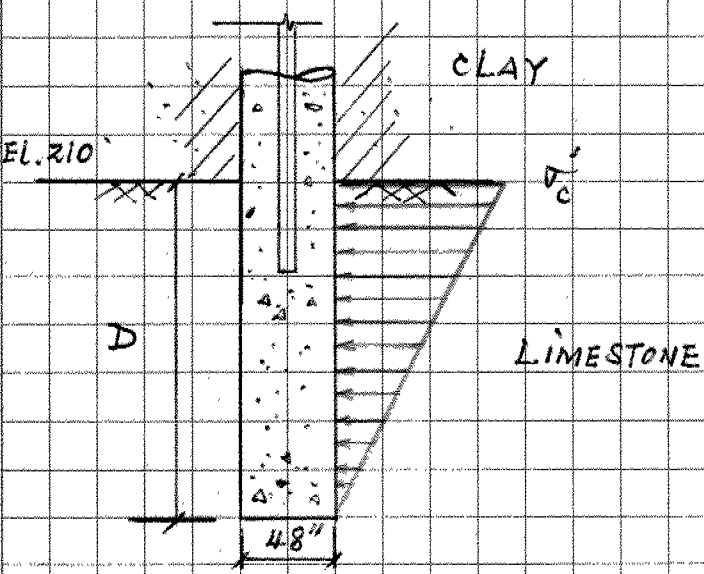
$$\therefore \sigma'_c = 2 \text{ ksi}$$

