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The City of Winnipeg Bus Rapid Transit System – Southwest Corridor Geotechnical Investigation and Preliminary Recommendations

Report

A03023A01.01

KLOHN CRIPPEN

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May 10, 2004

Dillon Consulting Limited
2nd Floor, 895 Waverley Street,
Winnipeg, Manitoba
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Norman Ulyatt, P. Eng.
Regional Practice Leader
Transportation Engineering NW Region

Dear Mr. Ulyatt:

The City of Winnipeg
Bus Rapid Transit System - Southwestern Corridor
Geotechnical Investigation and Preliminary Recommendations
Report

We are pleased to submit our report detailing the geotechnical site characterization and foundation recommendations for the City of Winnipeg Bus Rapid Transit System – Southwestern Corridor. This report was prepared by Klohn Crippen Consultants Ltd. for Dillon Consulting Limited.

Yours truly,

KLOHN CRIPPEN CONSULTANTS LTD.

Thomas K. Murray, P.Eng.
Project Manager

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Dillon Consulting Limited

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EXECUTIVE SUMMARY

The City of Winnipeg is currently planning construction of a new Bus Rapid Transit (BRT) system. The BRT system is based on light-rail transit principles, but instead of the required capital investment in trains and track, it utilizes buses in service that are integrated with key components of the automobile transportation infrastructure, including existing roads and rights-of-way, intersections, and traffic signals.

The BRT system will be constructed in phases with the Southwestern Corridor section to be constructed initially followed by an Eastern Corridor. Design and construction is scheduled to occur over the next several years. The majority of the route will parallel the existing CN railway mainline track and will involve several major structures for roadway, railway and river crossings. A series of geotechnical investigations are required to assist the planning and design of these facilities. This report describes an investigation of the Southwestern corridor and includes the following main structures: Osborne Street Overpass, CNR Underpass and the BRT Test Section Roadway.

The Southwestern Corridor section extends southwest from downtown Winnipeg along the west side of the Red River. For most of the alignment, the new BRT roadway will be constructed within or nearby the existing CNR right of way. At the northern end of the Southeast Corridor section of the BRT roadway, the alignment will follow the west side of CNR right of way and will cross Osborne Street immediately beside the existing overpass. At this location, the grade is expected to be about 2 m to 3 m above surrounding ground level and Osborne Street will pass underneath. Immediately south of the Osborne Street overpass, the BRT roadway will cross underneath the CN railway. The main tracks and sidings involve seven sections of track at this location. On the south side of the CNR underpass crossing, the BRT roadway will parallel the tracks on the east side for a length of approximately 1 km. This section will be constructed initially and will likely be operated as a test section prior to linking with other sections.

The site investigation program for the Southwestern Corridor included 13 holes drilled between June 16 and 19, 2003 and on June 27, 2003. Two test holes were drilled in the vicinity of the Osborne Street overpass, five test holes along the proposed CN railroad crossing and six test holes extending along the length of the BRT test section that runs parallel to the CN railway. The total depths of the drill holes varied from 3.2 m to 14.6 m below the existing ground surface. After completion of drilling, 25 mm diameter PVC standpipes piezometers were installed in selected test holes.

The investigation indicated the following subsurface conditions: fill (highly variable in thickness and type dependent on location), over lacustrine clays and silts (typically firm, high plasticity clay in excess of 11 m thick), over silty/gravely till. Index testing of the clay indicates liquid limits vary from 60% to 113% and average about 93%. Plasticity

indices average about 70%. Drilling refusal was encountered in the till at depths of 15 m to 16 m below the ground surface and bedrock was not encountered. Topsoil was typically less than 150 mm thick but was not present in all areas of the site dependent on the amount of development in a particular area.

Two water-bearing strata were identified in the site area. The lower aquifer is located in the gravelly till and standpipe piezometer readings indicated a water level of about 12 m below ground level. The upper aquifer comprises a silt seam varying in thickness from 0.30 m to 0.85 m at a depth between 2 m and 3 m below ground surface. This saturated layer was located above the lacustrine clay sediments and indicated a water level of about 2 m below ground level. From past experience, the upper aquifer is relatively small with low observed flow rates and is readily controlled through drainage and/or excavation. In comparison, the lower aquifer can produce significant flow rates and can impact the till strength.

Soluble sulphate concentrations were found to be negligible to severe indicating a potential for a considerable degree of sulphate attack in some areas. It is recommended that Type 50 cement be adopted for the project.

