

memorandum

GEOROS No:
30M15-79



To: Mr. J. Greg Ashbee
Maintenance & Storage Yard Co-ordinator
GO-ALRT
3625 Dufferin Street

Date: 1985 04 23

From: Foundation Design Section
Room 315, Central Building
Downsview

Re: Foundation Investigation
GO-ALRT Pickering to Oshawa
Project FS-331
Durham Region Maintenance and Storage Facility

This memo contains recommendations pertaining to the design and construction of the foundations for this project. These recommendations, with which you were provided during our meeting of 85 04 12, are intended to be sufficient to allow the design of the structures to proceed. Our complete Foundation Investigation and Design Report will be submitted in the near future.

General Recommendations (Applicable to All Foundation Alternatives)

EARTH PRESSURE CALCULATIONS:

Backfill to structures should consist of granular material in accordance with MTC Standard Special Provision #121 (83 10). Computation of earth pressures should be in accordance with Section 6.6.1.2 of the O.H.B.D.C.

For design purposes, the physical properties of the backfill are as follows:

MATERIAL	ϕ	γ
GRANULAR 'A'	35°	22.0 kN/m ³
GRANULAR 'B'	30°	21.2 kN/m ³

SETTLEMENT CONSIDERATIONS:

For the recommended design loadings, differential settlements should be less than 25 mm. However, it is recommended that the building should be designed accommodate some settlements, especially in those areas where foundations are placed on fill material.

SLOPE STABILITY:

Permanent slopes should be 2:1 or flatter; temporary slopes 1.5:1 or flatter.

...../2

Detailed slope stability analyses for the area near the existing creek (Sta.27+640) have not been completed. However, no problems are anticipated if the fill is constructed evenly across the valley.

FROST PROTECTION:

The minimum cover required for frost protection is 1.2 m.

DE-WATERING

De-watering will be required where portions of the structures are to be constructed 'in the dry' below the prevailing groundwater level, in order to prevent disturbance of the foundation soil. It should be noted that under conditions of unbalanced hydrostatic head, the cohesive material at this site is susceptible to basal heave, while the non-cohesive material is susceptible to boiling.

Also, a permanent drainage system will be required to relieve groundwater pressures beneath the structures.

During construction, it is recommended that the groundwater table be lowered a minimum of 1 m below the invert of excavations in which footings, pile/pier caps or floor slabs are to be constructed in the dry.

De-watering can be accomplished by a vacuum well point system, or alternatively, by a system of suitably designed sub-drains.

The sub-drain system could consist of a series of trenches, extending a sufficient depth below the excavation invert to lower the groundwater table as required. The trenches should be backfilled with free-draining material, such as MTC Granular B Type 1, and should contain a perforated pipe encased in a suitable geotextile material. The drain system should be designed so that the invert of the drain trenches is outside of a 2H:1V plane drawn from the edge of the footing base. Strategically located sump pumps could be used to remove water from excavations. The design of drain locations would depend on footing locations.

A series of drains, connected to a 0.6 m (minimum thickness) Granular B Type 1 pad beneath the structure floor slabs could provide the required permanent drainage for this project.

To dispose of water, the drains could be connected to a collector drain leading to a suitable drainage outlet.

RESISTANCE TO LATERAL LOADS:

A friction coefficient of 0.55 can be assumed to apply between the concrete base of spread footings and the underlying granular pad.

WATERPROOFING

A 0.3 m (minimum thickness) clay seal is recommended to provide waterproofing for the proposed tunnel, and for those areas of the building foundations where water leakage problems may arise.

At the tunnel, the clay seal should extend over ^{above} these areas of the foundation exposed to groundwater. "Volclay 90" panels would provide suitable waterproofing for the tunnel sides.

Refer to Ontario Provincial Standard Specification #1205-1 (attached) for the material specification for a clay seal. The clay mixture specified in Section 1205.05.03 is preferred.

FILL:

The material requiring excavation between Sta. 27+450 and 27+470 is suitable for fill. The material requiring excavation upchainage (east) of Sta. 27+470 is less suitable, but would be acceptable under the proper moisture content conditions.

All fill should be compacted in 200 mm (maximum thickness) lifts, to 95% of the standard Proctor density of the material.

A number of foundation design alternatives are recommended. The alternatives which lead to the least expensive design should be adopted.

Design Alternatives

ALTERNATIVE 1 - CAISSONS

All proposed structures may be supported on reinforced concrete caissons. Because of the high groundwater table, these caissons should be constructed using tremie techniques.

The following design values are recommended for 750± mm (30 inch) diameter caissons installed to the base elevations indicated in Table 1. Caisson base elevations may be interpolated between the indicated stations.

- (O.H.B.D.C. Method)
- Factored Capacity at U.L.S. = 1335 kN
 - Capacity at S.L.S. Type II = 890 kN

Table 1

<u>Location</u>	<u>Base Elevation</u>
Sta. 27+420	86.0 m
Sta. 27+520	82.0 m
Sta. 27+580	80.0 m
Sta. 27+640	78.0 m

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ALTERNATIVE 2 - STEEL H-PILES OR TUBE PILES

All proposed structures may be supported on steel H-Piles or concrete-filled tube piles. These piles are to be equipped with reinforced tips (driving shoes).

Piles should be driven in accordance with MTC Standard SS-103-10 or SS-103-11, but not below the elevations indicated in Table 2. The following ultimate capacities can be used for calculation purposes in the above-noted pile driving standards. The tip elevations provided in Table 2 can be used to estimate pile lengths. Pile tip elevations may be interpolated between the indicated stations.

<u>Pile Type</u>	<u>Ultimate Capacity</u>
H-Pile 310 HP 79	1870 kN
Tube Pile 324 mm X 6.3 mm	1870 kN

Table 2

<u>Location</u>	<u>Base Elevation</u>
Sta. 27+420	86.0 m*
Sta. 27+520	81.0 m
Sta. 27+580	79.0 m
Sta. 27+640	77.0 m

*Pre-augering for piles may be required, due to presence of very dense till material.

The following design values are recommended for piles installed in accordance with the above-noted criteria.

<u>Pile Type</u>	<u>Factored Capacity at U.L.S.</u>	<u>Capacity at S.L.S. Type II</u>
H-Pile 310 HP 79	935 kN	625 kN
Tube Pile 324 mm X 6.3 mm	935 kN	625 kN

ALTERNATIVE 3 - SPREAD FOOTINGS

The floor slab foundations, the pedestrian tunnel foundation, and the building column foundations between Sta. 27+450 and Sta. 27+470 may be supported on spread footings. A 0.6 m (minimum thickness) pad of properly compacted Granular B Type 1 is required beneath the spread footings.

Excavations for spread footings may be constructed in the dry provided that the criteria specified for de-watering are met. Alternatively, the excavations may be backfilled, with portions of the granular fill pad below water if necessary, so that the spread footings can be constructed in the dry in accordance with the de-watering criteria.

The following design values are recommended for the tunnel slab foundations and the building floor slab foundations.

- O.H.B.D.C. Method
- Factored Bearing Capacity at U.L.S. = 150 kPa
- Bearing Capacity at S.L.S. Type II = 100 kPa

The following design values are recommended for spread footings for building columns between Sta. 27+450 and Sta. 27+470.

- O.H.B.D.C. Method
- Factored Bearing Capacity at U.L.S. = 700 kPa
- Bearing Capacity at S.L.S. Type II = 300 kPa

Where spread footings on fill are proposed for future building extensions, further foundation investigations will be required to ascertain the properties of the existing foundation material.

If there are any questions, please contact this office.

D. H. Dundas

D. H. Dundas, P.Eng.
Foundations Engineer

DHD/nd

cc: G. Reid/A. Collier
Cole Sherman & Assoc. Ltd.



ONTARIO
PROVINCIAL
STANDARD
SPECIFICATION

(METRIC)
1205-1
OPSS 1205
DECEMBER 1983

MATERIAL SPECIFICATION FOR
CLAY SEAL

INDEX

1205.01	SCOPE	Ontario Provincial Standard Specification (Material)
1205.02	REFERENCES	
1205.03	DEFINITIONS	OPSS 1010 - Aggregates, Granular A, B, C, D and 16 mm Crushed Type B and Select Subgrade Material.
1205.04	SUBMISSION AND DESIGN REQUIREMENTS - Not Used	
1205.05	MATERIALS	
1205.05.01	General	
1205.05.02	Natural Clay	
1205.05.03	Clay Mixture	
1205.06	EQUIPMENT - Not Used	
1205.07	PRODUCTION - Not Used	
1205.08	QUALITY ASSURANCE	
1205.08.01	Sampling and Testing	
1205.09	MINISTRY PURCHASE OF MATERIAL BY PURCHASE ORDER - Not Used	
1205.10	DESIGNATED SOURCES REQUIREMENTS	
1205.01	SCOPE	
	This specification covers the requirements of clay seal material for use at the upstream or inlet side of culverts.	
1205.02	REFERENCES	
	This specifications refers to the following standards, specifications or publications:	
1205.03	DEFINITIONS	
	For the purpose of this specification the following definitions apply:	
	Bentonite: A commercial term applied to clay deposits containing sodium montmorillonite as the essential mineral.	
	Clay: A fine textured, (grain size smaller than 0.002 mm) sedimentary or residual deposit consisting of hydrated silicates of aluminum mixed with various impurities but no organics. It is a cohesive soil and plastic within a wide range of water content.	
	Liquid Limit: The water content between the semi-liquid and the plastic states of the soil.	
	Plasticity Index: The water content range of a soil at which it is plastic, defined numerically as the liquid limit minus the plastic limit.	
	Plastic Limit: The water content between the plastic and semi-solid states of the soil.	
1205.05	MATERIAL	
1205.05.01	General	
	Material used shall lie within the hatched	

area shown on Figure 1 Plasticity Chart. It shall be natural clay as specified in subsection 1205.05.02 or a mixture as specified in subsection 1205.05.03.

1205.05.02 Natural Clay

Not all clays are suitable for use as clay seal, clay material shall comply with the following:

- (1) Liquid limit shall be $>50\%$.
- (2) Plasticity Index shall be $>0.75 \times (\text{Liquid Limit} - 20\%)$.

1205.05.03 Clay Mixture

Alternatively material for clay seal may be made of the following mixture (volume) of Bentonite and granular A:

- 1 part Bentonite
 - 3.5 parts Granular A
- Granular A shall conform with the requirements of OPSS 1010.

The mixing of the material shall be carried

out in an approved mechanical mixer. The mixed material shall be left to cure for a minimum period of 24 h prior to placement.

At placement the moisture content of the mixture shall be maintained to within ± 1 percent of the optimum moisture content.

The permeability as determined from the falling head permeameter test shall not exceed 1×10^{-5} mm/s.

1205.08 QUALITY ASSURANCE

1205.08.01 Sampling and Testing

Samples of natural clay material proposed for use in clay seal shall be submitted for approval three weeks before use.