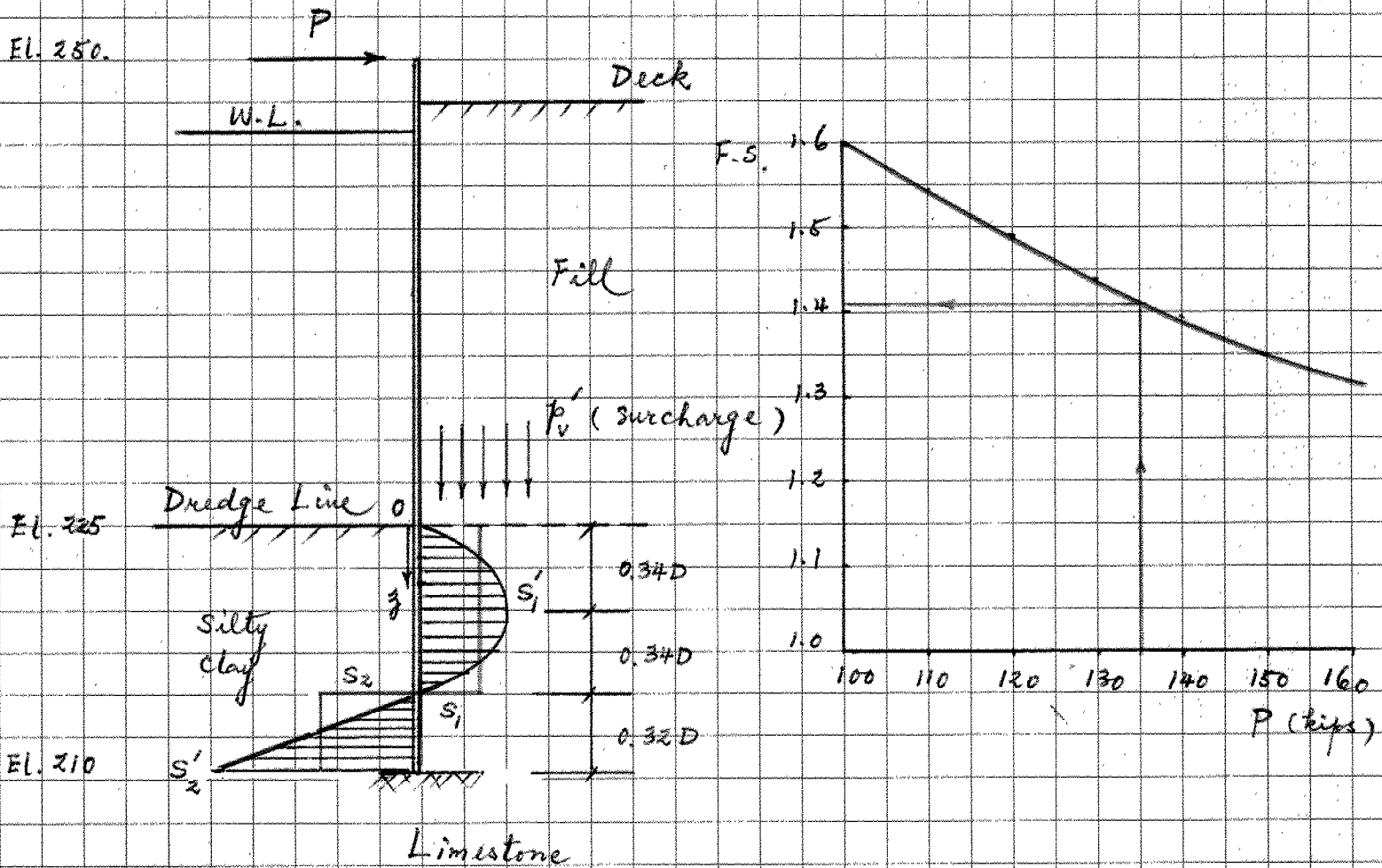
Design Against Overturning

$$\frac{\frac{1}{2} \times \sigma'_c \times 4 \times D \times \frac{2D}{3} \times 144}{P \times (40 + \frac{2D}{3})} = 2.0$$

Or

$$P = \frac{576 D^2}{120 + 2D}$$





$$p_v' = 1300 \text{ psf}$$

$$p_R = 1300 + 60 \times 3 + 2 \times 1500 = 4300 + 60 \times 3$$

$$S_1' = 4300 + 60 \times 0.34 D = 4300 + 60 \times 0.34 \times 15 = 4606 \text{ psf}$$

$$S_1 = \frac{2}{3} S_1' = 3071$$

$$S_2' = 4300 + 60 \times D = 4300 + 60 \times 15 = 5200 \text{ psf}$$

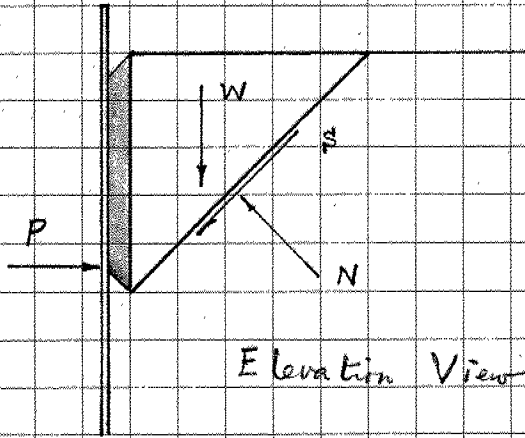
$$S_2 = \frac{1}{2} S_2' = 2600$$

Against Sliding.

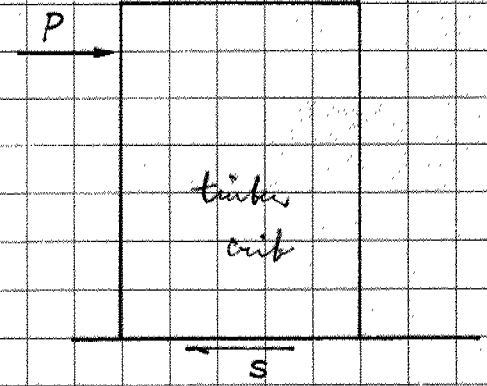
$$F.S. = \frac{3071 \times 14 \times 0.68 \times 15}{2600 \times 14 \times 0.32 \times 15 + P} = \frac{438.5}{174.7 + P}$$

(a)

(b)