At the time of the investigation, some of the observed water levels were within the maximum expected frost penetration depth. Road grades should be raised or drainage measures such as perimeter drains should be included along the roadway section. In addition, excavations such as the cut required for the track underpass will result in a relatively shallow water table relative to the finished grade. In these areas special measures such as pumping and insulation will be required to ensure frost related problems do not occur.

At the time of this report, no information was available regarding structure type or magnitudes of loading on foundations. Therefore the recommendations in this report are generic and preliminary in nature. In general, the following recommendations are provided:

For the Osborne Street overpass, the stratigraphic conditions comprise about 2.0 m to 2.5 m of fill or silt and clay over high plasticity lacustrine clay. The high plasticity clay extends to a depth of 14 m to 15 m below the ground surface and is underlain by a dense silty till. The upper groundwater table was found to be about 1.7 m below the ground surface, with the lower groundwater table in the till at about 12 m to 13 m below the ground surface. The recommended method of foundation support for the overpass structures is driven pre-cast concrete piles bearing in the till. Retaining walls will be required alongside the street with appropriate drainage measures.

The proposed underpass crosses under seven tracks of the CN railway and will involve a box type structure about 6 m high by 12 m wide that is approximately 145 m in length with an invert elevation of about 224 m or about 9 m below the tracks and a crown cover of about 3 m. The stratigraphic conditions comprise about 2.0 m to 3.0 m of fill or silt and clay over high plasticity lacustrine clay. The high plasticity clay extends to a depth of 12.5 m to 15 m (elevation 218 m) below the ground surface and is underlain by dense silty clay till. The upper groundwater table was found to be about 2.5 m below the ground surface, with the lower groundwater table in the till at about 12 m below the ground surface. The design profile indicates that the majority of the proposed underpass would be within the high plasticity clay unit with the crown in fill or silt and clay. Despite the high traffic volumes of the CN railway, it is considered that a staged "cut and cover" method is a suitable method to construct the underpass. The proposed configuration with horizontal and vertical curvature, shallow depth and soft ground is not appropriate for either conventional shield tunneling, full-face advance, or jacking a concrete box structure. Staged excavation to control ground deformations and face stability with primary support provided by a suitable combination of steel ribs, welded wire mesh and one or more layers of shotcrete may be feasible. However, this would be a very expensive and technically challenging approach due to the very small depth of cover over the crown.

The proposed grade for the test section is elevation 233 m. The subsurface stratigraphy is comprised of about 2 m to 3 m of clay and silt fill with occasional sand and gravel over high plasticity clay. Groundwater, where observed, was about 1 m to 4 m below the ground surface. The recommended roadway section should comprise a concrete pavement thickness of 250 mm on 450 mm of compacted A-Base over a prepared subgrade. The upper 75 mm of A-Base can be replaced with a porous asphalt to provide added stability and reduce the A-Base thickness to 300mm. All materials and construction are to be in accordance with the City of Winnipeg Standard Construction Specifications, Division 4, CW3110-R6, CW3310-R7 and CW3410-R5.

Additional geotechnical analyses will be required during detailed design when structure layouts and loadings are available.

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1. INTRODUCTION

The City of Winnipeg is currently planning construction of a new Bus Rapid Transit (BRT) system. The BRT system is based on light-rail transit principles, but instead of the required capital investment in trains and track, it utilizes buses in service that are integrated with key components of the automobile transportation infrastructure, including existing roads and rights-of-way, intersections, and traffic signals. The BRT system will be constructed in phases with the Southwestern Corridor section to be constructed initially followed by an Eastern Corridor. Design and construction is scheduled to occur over the next several years and may extend as long as 2010. The majority of the route will parallel the existing CN railway track and will involve several major structures for roadway, railway and river crossings. A series of geotechnical investigations are required to assist the planning and design of these facilities.

Tom Murray, P.Eng. of Klohn Crippen Consultants Ltd. and A. Dean Gould, P.Eng. of National testing Laboratories Limited met with Norm Ulyatt, P.Eng. of Dillon Consulting Ltd. on April 7, 2003 to discuss the scope of work for the overall project as well as the geotechnical investigation component. Subsequent to the meeting, Mr. Murray and Mr. Gould inspected each of the proposed structure sites. Based on discussions at the meeting with Mr. Ulyatt, the following main structures and BRT roadway components are included in the investigations.