When clay mixture is proposed for use, samples of the granular A and bentonite shall be submitted three weeks before use, when requested by the Engineer.

Testing of clay seal material will be by Authority Staff.

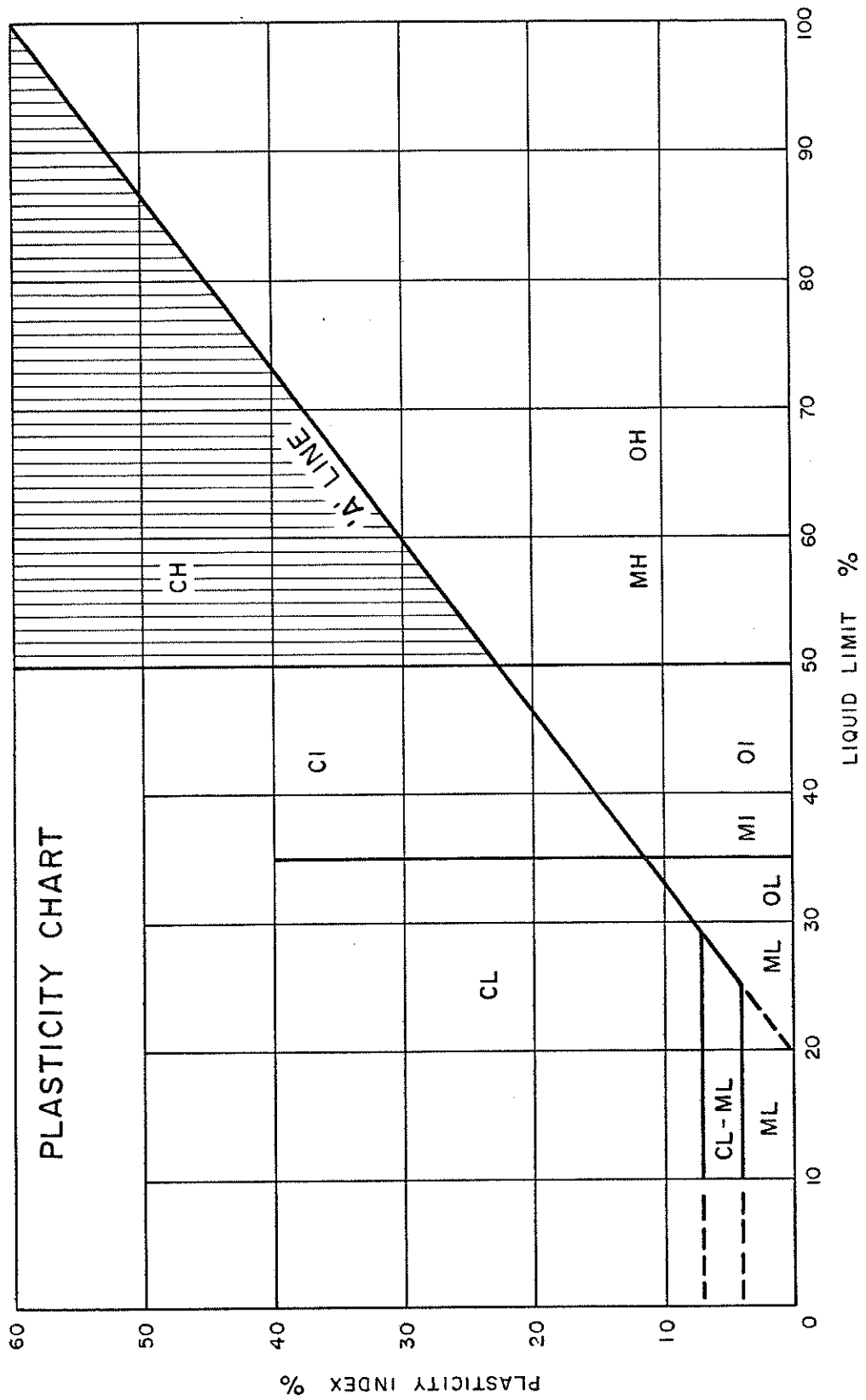


FIGURE 1



C. MIRZA ENGINEERING INC.
GEOTECHNICAL SPECIALISTS & CONSULTING ENGINEERS

Suite 31, 1262 Don Mills Road, North York, Ontario, Canada M3B 2W7 • Telephone (416) 441-2560 • Telex 06-966637

Geotechnical Investigation
For Guideway From East Of Durham
Maintenance Facility to West of Park Road
East Section
W.P. GO-ALRT EGG-000-1
City of Oshawa, Ontario
Durham Regional Municipality

Our File: 84-045
Consultant Agreement No: GO-ALRT EGG-000-1

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APPENDIX 2 - Treatment of Utilities - GO-ALRT Main Line

APPENDIX 3 - Grain Size Distribution Curves



SOILS INVESTIGATION REPORT

GO-ALRT Project EGG-000-1

Geotechnical Investigation for Guideway from East of Durham
Maintenance Facility to West of Park Road. East Section, City of
Oshawa, Ontario, Durham Regional Municipality

1. INTRODUCTION

1.1. Terms of Reference

As part of the proposed Government of Ontario Advanced Light Rail Transit system (GO-ALRT), the Central Region Geotechnical Section of the Ministry of Transportation and Communications has contracted C. Mirza Engineering Inc. to undertake a detailed soils investigation for the portion of the proposed GO-ALRT alignment from Thornton Road (station 28+250) easterly to Park Road (station 30+000) in the City of Oshawa. This report summarizes the subsurface conditions encountered along the proposed alignment and provides detailed geotechnical recommendations for sub-ballast design and the construction of cuts and embankments.

1.2. Scope of Project

The limits of the current soils investigation along the main alignment of GO-ALRT are as follows:

Description		Stations	
From	To	From	To
Thornton Road	CP Spur lines	28+240	28+450
CP Spur lines	Stevenson Road	28+450	29+080
Stevenson Road	Park Road	29+080	30+000

The proposed GO-ALRT alignment involves, from the east limits of the project westerly, structure crossings at Park Road, Stevenson Road, CP Spur lines and Thornton Road. The foundation investigations for the above mentioned structures were excluded from the present soils investigation contract.



2. GENERAL DATA

2.1. Main Line

The GO-ALRT system is proposed tentatively to consist of two parallel tracks. A track gauge width of 1435 mm will necessitate a spacing of 4200 mm between the centrelines of the two tracks. A surface right-of-way of 10 200 mm is anticipated for these tracks. General requirements for the design of the substructure to support the track ballast have been specified by GO-ALRT Systems Standard Part 2, Engineering Section 2.2, Civil and Structural, Subsection 2.2.10, "At-Grade Guideway-Substructure", a copy of which is presented in Appendix 1.

From east to west, the proposed alignment of the GO-ALRT main line trackage lies 15 m south of the existing CP Railways tracks. From station 28+800, westerly however, the alignment begins curving to the southwest. The curve continues southwest to Thornton Road at which point, the GO-ALRT main line trackage lies 170 m south of the CP tracks.

2.2. Services and Utilities

A number of underground municipal services and pipeline utilities are present at the site. Many of these will be affected by the proposed construction of the GO-ALRT Main line. Details of utility locations are included in Appendix 2.



3. DESCRIPTION OF SITE & GEOLOGY

3.1. General Site Description

The investigated area lies in a predominately single dwelling residential area within the City of Oshawa. The frequency of agricultural and undeveloped land increases near the west end of the site south of the CP tracks. North of the CP tracks, single dwelling residences predominate. The area is generally flat. However, a drumlin is located at the west end of the site trending more or less in a north-south direction.

3.2. Geology

The topography of the investigated area is gently undulating, reflecting the drumlinized till plain in this part of the physiographic region known as the "South Slope". The drumlins consist almost invariably of medium-textured tills. However, lenses of sand and gravel or even stratified clay are sometimes found in such drumlins.

3.3. Drainage

The area of the soils investigation generally drains to the south towards Lake Ontario. There are no major drainage courses in the investigated area.

3.4. Groundwater

The silty clay which underlies topsoil over much of the site is generally impervious to surface moisture. Wet and swampy areas are found in low spots where the silty clay is close to the ground surface. Trapped water is found within open graded sand and gravel lenses confined within the glacial till strata in this region.



4. INVESTIGATION

The field work was carried out with a muskeg-vehicle mounted power auger machine. Sampled boreholes were drilled at frequent intervals. Samples were obtained both as auger cuttings and in the Standard Penetration Test, the N values being noted in the latter case. In the deep cut areas, sealed Piezometers were installed in the completed boreholes to measure groundwater levels. In some boreholes, slotted standpipes were installed to enable groundwater readings in case the borehole caved.

Near the CP rail, the CP officials were advised to provide flagging services. However, such service was not provided, and the boreholes close to the CP line were completed without incident.

The laboratory soils testing program included visual classifications, moisture contents, Atterberg Limits and mechanical sieve analyses. Proctor were also performed on several samples. To expedite laboratory testing, all of the Proctor densities were determined using the MTC "One Point Proctor Method", which utilizes a family of density curves developed for cohesive and non-cohesive soils in Ontario by the MTC.

The individual borehole logs and results of the laboratory analysis are shown on the soil profile, which accompanies this report. These should be read in conjunction with this report and are an integral part of the recommendations.

All boreholes were located by reference to a revised GO-ALRT Centre Line staking carried out by MTC forces.



5. SUBSURFACE CONDITIONS

5.1. General Overview

In general, the subsurface conditions consist of topsoil overlying a stiff silty clay, which occurs at depths ranging from 300 mm to 1.8 m over most of the site.

The silty clay layer has an average thickness of 2m. Below the silty clay lies a dense silty sand glacial till. In some areas the glacial till occurs directly beneath the topsoil.

Soil conditions found in each segment of the project are summarized in the following sections.

5.2. GO-ALRT Main Line

The following paragraphs detail the subgrade conditions observed during the soils investigation along the centre line of the GO-ALRT line.

5.2.1 Stations 28+300 to 28+600 (CP Spur lines Area)

Between these stations a drumlin lies within farmers' field. The CP spur lines cut through the drumlin between stations 28+440 to 28+470. The spur line cut exposes 5 m of the glacial till to elevation 103.5 m. The ditches for the spur line cut contain standing water. The ground elevation rises from 106.0 m at station 28+300 to 108.5 m at station 28+570. The elevation then descends on the east flank of the drumlin to 105.2 m at station 28+600.

A black silty clay topsoil covers the area, varying in thickness from 400 to 800 mm. A brown sandy silt topsoil of 1.0 m thickness was found at station 28+520. The topsoil overlies a glacial till which is the predominant soil in the drumlin. The glacial till consists of essentially a sandy silt to silty sand with clay and occasional cobbles. The N values ranged from 34 to over 100 blows/ 0.3m. Based on these N values the glacial till is considered to be dense to very dense. The glacial till has moisture contents ranging from 7% to 13%, with a liquid limit of 11% and a plasticity index of 1% in this area.