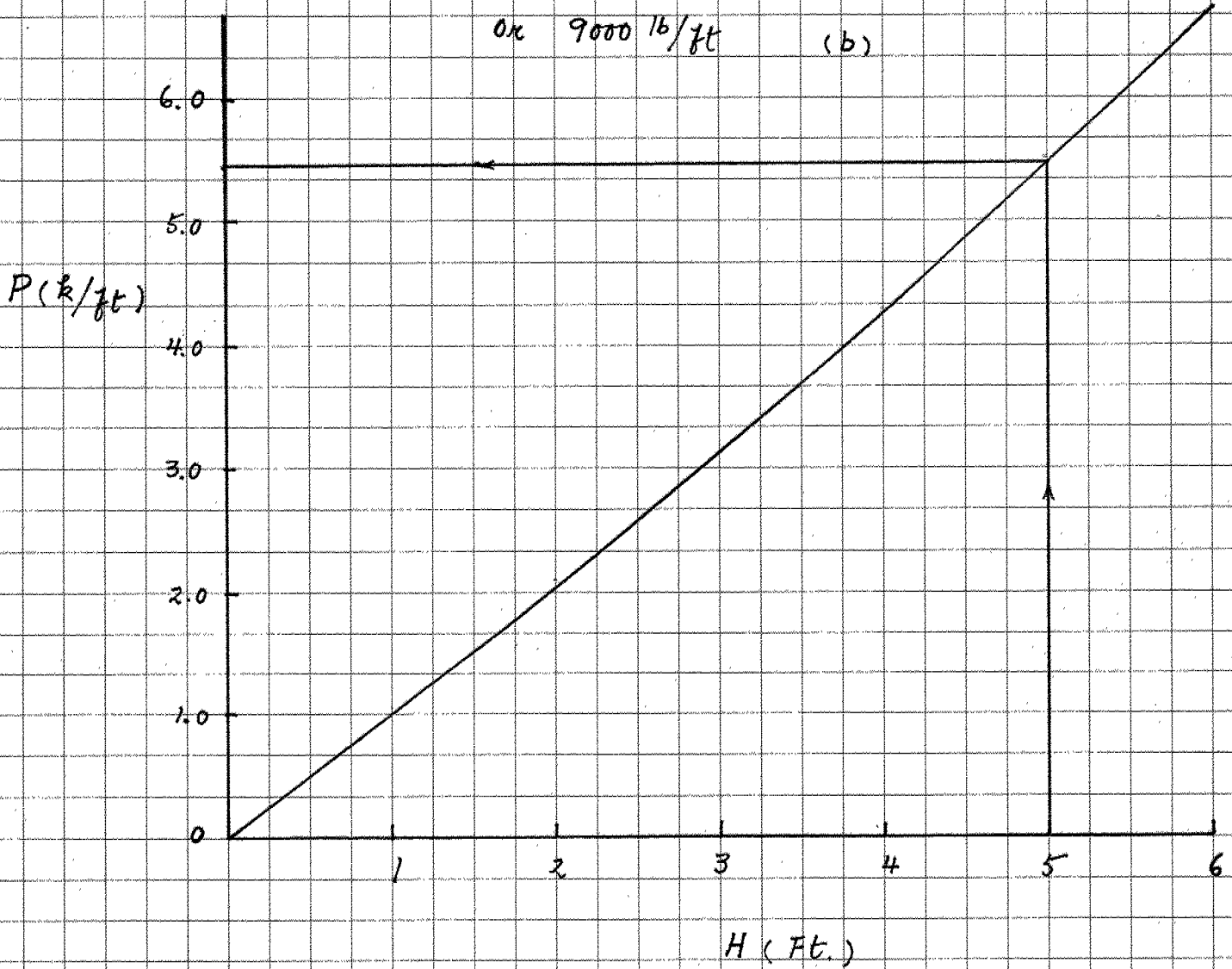
Elevation View



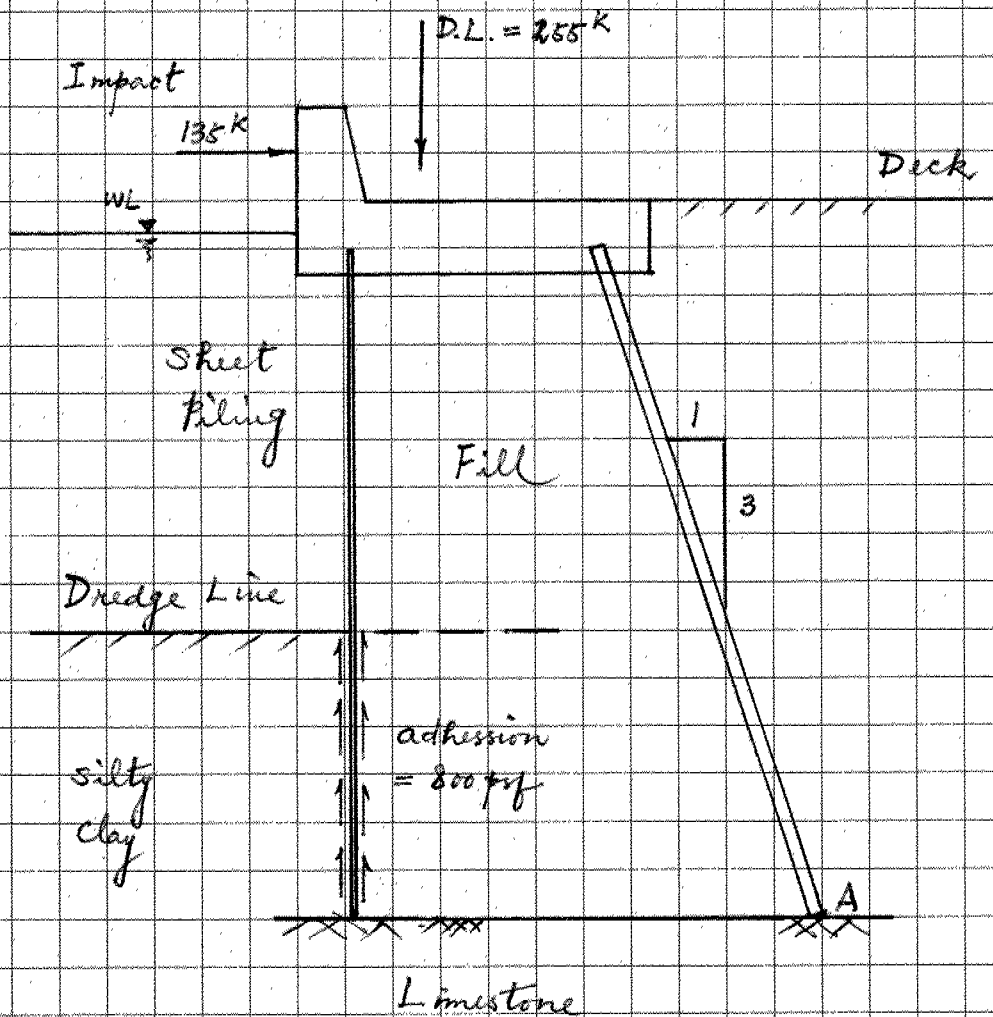
Plane View

$$P = 1000H + 20H^2 \quad (a)$$

$$\text{or } 9000 \text{ lb/ft} \quad (b)$$



Allowable Load on Sheet piling



$$\begin{aligned}
 F.S. &= \frac{(\sum M_R)_A}{(\sum M_O)_A} = \frac{255 \times 20 + 15 \times 14 \times 0.8 \times 2 \times 23.5}{135 \times 40} \\
 &= 2.4 \quad (O.K.)
 \end{aligned}$$