Southwestern Corridor (2003)

- Osborne Street Overpass
- CNR Underpass
- BRT Test Section Roadway

Eastern Corridor (2004)

- Red River Bridge
- Seine River Bridge
- Archibald Street Overpass

The first phase described in this report was carried out in 2003 for the Southwestern Corridor section and the second phase will be carried out commencing in 2004 for the Eastern Corridor section.

This report addresses only the geotechnical issues. The geotechnical investigation for this project was carried out in accordance with the discussed terms and is briefly summarized as follows:

- Collect and review existing geotechnical data in the area of proposed works.
- Undertake the new geotechnical investigations.
- Identify areas within the project site limits that have similar soil conditions and can be characterized in similar manner.
- Identify site and subgrade preparation requirements including topsoil stripping if required.
- Evaluate temporary excavation and groundwater control including slope stability of excavation slopes, dewatering requirements and freezing effects.
- Provide recommendations for bearing capacity and pile foundations.
- Evaluate settlement of structures and foundations.
- Provide recommendations for lateral loads for retaining walls.
- Provide recommendations for backfilling methods, materials and specifications.
- Identify the soil moisture profile and groundwater conditions and provide recommendations for permanent drainage.

- Identify requirements for buried services.
- Provide recommendations regarding the use of sulphate resistant cement in foundation substructures.
- Provide recommendations for frost protection and heaving.
- Provide construction recommendations.
- And identify other relevant geotechnical information.

2. SITE DESCRIPTION

The Southwestern Corridor section extends southwest from downtown Winnipeg along the west side of the Red River. For most of the alignment, the new BRT roadway will be constructed within or nearby the existing CNR right of way. At the north section of the BRT roadway, the alignment will follow the west side of right of way and will cross Osborne Street immediately beside the existing overpass. At this location the grade is expected to be about 2 m to 3 m above surrounding ground level and Osborne Street will pass underneath. The existing CN overpass structure consists of a two span structure with vertical retaining walls at both abutments and a central pier. It is understood the new structure for the BRT system will possibly involve three spans.

Immediately south of the Osborne Street overpass, the BRT roadway will cross underneath the CN railway. The main tracks and sidings involve seven sections of track at this location. The underpass will involve a box section that is approximately 145 m in length with approach grades of 65 m and 95 m on either side. Due to space limitations, the approach grades will require retaining walls on both sides.

On the south side of the CNR underpass crossing, the BRT roadway will parallel the tracks on the east side for a length of approximately 1 km. This section will be constructed initially and will likely be operated as a test section prior to linking with other sections.

3. GEOLOGICAL SETTING

The City of Winnipeg is located on the remains of the glacial Lake Agassiz that covered much of Manitoba for several thousand years following the last ice age. The lake left fine-grained sediments ranging from clay to silt precipitated from the lake and these have been divided into two distinct units (Baracos and Kingerski, 1998).

The upper unit is called the Complex Zone Unit and ranges from 1.0 m to 4.5 m thick with an average thickness across the City of about 3 m. The sediments in this unit have been affected by river flooding, erosion and deposition, desiccation, vegetation and human activity. A seam of lacustrine silt defines the bottom of this unit. A near surface water table exists in the Complex Zone Unit at a depth that is typically between 1.5 m and 3.0 m.

The lower lake sediment unit is known as the Silty Clay Unit and is more homogenous. It consists of a silty clay lake sediment and extends from the Complex Zone Unit to the underlying glacial till. The thickness of this unit is typically between 9 m and 12 m.

Underlying the lake sediments is a glacial till deposit left by ice sheets that covered most of Canada during the Pleistocene epoch. According to Baracos and Kingerski (1998), this till layer varies from zero to 10 m deep across the City; however, it is reportedly thin to non-existent in the project area. The gradation of till material is inconsistent and ranges from clay size to boulders. The upper part of the till is often softer and wetter than the underlying dense till. Sand and gravel seams can occur above, below or within the till unit. Baracos and Kingerski (1998) noted the difficulty in determining whether refusal during drilling has occurred due to a boulder, dense till or bedrock.