The matrix of the glacial till is cohesive as reflected by the Atterberg limits. One hydrometer test shows a clay and silt content (75 um) of 50%.

The glacial till deposit extends below the subgrade elevation and its full extent was not explored below elev. 90.5m.

Contained within the drumlin are a number of isolated pockets or lenses of sand and gravel. Such pockets were encountered in Boreholes at Stations 28+350, 28+450, 28+520 and 28+560. These were fully penetrated at all locations except Sta. 28+520 where the evidence was unclear as to the full extent of this type of



pocket, since the borehole was extended at this location by wash boring techniques and only wash water samples could be collected. The thickness of these layers ranges approximately from 1m at Sta. 28+520 to over 6m at Sta. 28+520.

These granular pockets or lenses contain fine to medium grained sands with gravel, (see Fig. 4, Appendix 3), generally becoming coarser with depth. The sands are fairly clean (-75um 10%) and fairly well graded. The moisture content ranged from 3 to 15%.

It is inferred from the geology in this section that occasional cobbles and boulders are also present, at random, within the glacial till matrix.

The water table in this section varies in elevation from 104.0 to 102.0 m. Deep piezometers were installed to monitor the seepage condition in the cut area. No excess porewater pressures were found in the drumlin area. The water level readings are given below.

Station	Tip Elev.(m)	Water Level Elevation (m)				
		1984-12-13	1985-01-02	1985-01-25	1985-01-26	1985-01-28
28+300	piezo.@ 95.2	-	104.8	104.1		
	piezo.@ 97.0	-	104.8	104.2		
28+350	piezo.@ 98.8	-	-	-	-	101.9
28+375	sp. @101.0	-	-	-	-	102.8
28+400	piezo.@ 93.4	103.4	103.4	103.0		
	piezo.@ 98.4	102.9	103.3	103.0		
28+450	piezo.@ 98.6	-	-	-	-	103.0
	piezo.@101.2	-	-	-	-	103.0
28+520	piezo.@ 96.5	-	-	-	-	102.5
	piezo.@ 98.5	-	-	-	-	102.5
28+560	s.p. @ 94.5	-	-	-	-	101.6
	piezo.@102.5	-	-	-	-	dry
28+600	piezo.@100.9	104.3				
28+700	piezo.@ 94.8	98.0				
	piezo.@ 99.1	103.2				

It would appear that the spurline cut acts as a drain for the drumlin. The flat drawdown gradient from elev. 104 on either side of the cut to elev. 102+ in the cut attests to the fairly permeable nature of the glacial till deposit.

5.2.2. Stations 28+650 to 28+920 (East of Spur line to West of Stevenson Road)

This lowland area beside the drumlin is wet and swampy in places, with the water table near the ground surface. The area is overgrown with bushes and small trees. There is a topsoil stockpile between stations 28+700 to 28+740 with an average height of 1.5 m. A swamp exists from stations 28+820 to 28+850 with up to 300mm of standing water. A black organic silt material in the swamp area



ranges from 300 to 800mm in thickness.

A black silty clay topsoil covers most of the area, varying in thickness at the locations drilled from 300 to 800 mm. However, by inference from the lie of the ground, the topsoil could be as much as 1200mm in thickness in some places. A black sandy silt topsoil of 150 mm thickness was found at station 28+650. The topsoil overlies a loose, fine sand layer. The sand layer varies in thickness from 0.8 to 1.5 m and rests at an elevation ranging from 101.0 m to 103.0 m. The sand's water content is approximately 18%.

Below the sand layer, there exists a brown to grey soft to stiff silty clay layer which varies in thickness from 1.0 to 5.0 m. The elevation at the base of the silty clay ranges from 100.4 to 96.8 m. Water contents of the silty clay range from 20% to 37% with a liquid limit of 34% and a plasticity index of 16%.

Based on N values ranging from 3 to 14 blows/0.3m, this layer is considered to range in consistency from soft to stiff. Also, given the fact that the field moisture content is significantly higher than the plastic limit, it is quite probable that the clay deposit is quite compressible.

Below the silty clay layer, a dense sandy silt with glacial clay till is present, with a moisture content of 7%. Cobbles and boulders were found at station 28+700 at elevations 97.0 to 95.0 m. The glacial till deposit extends below the subgrade elevation and its full extent was not explored below elevation 95.0m. One N value in this deposit was 38 blows/0.3m indicating it to be dense.

The water table varies in elevation from 103.5 to 102.0 m and is at the ground surface.

5.2.3. Stations 28+920 to 29+200 (West of Stevenson Road to East of Stevenson Road)

This area is flat lying and has been previously worked by man. An Ontario Hydro maintenance storage area is situated west of Stevenson Road and an apartment building parking lot is situated east of Stevenson Road. The GO-ALRT alignment between stations 29+040 and 29+110 crosses the Stevenson Road fill embankment. There are fair sized trees along the apartment parking lot which will require grubbing.

A black silty clay topsoil is found covering the Stevenson Road fill embankment, varying in thickness from 150 to 300 mm. The parking lot consists of 100 mm average thickness overlying some 200mm of granular base materials of asphalt. The maintenance storage area is covered with up to 900mm of sand and gravel fill at ground surface. Only one borehole was put down at the base of the Stevenson Road embankment. The fill material was sand with clay. (We understand other investigations along the embankment will identify the nature of this fill material more fully.)

A black silty clay topsoil layer is sandwiched within the fill between stations 28+920 and 29+120. The thickness of the buried topsoil ranges from 200 mm to 1.2 m and overlies a fine sand layer. The thickness of this lower sand unit varies



from 200 to 900 mm.

A stiff silty clay layer lies below the sand and fill materials. It varies in thickness from 2.0 to 3.0 m and overlies glacial till at an elevation of 99.0 m. The contact between the silty clay layer and the glacial till is probably horizontal judging by the lay of the land, at an elevation ranging from 98.0 to 99.0m.

The water table varies in elevation from 102.5 to 101.0m and is about 1 to 2 metre below ground surface.

5.2.4. Stations 29+200 to 29+750 (East of Stevenson Rd. Easterly to West of Park Road)

This is a cleared and generally flat area. Previous topsoil stockpiling has left a windrow pile alongside the GO-ALRT alignment from stations 29+300 to 29+450. The pile is approximately 3.5 m in height. From stations 29+500 to 29+640 a low, wet, swampy area exists with up to 50mm of standing water. A black organic sand material in the swamp area ranges from 400 to 600mm in thickness. From stations 29+640 to 29+750, the area is generally flat, as this area is part of a school yard.

A black silty clay topsoil layer covers the area. The thickness varies from approximately 500 mm in the swamp area to 4.5 m at the topsoil windrow pile location. The school ground has an average topsoil cover thickness of 1.0m.

A stiff silty clay layer lies below the topsoil except between stations 29+550 and 29+700. The silty clay varies in thickness from 400 mm to 3.0 m.

Laboratory testing showed the silty clay material to have moisture contents from 16% to 20%. Field Vane tests gave an undrained shear strength of over 100 kPa. indicating the silty clay to be of very stiff consistency. This was confirmed by N values ranging from 21 to 29 blows/0.3m.

A seam of clayey and silty sand is found sandwiched between the topsoil and the silty clay layers between stations 29+550 and 29+700. The thickness of the sand seam ranges from approximately 200mm to 1.0 m.

A glacial till consisting of silty sand with clay till lies beneath the silty clay layer. Cobbles and boulders were encountered in the till at station 29+700 between elevations 100.0 m and 99.0 m.

The till material was found to have moisture contents ranging from 9% to 10%, with a liquid limit of 10% and plasticity index about 3% in this area. This indicates the till matrix is slightly cohesive. Some "loosened" zones were encountered in this till deposit as evidenced by N values ranging from 4 to 9 blows/0.3m.

The water table varies in elevation from 101.5 m to 100.0 m.



5.2.5. Stations 29+750 to 30+000 (Park Road)

The ground surface is flat lying, in a single dwelling residential area.

Black silty clay topsoil covers the area ranging in thickness from 300 to 900 mm. A stiff to very stiff silty clay lies beneath the topsoil except at station 30+000 where the glacial till directly lies beneath the topsoil. The silty clay layer varies in thickness from 100 mm at station 29+750 to 2.2 m at station 29+900. The base of the silty clay varies in elevation between 101.0m to 102.5m. where it overlies a compact to very dense silty sand glacial till. Laboratory testing showed the silty clay to have moisture contents from 24% to 27% with a liquid limit of 31% and plasticity index of 14%. Based on N values ranging from 13 to 24 blows/0.3m, this layer is considered to range in consistency from stiff to very stiff.

The glacial till is found at elevations 103.5 m at station 30+000 to elevation 101.0 m at station 29+845. Cobbles and boulders were encountered in the glacial till at stations 29+750 and 29+800 between elevations 100.0 m and 102.5 m. The silty sand till moisture content ranges from 6% to 11%, with a liquid limit of 12% and plasticity index of 2%. The N values ranging from 12 to over 100 blows/0.3m. Based on these N values the glacial till is considered to be compact to very dense.

The water table varies in elevation from 103.0 m to 101.5 m.



6. DESIGN CONSIDERATIONS

6.1. General - Settlement and Stability

It is understood that maintenance of alignment and grade will be crucial to the efficient performance of the GO-ALRT vehicles. For this reason, differential settlements and heaves must be minimized. This is especially true if a tie and ballast system is adopted for the track design. In this investigation, areas of potential long term settlement and differential frost heaving have been identified, both from a subgrade soils point of view and due to prevailing water table conditions. These areas are dealt with under Section 8 "Recommendations" of this report.

Starting at the east end of the GO-ALRT alignment from station 30+000 to 29+720, the main line track profile grade is 500 mm to 1.0 m below the existing grade. Therefore no cut stability or settlement problems are anticipated in this area after excavation of organic topsoil and silty clay to firm competent glacial till.

From station 29+720 to 29+200, the main line track profile is 1.0 to 2.5 m above the existing grade. The low swamp area will need to be excavated of organic topsoil and softened materials to firm competent glacial till material to ensure no settlement problems.

From station 29+200 to 28+820, the main line track profile is just at or slightly above the existing grade. Therefore no cut stability or settlement problems are anticipated in this area after excavation of organic topsoil and silty clay to firm competent glacial till.

From station 28+820 to 28+300, the main line track profile is below the existing grade. Cuts will be up to 13 m deep. Most of the cuts will be in glacial till materials.

The glacial till is considered competent to support 2:1 final side slopes without danger of deep-seated rotational or sliding wedge types of failure. Benching of the cuts will reduce surface erosion problems. (see section 8.1.5)

The glacial till and the pockets of sand and gravel within the drumlin between station 28+820 to 28+300 are suitable for embankment construction.