Fig. (2) Stability Against Overturning

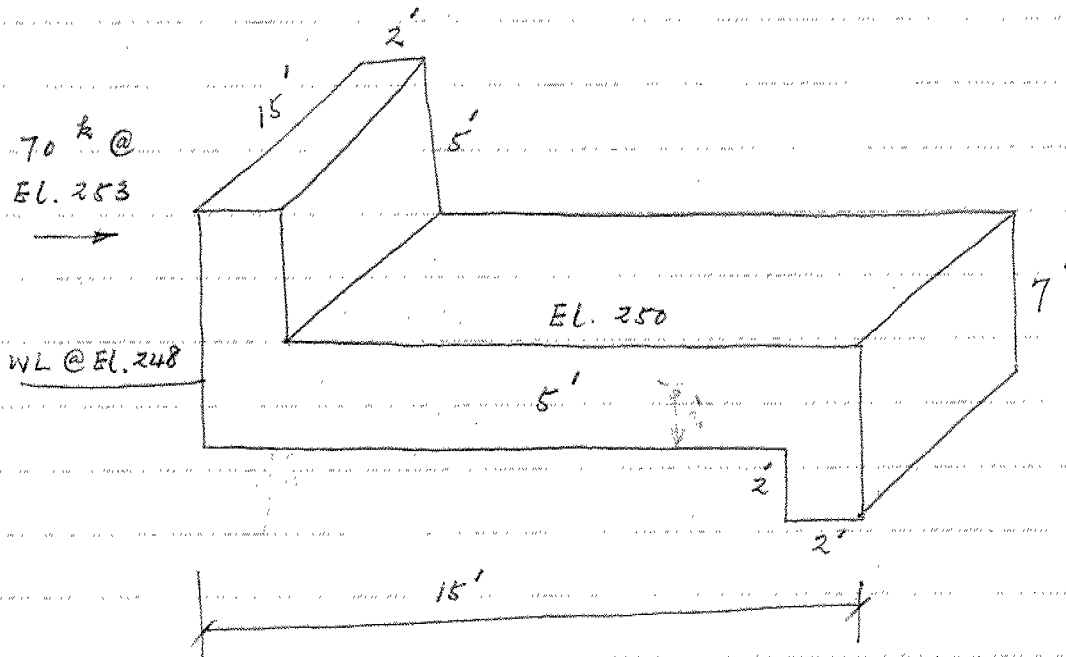
References for Kingston Ferry Project

- Report on Small Craft Harbours,
ASCE Manual 50, 1969 139 pp.
- Analytical Treatment of Problems
of Berthing and Mooring Ships
1965 NATO Study, 344 pp.

Sept 19/76.

Em.

Kington Dock



$$W_c = 15 \times 5 \times 2 \times 0.15 + 15 \times 15 \times 5 \times 0.15 + 2 \times 2 \times 15 \times 0.15$$

$$- 15 \times 15 \times 3 \times 0.0625 - 2 \times 2 \times 15 \times 0.0625$$

$$= 154.3 \text{ k}$$

$$\tan \delta = 0.5$$

$$R_1 = 77.2 \text{ k}$$

$$P_p = \frac{3}{2} \times 0.06 \times 36 \times 15 = 48.6 \text{ k}$$

Against sliding

$$f.s. = \frac{77.2 + 48.6}{70} = 1.79 \text{ O.K.}$$

Against Overturning

$$M_R = 15 \times 5 \times 2 \times 0.15 \times 14 + 15 \times 15 \times (5 \times 0.15 - 3 \times 0.062) \times 7.5 + 2 \times 2 \times 15 \times 0.09 \times 1 + 48.6 \times 2 = 1369$$

$$M_o = 70 \times 10 = 700$$

$$f.s. = 1.96 \quad \text{o.k.}$$

$$v_{ave.} = \frac{154.3}{15 \times 15} = 0.685$$

$$M = 70 \times 8 - 15 \times 4 \times 2 \times 0.15 \times 6.5 - \frac{15}{2} \times 3 \times 0.06 \times 5^2 \times 1.7 = 385$$

$$\sigma \times \frac{7.5}{2} \times 75 \times \frac{3}{8} \times 75 \times 2 = 385$$

$$\sigma = 0.685$$

$$\therefore \sigma_{max} = 1.37 \text{ kgf}$$

$$\sigma_{min} = 0$$

Bearing Capacity : should be o.k.
for $\sigma_{max} = 1.37 \text{ kgf}$.

Rock fill & Gr. fill will have some arching effect. $\therefore \sigma$ may not be large.

$$\Delta T = 684$$

$$- 5 \times 60$$

$$= 384$$

$$\frac{V_u \times Y_{ur}}{V_s \times Y_s} = w$$

$$e_o = w s$$

$$= 1.5 \times 27 = 4$$

$$\delta = \frac{3 \times 12}{1 + 4} \times 2.5 \times \log \left(1 + \frac{384}{1200} \right)$$

$$= 2''$$

24" ϕ
1/2 in thick wall
cubbing with
heavy drive



prevent the pipe from
penetrating
Socket into the rock.

~~\$4000~~
\$500

~~\$400~~
3 to 4 ft into
the rock.