The bedrock below most of the City of Winnipeg is generally comprised of dolomite and dolomitic limestone. In the vicinity of the project area, the bedrock is of the Fort Garry Member of the Red River Formation. The Ordovician Formations, including the Red River Formation dip to the southwest at a slope of approximately 0.004. The top of bedrock in the project area is typically found at depths ranging from 12 m to 15 m and the thickness of this dolomite/dolomitic limestone is at least 100 m. The top 15 m to 30 m of carbonate bedrock is typically very porous due to fracturing and solution. Sinkholes, caves, caverns and conduits give the bedrock a high water storage capacity. This zone is referred to as the Upper Carbonate Aquifer.

4. JUNE 2003 INVESTIGATION

4.1 Field Program

Prior to the commencement of the field program, aerial photographs were provided to Klohn Crippen by Dillon Consulting Ltd to aid in the program layout. The proposed hole locations were surveyed in the field and marked with stakes by Dillon Consulting Ltd. Utility locates were performed by the National Testing Laboratories Ltd. (NTL) of Winnipeg, during the week before drilling commenced, and was ongoing during drilling. Utility clearances were obtained from Winnipeg Hydro, Manitoba Hydro, the City of Winnipeg and CN Railways.

The proposed test hole program included 15 holes with four test holes in the vicinity of the Osborne Street overpass, five test holes along the proposed CN railroad crossing and six test holes extending along the length of the BRT test section, which runs parallel to the CN railway. However, due to utility restrictions, only two of the four holes were drilled near the Osborne Street overpass. As a result, a total of 13 holes were drilled. Initially, 12 holes were drilled between June 16 and 19, 2003 and due to access restrictions, one hole was drilled afterwards on June 27, 2003. The drill hole locations are shown on Drawings 3023-001 to 3023-003.

Drilling was performed by Paddock Drilling Ltd. from Brandon, Manitoba using a Canterra CT250 multipurpose rig, and an Acker MP-5. The work was supervised in the field by Mr. Scott Taylor, EIT, and Mr. Joel Hilderman, EIT, of Klohn Crippen Consultants Ltd. The total depths of the drill holes varied from 3.2 m to 14.6 m below the existing ground surface. The majority of the holes were drilled with solid stem auger with a single hole drilled with hollow stem auger.

For the holes in the Osborne Street and CNR sections, a combination of Shelby tube and Standard Penetration Test (SPT) sampling methods was used to obtain representative samples at regular intervals. Where possible, alternating SPT and Shelby samples were taken every 0.75 m up to a depth of 4.5 m. After this depth, samples were taken at intervals of 1.5 m. In addition, grab samples from the auger flights were taken in coarse material and near surface, where other sampling techniques were not possible. The holes were drilled until practical auger refusal was met, typically at a depth from 14.8 m to 16.2 m.

The holes along the BRT test section were drilled to a depth of 5.0 m. These holes were sampled by SPT every 1.5 m with intermediate grab samples taken from the auger flights.

All soil samples were transported to the NTL laboratory for testing. Test hole logs for the 2003 drill holes were prepared by Klohn Crippen and are presented in Appendix II. The descriptions applied to the various soil units as shown on the logs follow the Unified Soil Classification system with slight modification to recognize inorganic clays to medium plasticity (CI). Such descriptions are judgmental in nature and may differ in detail from that actually encountered in the field. The descriptions noted in the test hole logs are based solely on inspections of soil samples recovered or cuttings observed on the auger flights. The actual nature of the materials between samples may vary.

After completion of drilling, 25 mm diameter PVC standpipes piezometers were installed in selected holes. Each standpipe was backfilled with sand (No. 65) surrounding the hand-slotted section of pipe (wrapped in a filter sock) and the remainder of hole was backfilled with bentonite chips to seal off the response zone. Each standpipe was also protected with a lockable surface casing. As hole AH03-06 was located immediately adjacent to a set of railway tracks, a bolted flush-mount casing was installed. Test holes

AH03-01, 02 and 08 had double standpipe installations to measure the water levels in both the near surface aquifer and the till below.

The test hole coordinates are shown on the logs in Appendix II and are also listed in Table 1. Groundwater levels below ground level were recorded in all test holes wherever observed and corresponding water levels are shown on the test hole logs and on Table 2. Where no groundwater depth value is shown, the hole was observed to be dry at the time of the investigation or no water was observed in the standpipes.