6.2. Subgrade Loading

The tie and ballast design will transmit imposed static and dynamic loads to the underlying subgrade. In designing the sub-ballast and ballast thicknesses, such imposed axle loads have been taken into consideration, so that the net stress increase on the subgrade, due to vehicular axle loading (static, rolling and impact loads) will be minimal, when distributed in accordance with accepted soil mechanics principles.



6.3. Effects of Loading on Utility Crossings

The construction of the GO-ALRT embankment and subsequent dynamic loading due to rolling stock will transmit loads on to buried water lines, sewers, electric and telecommunications cables, and gas and oil pipelines. Regulations for buried utility crossings along railroad rights-of-way are set by Canadian Transport Commission General Order 1981-8 RAIL. Sections of that document which specifically relate to this project are summarized below (values have been converted to metric):

- (i). The highest point of buried sewer and water pipe, including the required cover, shall be no less than 1.2 m below the base of rail, over the entire right of way of the railroad. The highest point of buried oil and gas pipelines, including the required cover, shall be no less than 1.7 m below the base of rail over the entire right of way.
- (ii). Pipes constructed of hard or glazed tiles shall be encased in concrete on 100 mm minimum thickness.
- (iii). Open drains shall be safely covered for at least 1.5 m from the gauge side of each rail.
- (iv). Water pipes shall be equipped with accessible emergency valves on the pressure side of the crossing.
- (v). Pipes carrying liquid or gaseous hydrocarbons shall conform to CSA Standard Z183 (1973) for Oil Pipeline Transmission Systems and CSA Standard Z184 (1975) for Gas Transmission and Distribution Piping Systems.
- (vi). Pipelines shall be located to cross railway tracks at an angle as close as possible to 90 degrees, but not less than 45 degrees.
- (vii). Pipelines shall not be located within 9.1 m of any structure on the railway right of way which may be damaged by leakage from the pipeline.

CTC General Order 1981-8 RAIL does not apply to pipelines constructed before 1977 unless additional tracks are constructed over the pipeline crossing after October, 1981.

Where utility crossings satisfy C.T.C. regulations, measures must be taken to ensure that the effects of new loadings, caused by cut or fill construction and subsequent traffic, on each installation are minimal.

Recommended treatments for the affected utilities are given in Appendix 2 of this report.



7. CONSTRUCTION FEATURES

7.1. Topsoil

Topsoil greater than 300 mm in thickness can lead to appreciable settlement of overlying fills. Therefore, the guidelines for stripping topsoil are as follows:

- (i). All fills under 1.5 m in height (fills include sub-ballast and ballast).
- (ii). Where deeper than 300 mm, for fills 1.5 m or greater in height.

The topsoil should be stockpiled for later use in right-of-way landscaping. Actual stripping requirements are given in Section 8.

7.2. Groundwater

The groundwater table ranges in depth below existing grade from 0 to 2.5 m. The water table was at the surface at the following locations during the period of this investigation:

- Stations 29+450 to 29+650 in a swampy area.
- Stations 28+700 to 28+900 in a swampy area.

The excavation of organics at the above locations will have to be made below the water table. Elsewhere, the groundwater is not expected to pose a serious construction problem. Pumping from sumps should be adequate. In a particularly wet construction season, advance ditching may prove beneficial.

However, in the deep cut areas between stations 28+300 to 28+700, special subdrain treatment is required for long term seepage stability control of the sand and gravel lenses (see Section 8.1.11 Subdrains).

7.3. Cut Materials

Cuts will be made from west of Thornton Road easterly to Sta. 28+850 and from Station 29+725 easterly to Park Rd. The latter cut is only about 1 metre in depth below existing grade to proposed Profile Grade. However, the major cut will be from the west limits of the project to about Sta. 28+800. Here, the maximum depth of cut to Profile grade will be about 12 metres adjacent to the CP Spur cut.

All surficial organic materials and topsoil should be stripped and stockpiled for later re-use in landscaping. The underlying soft to stiff silty clay material is unacceptable as fill and should be disposed of outside the right of way.



The major portion of usable cut material will be the slightly cohesive sandy silt glacial till within the drumlin, and its inclusions of sand and gravel pockets and lenses. The compaction characteristics of these materials are shown in the Table below.

Materials	Location (Sta.)	Natural Moisture(%)	Optimum Moist- ure content(%)	Std. Proctor maximum wet density(t/m ³)
silty sand till	28+300 to 28+600	4 to 16	8.5	2.3
fine to med- ium sand and gravel lenses	28+500 to 28+540	3 to 15	7.2	2.4

During excavation of these cuts it may prove advisable to isolate the fairly clean sand and gravel lenses from the general till material in the drumlin for use as select subgrade material in specified locations below the water table.

The silty sand to sandy silt glacial till material is acceptable for use as earth fill. However, it may also be used as select subgrade material if isolation of the sand and gravel lenses is not possible and a mix of the two materials is obtained during excavation. However, due to the high silt content (and therefore high susceptibility to frost action) this material will need to be protected with a polystyrene treatment when used within 1.2m of the sub-ballast (see section 8.1.7)

7.4. Sources of Granular Materials

Recent Aggregate Sources Lists, compiled by the MTC, identify several commercial sources of Granular 'A' and 'B' in the vicinity of the Towns of Whitby and Ajax. The haul distances to these sources range from 12 to 15 km.

7.5. Select Subgrade Materials

A non-cohesive select subgrade material is recommended for the backfill to subexcavations. Use of such materials particularly below the prevailing water table will ensure stable behaviour in the long term.

7.6. Polystyrene Frost Protection Treatment

The depth of frost penetration on this project is 1.2 m below the top of



subballast or finished exterior grade. It is suggested that the ballast material, being very porous, will not have any insulating value. Therefore, all frost-susceptible materials within 1.2 m of top of subballast will require treatments through cut areas and shallow fills (less than 1.2 m) to protect the subgrade from differential frost heaving. Also, the polystyrene sheets will dampen the magnitude of vibrations transmitted to the subgrade and consequently minimize the pumping of any fines from the subgrade. Details of the polystyrene treatment to the sub-ballast are presented as part of the GO-ALRT Systems Standards in Appendix 1.

7.7. Geotextiles

Geotextiles are not required on any portion of this project, with the exception of subdrain enclosures.

7.8. Chainage

In this report, the chainage stations along the main line of GO-ALRT correspond to the stations staked by the MTC in the field. As far as can be discerned, these correspond also to the stations shown on the plan and profile supplied by Dillon Consulting Engineers & Planners.



8. RECOMMENDATIONS

8.1. GO-ALRT Main Line

8.1.1. Topsoil Stripping

Topsoil should be stripped over the full plan width of the embankments (toe to toe) along the entire length of the project. The following topsoil average depths may be used to calculate stripping quantities.

<u>Stations</u>	<u>Topsoil Thickness</u>	
	<u>Average</u>	<u>Range</u>
30+000 to 29+650	660mm	300 - 900mm
29+650 to 29+510	530mm	300 - 900mm
29+503 to 29+210	1.5m	300mm - 1.8m
29+205 to 28+920	200mm	0 - 300mm
28+920 to 28+300	800mm	200mm - 1.0m

The above Table does not include the topsoil stockpile at Sta. 28+720. It is recommended that the quantity available of this stockpile and the windrow from Sta. 29+300 to Sta. 29+450 be surveyed and calculated separately.

8.1.2. Subexcavation of Unacceptable Materials

Subexcavation of organics and unacceptable fill and/or softened materials is recommended in the following areas:

<u>Stations</u>	<u>Average Depth</u>	<u>Remarks</u>
30+000 to 29+700	1.5m	Remove all material to glacial till
29+700 to 29+200	2.0m	Remove all material to glacial till
29+200 to 28+850	4.0m	Remove all material to glacial till
28+850 to 28+650	4.0m	Remove all material to glacial till



Backfill in these areas should consist of a non-cohesive, select subgrade material. All silty clay cut material is to be wasted with other suitable cut materials but which are impractical to separate from the silty clay during excavation operations. Materials to be wasted are shown as unsuitable materials on the profile

8.1.3. Boulders and Cobbles

Several boulders and cobbles were encountered during drilling operations in the drumlin area, between stations 28+300 and 28+600, at elevations of 100.0 m to 91.7 m. There is an estimated 3% of boulders in the cut sections. Any boulders found in cut sections should be treated as per MTC Standard DD-416.

Three surface boulders 0.5 cu.m. were visible at approximately station 28+665, 15 m left of centreline. Boulders and cobbles visible at the surface within the limits of the proposed embankments should also be removed.

8.1.4. Utility Treatment

A number of utility installations cross and/or lie within the limits of the GO-ALRT guideway structure. Recommendations for the treatment of utility crossings along the GO-ALRT main line are presented in Appendix 2.

8.1.5. Construction of Cuts and Fills

All cut and fill side slopes should be designed to a minimum 2:1 geometry. All excavations should conform to the requirements of the Occupational Health and Safety Act of Ontario.

General embankment construction should be in conformity with M.T.C. Form 200 and GO-ALRT Standards given in Appendix 1.

The upper 1.0 m of fill material for embankments should consist of material compacted to a minimum Standard Proctor density of 100% in lifts not exceeding 300 mm.

The remainder of the fill may consist of suitable earth compacted to a minimum 95% Standard Proctor density in lifts not exceeding 300 mm. Any surplus stripping should be disposed outside of the GO-ALRT right of way.

For earth cut sections, the subgrade must be scarified to a depth of 150 mm and recompacted to a minimum 100% Standard Proctor density immediately prior to placement of granular lifts.

The current GO-ALRT design standard specifies that the top of subgrade be graded to a 3% crossfall. The top of subballast should be horizontal (0% grade) beneath the ballast and graded to 3% crossfall beyond the ballast toe.



All cut and fill slopes should be protected from erosion by placement of topsoil with sodding or seeding. In glacial till cuts, the surface should be scarified and mixed with the first 50 mm of topsoil.

All cuts deeper than 8m should be provided with a half-height bench, atleast 2.5m width and sloped back into the cut at a 1% gradient. The contact swale should be graded along the cut to drain away accumulated surface waters.

8.1.6. Volume Adjustment Factor

The volume adjustment factor to be used in mass haul and earth fill calculations are as follows:

Earth Cuts (silty sand till)
10 percent compaction
(1 cu. m. insitu = 0.90 cu. m. recompacted)

8.1.7. Frost-susceptible Subgrade

The following areas contain frost susceptible soils and should be treated as shown below.