Table 1 2003 Test Hole Summary

Test Hole	Northing (m)	Easting (m)	Ground Elevation (m)	Total Depth (m)	Location
AH03-01	5526235.4	633589.4	233.32	16.2	Osborne St.
AH03-02	5526165.9	633565.1	232.10	15.6	Osborne St.
AH03-05	5525985.5	633502.1	232.84	15.4	CNR
AH03-06	5525939.3	633513.3	232.24	15.2	CNR
AH03-07	5525903.1	633518.1	233.05	15.3	CNR
AH03-08	5525848.3	633516.7	232.62	14.8	CNR
AH03-09	5525792.1	633526.2	232.60	5.0	Test Section
AH03-10	5525647.0	633509.5	232.40	5.0	Test Section
AH03-11	5525375	633442	232.10	5.0	Test Section
AH03-12	5525177.8	633361.7	232.32	5.0	Test Section
AH03-13	5524942.1	633268.7	232.87	5.0	Test Section
AH03-14	5524571.2	633130.7	232.97	5.0	Test Section
AH03-15	5524291.9	632995.0	232.72	5.0	Test Section

Table 2 Standpipe Details

Test Hole	Ground Elevation (m)	Response Zone (m)	Water Depth BGL (m)	Water Level Elevation (m) (June 20/03)
AH03-01a	233.32	11.3 – 15.4 217.92 – 222.02	12.76	220.52
AH03-01b	233.32	2.1 – 3.5 229.82 – 231.22	2.63	230.69
AH03-02a	232.10	10.3 – 15.6 216.5 – 221.8	12.03	220.07
AH03-02b	232.10	0.7 – 3.0 229.1 – 231.4	1.71	230.39
AH03-06	233.24	11.3 – 15.2 218.04 – 221.94	12.34	220.90
AH03-08a	232.62	6.1 – 14.8 217.82 – 226.52	9.87	222.75
AH03-08b	232.62	1.5 – 3.6 229.02 – 231.12	2.70	229.92
AH03-09	232.60	1.3 – 5.0 227.6 – 231.3	1.73	230.87
AH03-11	232.10	0.9 – 5.0 227.1 – 231.2	3.54	228.56
AH03-13	232.87	1.1 – 5.0 227.87 – 231.77	1.19	231.68
AH03-14	232.97	0.8 – 5.0 227.97 – 231.17	1.28	231.69

4.2 Laboratory Testing

Laboratory testing was conducted by the National Testing Laboratories Ltd. of Winnipeg and the corresponding test program is listed below. The laboratory test results are shown on test hole logs in Appendix II where appropriate, or are included separately in Appendix III.

- Grain Size Distribution (Sieve and Hydrometer) - 4 tests
- Atterberg Limits - 12 tests
- Standard Proctor Maximum Dry Density - 2 tests

- Moisture Content - 180 tests
- Soluble Sulphate - 2 tests
- Consolidation Test - 2 tests
- Unconfined Compressive Strength – 4 tests
- Direct Shear Test - 1 test

The laboratory tests were performed following ASTM standard soil testing procedures or protocol, unless otherwise noted. The test results are intended to provide a general indication of some of the engineering properties of the material.

4.3 Soil Description

The investigations indicate the following stratigraphic sequence (listed from lower to upper). Summary cross sections are provided on Drawings 3023-001 to 3023-003.

i) Till
The till deposit is typically silty and gravely with some sand and clay. In test hole AH03-02 a seam of fine sand was observed beneath or within the till and occurred just above the refusal depth. The colour of the till ranges from pinkish or reddish brown to light brown. Observed samples of the till were typically very wet, with measured water contents of 10% to 20%. The surface of the till deposit varied from elevation 217.9 m to 220.1 m, and was typically at about 218 m. From past experience, the till is typically wet when the thickness over the bedrock surface is relatively thin.

ii) Lacustrine Clays and Silts
As discussed in Section 3, there are two defined units of lacustrine sediments. In many of the test holes the Complex Zone Unit was observed. In some holes, however, the entire upper unit has been excavated and replaced with fill. The top of this unit, where present, consists of a thin layer of clay. This clay ranges from low to medium plasticity and is firm to stiff. The colour varies from grey to brown. Below this clay is a seam of lacustrine silt ranging in thickness from 0.30 m to 0.85 m. The silt is soft, light brown and saturated. Its relatively high permeability

creates a perched water table. The bottom of the silt seam, which separates the Complex Zone Unit from the Silty Clay Unit was found to be at an elevation ranging from 230.1 m to 230.9 m, or approx. 2 m below ground surface within the seasonal frost zone.