<u>Station</u>	<u>Soil</u>	<u>Treatment</u>
30+000 to 29+710	insitu silty sand till	Cut area. Frost protection treatment in subballast, as below.
29+710 to 29+200	silty sand till back-fill	Fill area. Frost protection treatment in subballast, as below.
29+200 to 28+810	silty sand till back-fill	Fill area. Frost protection treatment in subballast, as below.
28+810 to 28+630	insitu silty sand till	Cut area. Frost protection treatment in subballast, as below.
28+630 to 28+300	insitu silty sand till	Cut area. Frost protection treatment in subballast, as below.



The limits of treatment as indicated above, are approximate in that they represent the limits of frost susceptible materials and/or free and capillary water within 1.2 m of profile grade taken from the soils profile.

In cut areas, the frost protection treatment should consist of 260 mm of granular 'B' Type 1 over 40 mm polystyrene (styrofoam HI-60- or equivalent) over 300 mm of compacted granular 'B' on subgrade. In fill areas, 275 mm of granular 'B' is required over 25 mm polystyrene over 300 mm of compacted granular 'B' on subgrade. For the transition areas from cut to fill, the 40 mm polystyrene is extended to the fill area until there is a minimum of 1.2 m of compacted fill below the subballast. This is a revision to the GO-ALRT Standards (Appendix 1).

The polystyrene should extend from outside shoulder to outside shoulder.

The granular layers should be compacted to minimum 100 percent Standard Proctor density, in lifts not exceeding 300 mm below the treatment and 200 mm above the treatment.

8.1.8. Benching

The GO-ALRT mainline right of way width will interfere with the existing CP railway embankments, In particular between Stations 28+700 and 30+000. The GO-ALRT embankment should be keyed into the CP embankment as per MTC Std. DD-414.

8.1.9. Granular Materials

Granulars 'A' and 'B', Type 1 are recommended for use on this project. Granular materials should be placed full width. For both cuts and fills the sub-ballast material should consist of 600 mm of granular 'B' compacted to a minimum 105 percent Standard Proctor density in loose lift thicknesses not greater than 200 mm. The sub-ballast granular should extend full width daylighting at a 2:1 (horizontal:vertical) slope with a minimum 3 percent subgrade crossfall for internal drainage.

8.1.10. Transition Treatment

All transitions between cuts and fills should be treated according to MTC Standard DD-411 with 20:1 tapers.

Transition treatments are required at the following locations:

<u>Stations</u>	<u>Remarks</u>
29+740	cut to fill
28+780	fill to cut
28+730	cut to fill
28+680	fill to cut

*use t=1m



8.1.11. Dewatering

In the main drumlin cut, the water table will be encountered below about elevation 103. Drainage of the cut should be facilitated by advance ditching.

The sand and gravel lenses contained within the drumlin contained confined water. As the cut is deepened through these lenses, free water will emerge and tend to wash out the non-cohesive materials as it does so, causing sloughing. Hence, dewatering by advance ditching will help to drain these pockets and minimize sloughing of the slopes.

8.1.12. Subdrains

Subdrains should be installed only when property restriction limit the right of way available for construction of open ditches.

In order to control seepage over the long term from the sand and gravel lenses, it is recommended that subdrains be installed approximately at elevation 97m. from the westerly limit of the project to Sta. 28+600. Proper outfall facilities should be provided at either end of the subdrain. Subdrain construction should be in conformity with M.T.C. Form 405/406. Use 19 mm clear Stone for granular backfill.



9. MISCELLANEOUS

The field work for this project was carried out using drilling machines rented from Master Soil Investigations Ltd., under the supervision of Mr. R.H. Yamamoto, Project Engineer, with field/office coordination by Mr. R. Blackburn. Additional field work in the drumlin cut areas was carried out with a power auger machine rented from Morton and Partners Ltd. The soils design report and associated profile were written and prepared by Mr. R.H. Yamamoto under the technical direction of Mr. C. Mirza, Principal.

Yours very truly,
C. MIRZA ENGINEERING INC.

R.H. (Ray) Yamamoto
Geotechnical Engineer

For:
Cameran Mirza, P. Eng.
Consulting Geotechnical Engineer.





APPENDIX 1. GO-ALRT SYSTEMS STANDARDS

This Appendix contains preliminary standards for the substructure design of the GO-ALRT system entitled:

Systems Standards, Part 2 Engineering
Section 2.2 Civil and Structural,
Subsection 2.2.10 : At-grade Guideway Substructure
dated October, 1983.

It is understood this Standard has since been revised.

2.2 CIVIL AND STRUCTURAL
2.2.10 AT GRADE GUIDEWAY - SUB-STRUCTURE
2.2.10.1 Tie-and-Ballast System

.1 Scope

This Standard covers substructure design to support ballast, it does not cover the design of tie-and-ballast track itself which is covered under Item 2.2.12, At-Grade Tie-and-Ballast Track.

This Standard gives general requirements only. The final design is site specific and therefore this Standard must be read in conjunction with the "Soils Design Report" written by the Soils Consultant for design of that specific section of guideway.

.2 Fill Materials

Sub-Ballast

The sub-ballast material shall consist of 600 mm of granular material equivalent to Granular 'B', Type 1 compacted to a minimum 105% Standard Proctor density in loose lift thickness not greater than 200 mm. The sub-ballast granular material has to be approved by the Geotechnical Consultant.

Typically, the sub-base granular will extend full width daylighting at a 2:1 (horizontal:vertical) slope with a 3% subgrade crossfall to insure adequate drainage of the trackbed structure.

Embankment Fill (Figure A)

The upper 1.0 m of fill for embankments located immediately below sub-ballast shall consist of borrow material compacted to a minimum Standard Proctor Density of 100% in lifts not exceeding 300 mm. The remainder of the embankment fill should consist of suitable borrow compacted to a minimum 95% Standard Proctor Density in lifts not exceeding 300 mm.


.3 Side Slopes

All cut and fill and ditch side slopes shall be designed to a minimum 2:1 geometry.

.4 Sub-Soil Preparation

Topsoil shall be removed and shall not be reused as fill material.

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Pockets of deleterious material shall be replaced with properly compacted borrow material, all as specified by the Geotechnical Engineer.

In case of extremely weak sub-soil, piled or caissoned support structures should be considered.

The sub-soil both in cut and for fill must be scarified to a depth of 150 mm and recompact to a minimum 100% Standard Proctor Density immediately prior to placement of granulars.

.5 Transition Between Cut and Fill (Figure D)

All transition point treatment should be carried out for full frost depth requirements and minimum tapers of 20:1 shall be incorporated. The frost depth is measured from top of sub-ballast and is assumed to be 1.2 metres.

.6 Insulation (Figure B)

In frost susceptible cut locations, provided soil conditions and economies dictate, the rigid insulation board shall be used to reduce the quantities of subexcavation and insure a uniform trackbed design. In these site specific locations, the sub-ballast material shall consist of 250 mm granular on 50 mm of Styrofoam HI-60 insulation board on 300 mm granular overlying subgrade. Adequate permanent sub-drainage is required with this styrofoam alternative. The granular shall be compacted to a required minimum 105% Standard Proctor Density, as before, however, the lower 300 mm should be placed in one lift.

.7 Geotextiles

Depending on the gradation of sub-grade material an appropriately designed geotextile may be required between the sub-ballast and sub-grade to prevent pumping of fines and the resulting contamination of the sub-ballast materials.


.8 Drainage

General

Trackbed drainage is provided with full width granular, 3% crossfall of sub-ballast and sub-grade, and an adequately designed ditch in the standard section.

Bottom of ditches shall be kept a minimum of .5 m below bottom of sub-ballast.

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Sub-Grade Drainage (Figure B and C)

In Cut

Provided property restrictions (no space for open ditches), utility concerns and/or high groundwater level exist, an effective sub-drain scheme will be required to ensure the sub-ballast remains unsaturated and that groundwater is intercepted. A 100 mm diameter perforated pipe surrounded by 19 mm clear stone placed in a trench enclosed with geotextile outletting every 50 metres into general guideway drainage (sewer or water course) would provide an effective sub-drain design. This sub-drain shall be below and in direct contact with the sub-ballast.

.9 Erosion Control

Proper temporary drainage and erosional control techniques must be maintained during construction to insure the integrity of both the subgrade and sub-ballast granulars particularly if tie and ballast placement is delayed.

Normal seeding and mulching techniques will insure the integrity of most cut and fill slopes, however, more elaborate techniques including interceptor drains, erosion control blankets, sodding, etc. will be required at specific locations. Considering the need to minimize both short and long term maintenance procedures, these suspect seepage locations should be identified during design and treatments incorporated in construction, rather than addressing them later when problems occur.

.10 Settlement Criteria

(to be completed)

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FIGURE 'A'

Geo-ALERT

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ENGINEERING

TITLE

SECTION

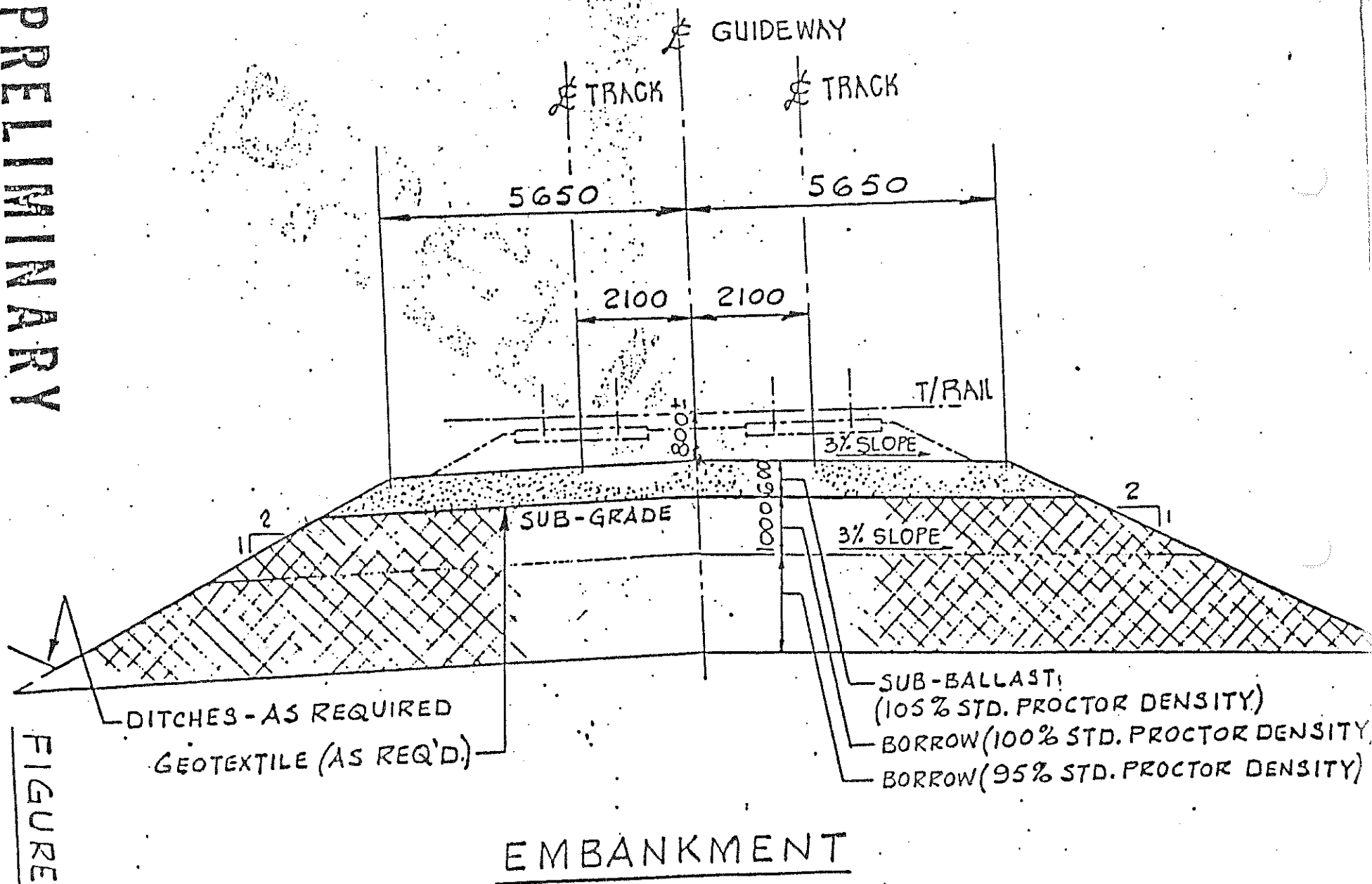
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CIVIL AND STRUCTURAL

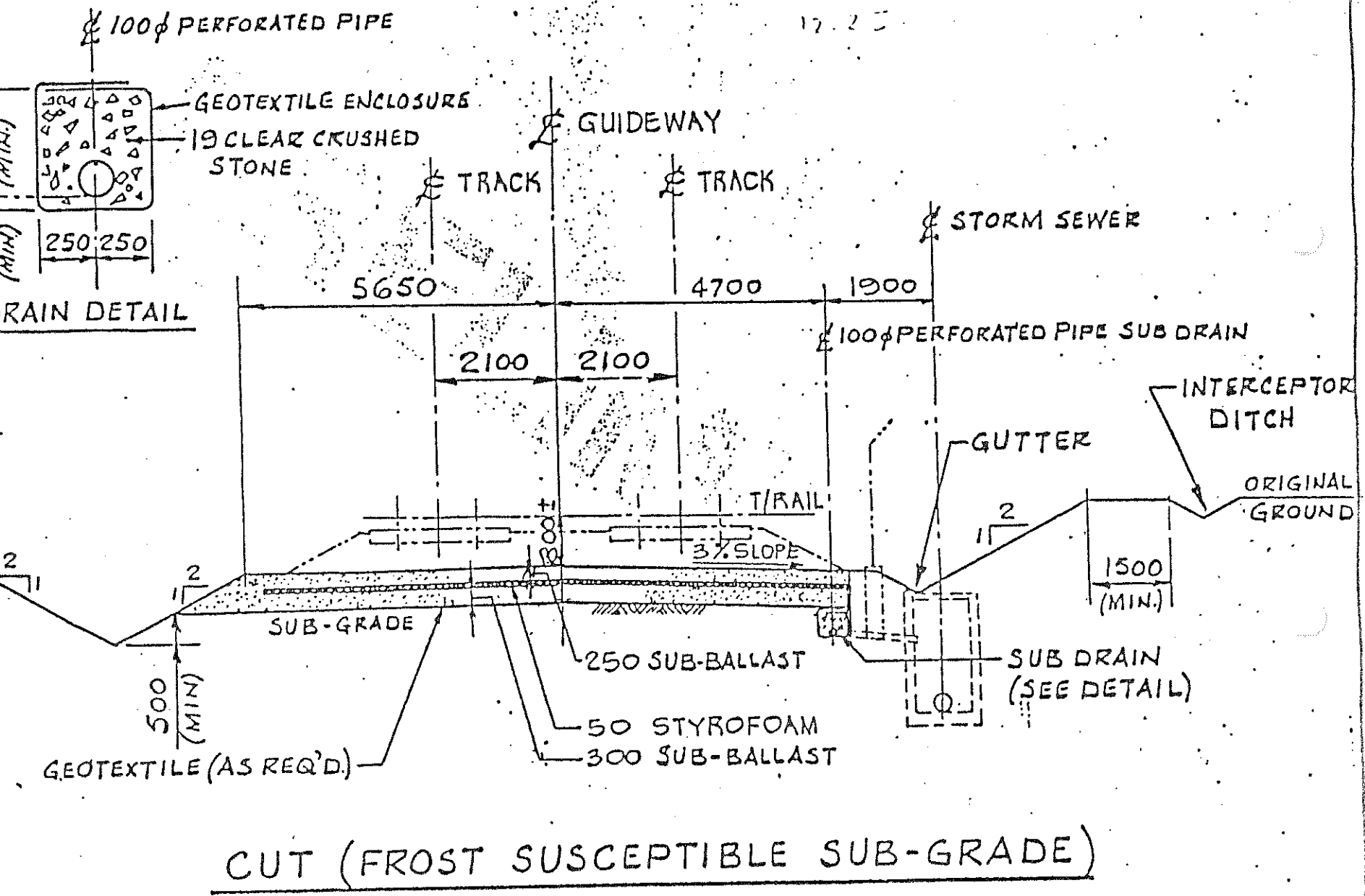
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FIGURE 'B'



PRELIMINARY

FIGURE 'C'

GO-AL-BE

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2.2

INTERCEPTOR DITCH

ORIGINAL GROUND

1500
(MIN.)

2

500
(MIN.)

T/RAIL

2100

2100

5650

4700

1900

TRACK

TRACK

STORM SEWER

100 ϕ PERFORATED PIPE
SUB DRAIN

3% SLOPE
SUB-GRADE

3% SLOPE
SUB-GRADE

400
SUB-BALLAST

GEOTEXTILE (AS REQ'D.)

SUB DRAIN
(SEE DETAIL
ON FIGURE B)

CUT (NON FROST SUSCEPTIBLE SUB-GRADE)

SCALE: 1:50

GUIDEWAY

5600

(INSIDE FENCE)

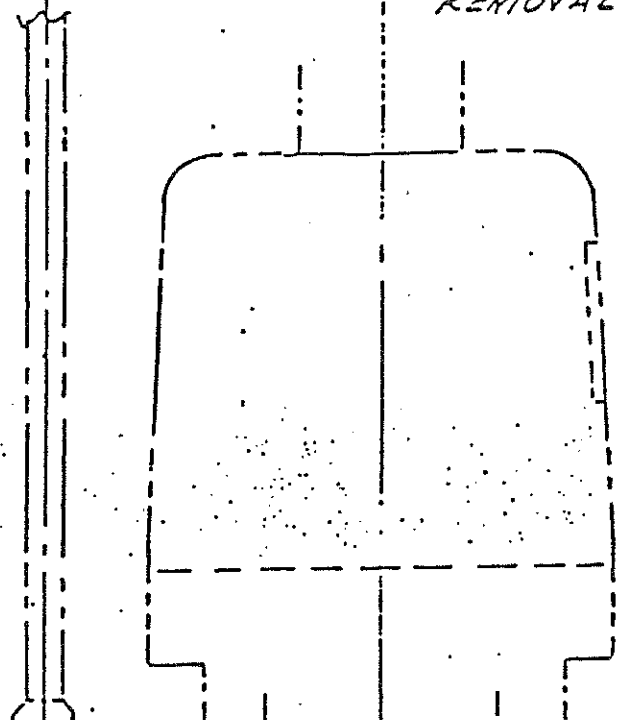
TRACK

2100

3500

(DISTANCE REQ'D. FOR
REMOVAL OF 8'-6" TIE)

THESE DIMENSIONS USED AS
BASIS FOR SUBSTRUCTURE
PRELIMINARY STANDARDS
SECTION 2.2.10 DATED OCT. 3/83



RT/RAIL

800

400

TIE

BALLAST

3%

600

SUB-BALLAST

3%

SUB-GRADE

800

1300

1300

400

1400

450

(8'-6" TIE)

5650 (SUB-BALLAST SHOULDER)

2400

FENCE

2

1

500
(MIN)

NOTE: IT IS PROPOSED THAT IF AN 8'-3" TIE IS USED IN LIEU OF THE 8'-6" TIE SHOWN, THEN THE 450 SUB-BALLAST SHOULDER WIDTH WILL INCREASE, BUT THE 5650 WILL REMAIN THE SAME PRINCIPLE WOULD APPLY IF THE BALLAST DEPTH IS REDUCED.

PRELIMINARY

HATCH ASSOCIATES LTD.
Consulting Engineers
GO-ALRT - TIE & BALLAST TRACK
AT GRADE GUIDEWAY SUBSTRUCTURE

DWG. NO.

6773-SK-15



APPENDIX 2 - SERVICES AND UTILITIES



APPENDIX 2 - SERVICES AND UTILITIES

Utility Treatments

A number of utility installations cross and/or lie within the limits of the GO-ALRT guideway substructure. Crossings of buried conduits must satisfy the regulations set by C.T.C. General Order 1981-8 Rail (summarized in Section 6.3). This should be verified at the detailed design stage. The conditions of trench backfill materials at these crossings are not known since borings were not allowed close to the buried conduits.

<u>Utility</u>	<u>Crossing Location</u>	<u>Conduit Details</u>
Region of Durham	Sta.29+933+(Park Road)	water line, 400mm Ø
Note:	Sta.29+925 to east(along Sinclair Ave.,offset 10m Rt. of GO-ALRT centreline)	sanitary sewer
Consumers' Gas	Sta.29+932+(Park Road)	gas pipeline
	Sta.29+120+(Stevenson Rd.)	gas pipeline
Pine Ridge Cable	Sta.29+923+(Park Road)	cable line
TV		
Bell	Sta.29+920+(Park Road)	telephone cable
	Sta.28+250+(Thornton Rd.)	telephone cable
Region of Durham	Sta.29+925+(Park Road)	storm sewer, 610mm Ø
	Sta.29+115+(Stevenson Rd.)	storm sewer, 1700mm Ø
Oshawa Hydro	Sta.29+100+(in Stevenson Rd. overpass)	electric power line
Region of Durham	Sta.29+510+	sanitary sewer, 410mm Ø
City of Oshawa	Sta.29+750+(Cromwell Ave.)	storm sewer, 460mm Ø
Note:	Sta.29+650 to 29+840(offset 5m Rt. of GO-ALRT centre- line)	storm sewer, 610mm Ø
Region of Durham	Sta.29+092+(Stevenson Rd.)	water line, 610mm Ø
Note:	Sta.29+308+(offset 7m Lt. along ditch)	culvert,700mm Ø
	Sta.29+054+(Stevenson Rd.)	water line



Regardless of CTC requirements it is recommended that all relocated or existing utilities be located at depths of 1.7 m below bottom of rail, the depth being measured to the pipeline crown level.