The Silty Clay Unit of lacustrine sediments is typically in excess of 11 m thick. The base of the clay layer is found between an elevation of 218 m and 220 m. The stratigraphy of the sediments is quite consistent with the vast majority of the sediments being high plasticity clay. Index testing of the clay indicates liquid limits varying from 60% to 113% with an average of about 93%. Plasticity indices average about 70%. Natural moisture contents of the clay till typically range from about 45% to 55%. Actual values are shown versus depth on Figure 1A. Laboratory test results for the clay till are summarized in Table 3. The clay is typically firm to stiff near the top but becomes softer and wetter with depth. The colour is brown to olive grey with frequent gypsum inclusions. The clay has frequent till inclusions near its base.

The majority of Standard Penetration Test (SPT) results indicate a range of SPT N blow counts values of about 4 to 7 blows per 300 mm and are shown versus depth on Figure 1C. This indicates that the consistency of the clay is firm. This consistency is confirmed from pocket penetrometer and unconfined strength testing indicating an undrained strength of about 25 kPa to 60 kPa.

Table 3 Typical Properties of the Lacustrine Clay

Parameter		2003 Investigation Range (Average)
Moisture Content (180 tests)	(%)	45 – 55 (50)
Plasticity (12 tests)	Liquid Limit (%)	60 – 113 (93)
	Plastic Limit (%)	21 – 28 (24)
	Plasticity Index (%)	33 – 88 (70)
Gradation (4 tests)	% Sand	0.1 – 0.3 (0.2)
	% Silt	12.2 – 41.7 (22.5)
	% Clay	58.0 –87.6 (77.3)
Proctor (2 tests)	Max. Dry Density (kg/m³)	1390 – 1400 (1395)
	Optimum Moisture Content %	23.5 – 28.0 (26)
Soil Sulphate (2 tests)	(%)	0.01 – 1.63 (Neg.-Severe)
Unconfined Compressive Strength (4 tests)	(kPa)	52 – 69 (60)

Direct shear test sample results are presented in Table 4 and the test result is summarized on Figure 2. Based on normal consolidation stresses of 30 kPa, 60 kPa, and 120 kPa, the interpreted peak friction angle (ϕ') is 19.5° with a cohesion value of 16 kPa. The sample was sheared sufficiently to obtain a residual friction angle.

Table 4 Direct Shear Test Sample Summary

Hole ID	Depth (m)	Elevation (m)	Moisture Content (%)	Wet Density (kg/m³)	Dry Density (kg/m³)
AH03-06	7.6-8.2	225.3	42.4	1754	1232

Consolidation test results are presented in Table 5.

Table 5 Consolidation Test Summary

Hole ID	Depth (m)	Elevation (m)	Moisture Content (%)	Wet Density (kg/m³)	Dry Density (kg/m³)	e_0	Pc' kPa	Swell Pressure (kPa)	Cc
AH03-02	3.8-4.4	228.0	56.9	1695	1080	1.56	220-250	100	0.63
AH03-06	7.6-8.2	225.3	40.9	1800	1277	1.16	430	80	0.45

iii) Fill

The depth and type of fill was highly variable and dependent on location, however, fill was present in all holes drilled. Test hole sites located on the railroad bed had 0.3 m to 0.5 m of crushed rock and coarse gravel on the surface. This was underlain by a mixture of cinders, sand, silt and gravel. The black granular fill was dry to wet depending on location. The majority of holes also had a layer of silty clay fill beneath the granular fill. This silty clay fill is probably reworked native material that originally belonged to the Complex Zone Unit of lacustrine sediments.

The area to the east of the CN railway crossing includes sections of concrete walls and building foundations that are buried with overlying fill to a depth of approximately 3 m. Test holes BH03-08 and BH03-09 were drilled in the area of buried building foundations.

Topsoil was typically less than 150 mm thick at the ground surface where encountered.

4.4 Groundwater Conditions

There are two water-bearing strata of interest in the site area. The lower aquifer is located in the bedrock and is transmitted to the top of the till layer. From samples obtained during drilling, the till appears to be composed mainly of saturated silt and gravel. A total of four standpipes were installed into this aquifer and groundwater level information for these test holes is shown in Table 6.

Table 6 Lower Aquifer Groundwater Level Readings (June 20, 2003)

Test Hole	Ground Elevation (m)	Water Level Depth BGL (m)	Elevation of Water (m)
AH03-01a	233.32	12.76	220.52
AH03-02a	232.10	12.03	220.07
AH03-06	233.24	12.34	220.90
AH03-08a*	232.62	9.87	222.75

* not yet stabilized.