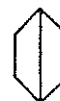
Since many of the utilities will likely be trenched within the glacial till or the stiff silty clay layer, backfilling should be as per MTC Standard DD-823 (Class C-3).

Preliminary calculations show that at depths of 1.7 m or greater, the imposed static and rolling loads produce minimal additional stresses on the buried pipes. The utilities are considered to be negatively projecting conduits which attract loads through negative arching. Therefore, to maximize positive arching, the upper 300 mm of backfill above the pipe crown should be placed in a loose condition.

If any of the utility pipes cannot be placed at depths of 1.7 m or greater below base of rail, consideration should be given to providing a 150 mm thick reinforced concrete load relieving slab extending at least one pipe diameter to either side of the trench excavation and resting on competent bearing material such as glacial till or compacted granular.

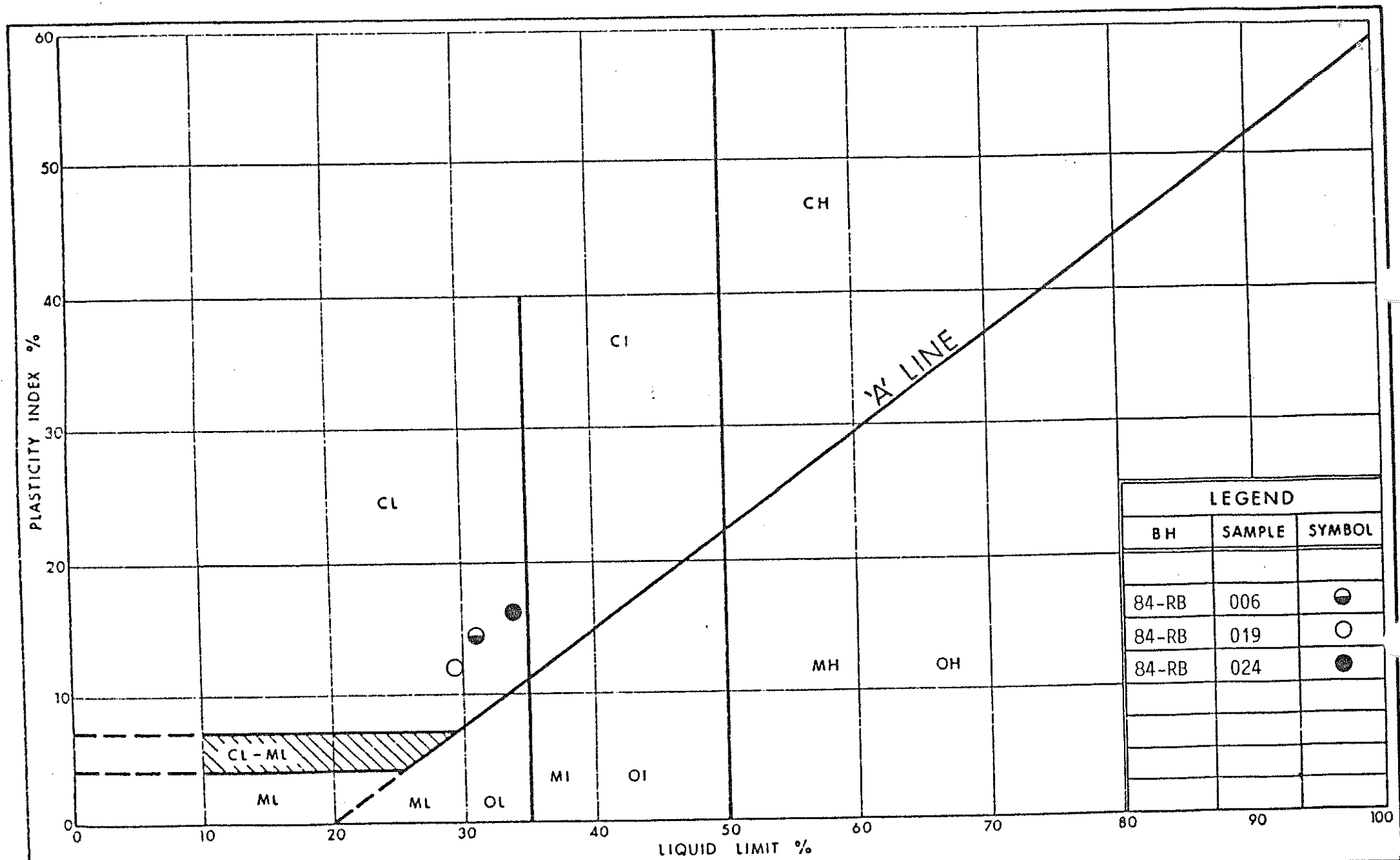
Utility Trench Backfilling.

Several utilities lie within the limits of the GO-ALRT embankment or cuts. In locations where these utilities are to be relocated, the vacated trenches should be purged of the native backfill material and backfilled with non-cohesive select subgrade materials, compacted to minimum 100 percent of the Standard Proctor Density, within 1.0 m of the subgrade elevation and minimum 95 percent Standard Proctor Density below 1.0 m.



APPENDIX 3 -
GRAIN SIZE DISTRIBUTION CURVES

- Figure 1. Plasticity Chart for silty Clay.
- Figure 2. Plasticity Chart for glacial till.
- Figure 3. Grain size distribution for silty Clay.
- Figure 4. Grain size distribution for sand, sand with gravel.
- Figure 5. Grain size distribution for glacial till.



Ontario

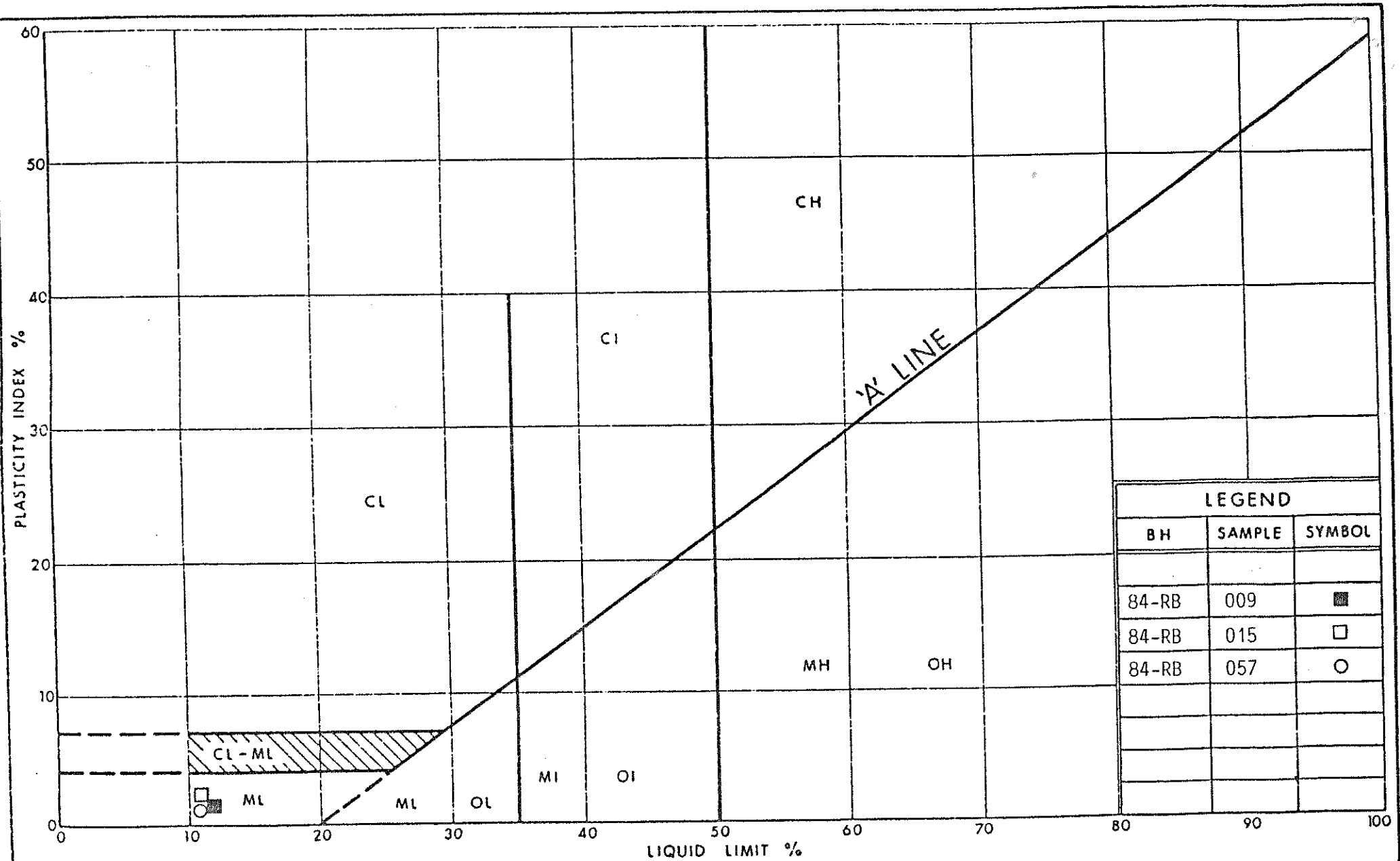
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PLASTICITY CHART

SILTY CLAY

FIG No 1

W P GO-ALRT EGG-000-1



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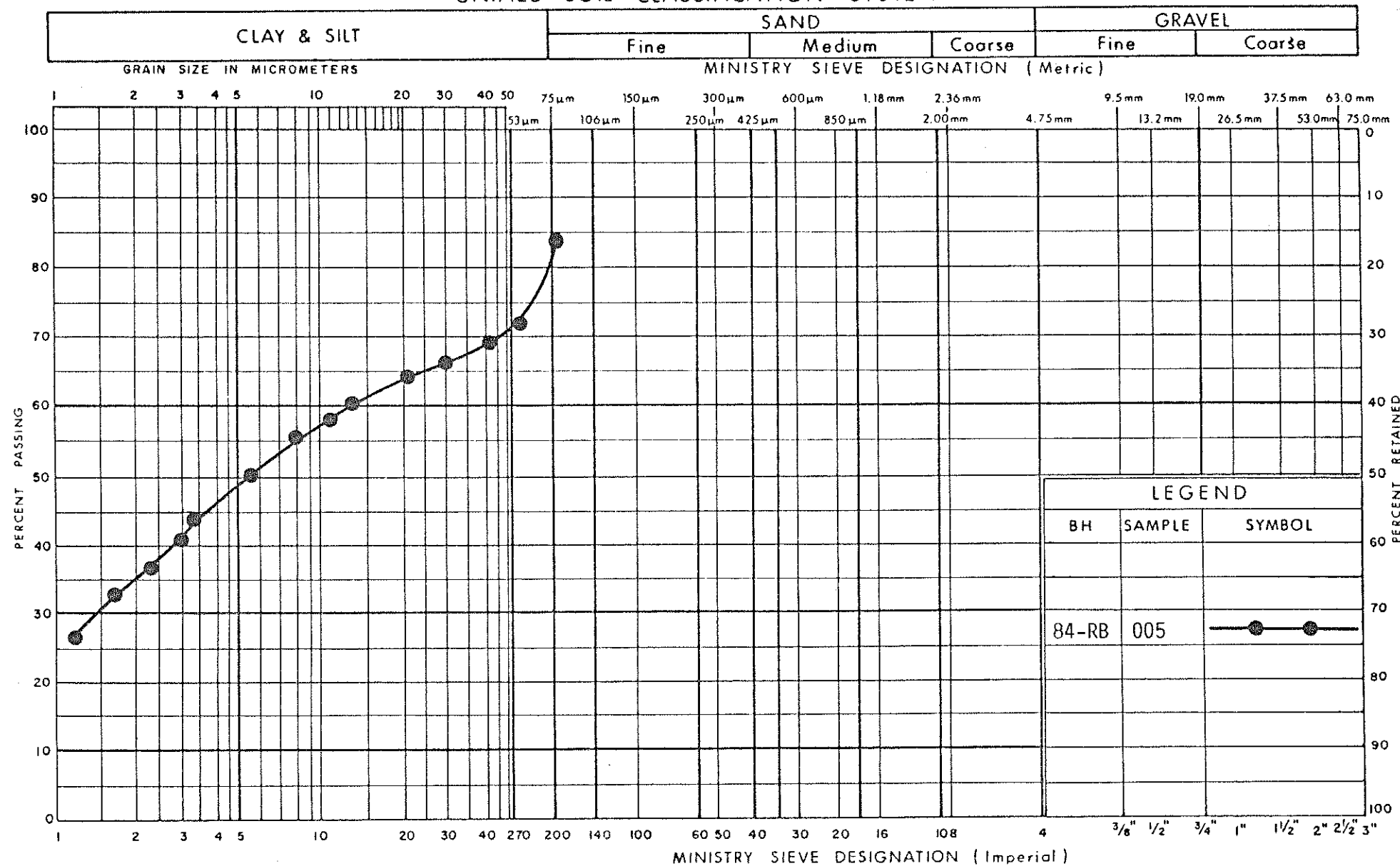
PLASTICITY CHART

GLACIAL TILL

FIG No 2

W P 60-ALRT EGG-000-1

UNIFIED SOIL CLASSIFICATION SYSTEM



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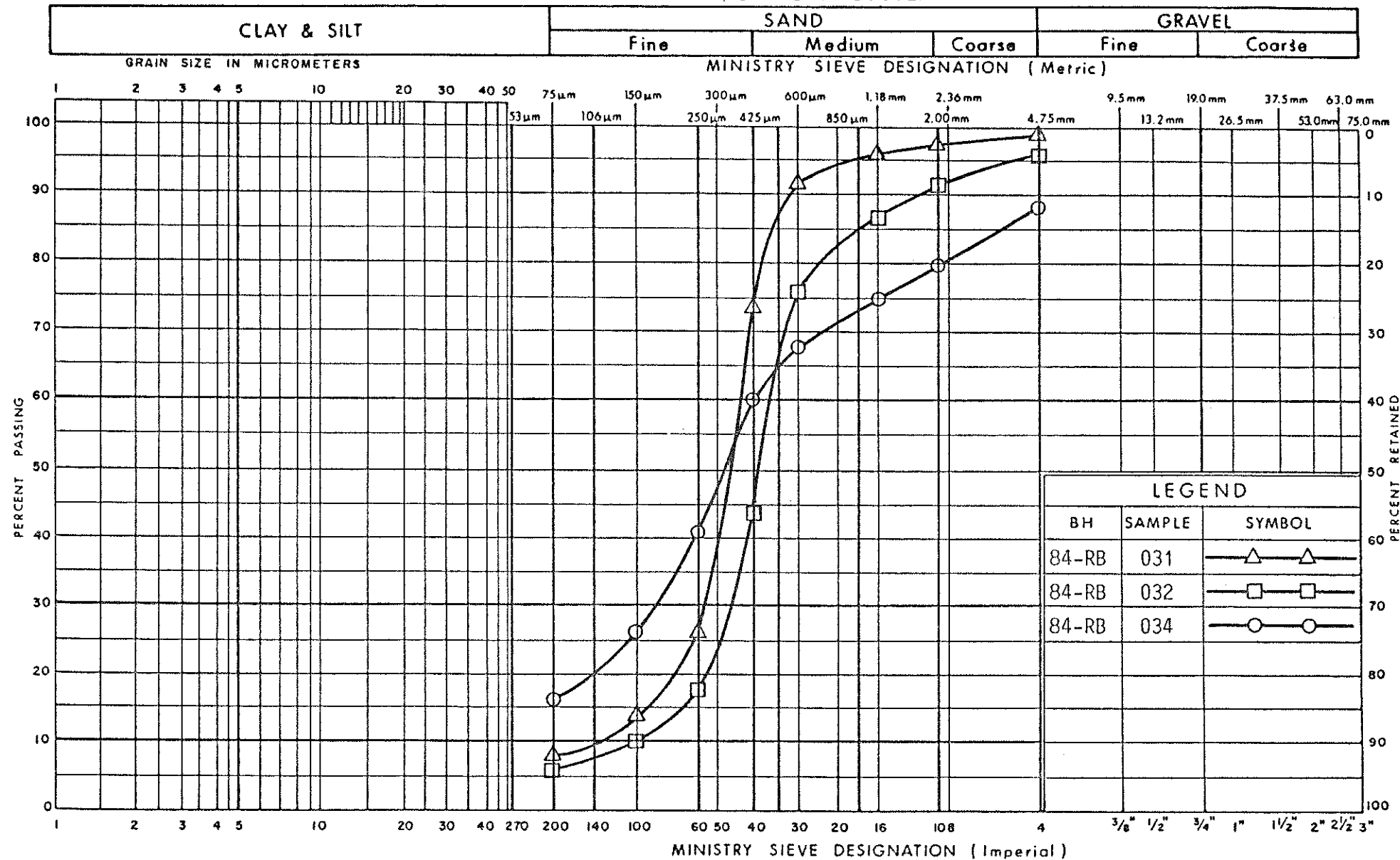
GRAIN SIZE DISTRIBUTION

SILTY CLAY

FIG No 3

W P GO-ALRT EGG-000-1

UNIFIED SOIL CLASSIFICATION SYSTEM



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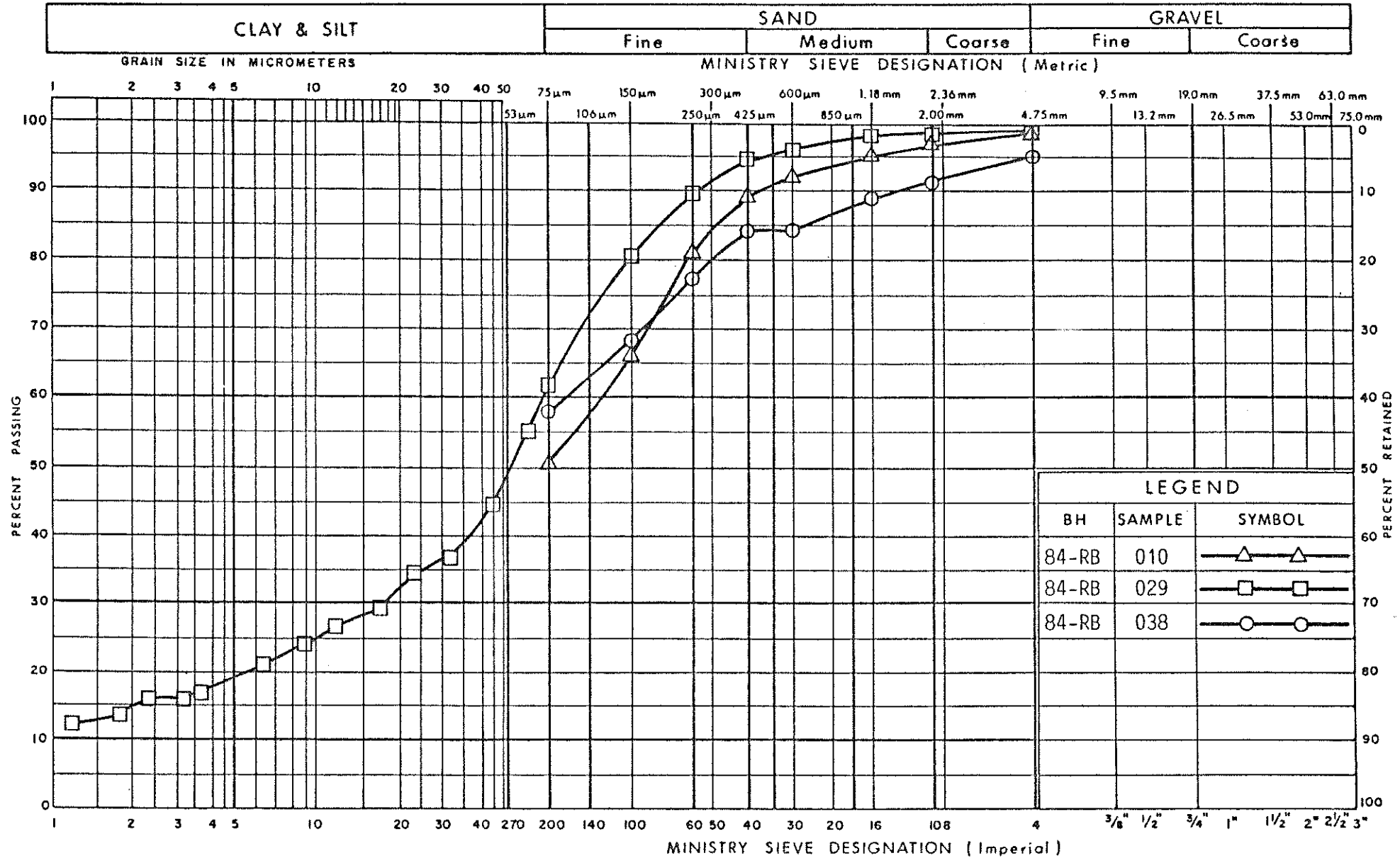
GRAIN SIZE DISTRIBUTION

SAND, SAND WITH GRAVEL

FIG No 4

W P GO-ALRT EGG-000-1

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

GLACIAL TILL

FIG No 5

W P GO-ALRT EGG-000-1