The upper aquifer comprises a silt seam varying in thickness from 0.30 m to 0.85 m. This saturated layer is located above the Silty Clay Unit of lacustrine sediments and is observed consistently across the entire site. A total of seven standpipes were installed in the surficial soils. Five of these standpipes were screened across the silt seam. The remaining two test hole locations had been previously excavated and were backfilled with fill. The groundwater level information for the seven test holes is shown in Table 7.

Table 7 Upper Aquifer Groundwater Level Readings (June 20, 2003)

Test Hole	Ground Elevation (m)	Water Level BGL (m)	Elevation of Water (m)
AH03-01b	233.32	2.63	230.69
AH03-02b	232.10	1.71	230.39
AH03-08b*	232.62	2.70	229.92
AH03-09*	232.60	1.73	230.87
AH03-11	232.10	3.54	228.56
AH03-13	232.87	1.19	231.68
AH03-14	232.97	1.28	231.69

* fill

From past experience, the upper aquifer is considered a relatively insignificant construction issue and can be handled readily by either removal of the silt or drainage measures.

5. SITE CHARACTERIZATION AND FOUNDATION ALTERNATIVES

5.1 General

The site stratigraphy for the various areas of the project is provided in the following sections. No information has been provided regarding structure type or magnitudes of loading, and therefore the foundation recommendations in the following sections are generic and preliminary in nature.

5.2 Osborne Street Overpass

The applicable holes for the Osborne Street overpass include AH03-01 and AH03-02. The stratigraphic conditions comprise about 2.0 m to 2.5 m of fill or silt and clay over high plasticity lacustrine clay. The high plasticity clay extends to a depth of 14 m to 15 m below the ground surface and is underlain by a dense silty till. The upper water level was found to be about 1.7 m below the ground surface, with the lower groundwater table in the till at about 12 m to 13 m below the ground surface. It should be noted that the upper water level may be affected by the drainage measures for the existing underpass.

At this location the roadway grade is expected to be about 2 m to 3 m above surrounding ground level and Osborne Street will pass underneath. The existing CN overpass structure consists of a two span structure with vertical retaining walls at both abutments and a central pier. It is understood the new structure for the BRT system will possibly involve three spans.

The current conceptual design involves locating the abutments offset further from the existing retaining walls. An estimate of the bridge overpass dimensions indicates that the spans will be 17.5 m, 35 m and 17.5 m. This will involve installation of deep foundations for piers immediately behind the retaining walls. The recommended method of foundation support for the piers, abutments and walls are driven precast concrete or steel H-piles bearing in the till. Further recommendations regarding piled foundations, bridge retaining walls and embankment fills are provided in Section 7.

5.3 CN Railway Underpass

The proposed underpass crosses under seven tracks of the CN railway. The underpass structure will involve a tunnel section that is approximately 145 m in length with an invert elevation of about 224 m (about 9 m) below the tracks and a crown cover of about 3 m. The underpass crosses under the tracks at a skewed angle with horizontal and vertical curvature.

The applicable holes from the recent investigation for this area include AH02-05 to AH02-08 inclusive. The stratigraphic conditions comprise about 2.0 m to 3.0 m of fill or silt and clay over high plasticity lacustrine clay. The high plasticity clay extends to a depth of 12.5 m to 15 m (elevation 218 m) below the ground surface and is underlain by a dense silty till. The upper groundwater table was found to be about 2.5 m below the ground surface, with the lower groundwater table in the till at about 12 m below the ground surface.

Various construction approaches are available for this type of structure with varying degrees of suitability. These are discussed individually below:

> Cut and Cover
> This is the simplest approach and involves closing the CN lines and excavating across the whole width. The underpass can then be constructed as a bridge or concrete box structure. The major drawback is that CNR may not agree to a complete shutdown of the line.

Staged Cut and Cover (Recommended Method)
To maintain CN rail traffic, this approach closes about half to two-thirds of the number of the operational tracks at a single time in order to construct a double span bridge or a cast in place box structure to carry the track loading. When one side is complete, the track operations can be switched and construction can continue on the second half. Temporary and permanent ground support could be provided by driven piles for this method. Alternatively, side and head slopes of about 2H:1V may be adopted, however, more tracks may have to be closed to ensure the stability of the excavation. This approach requires significant coordination with CNR regarding the staging and the construction of track, switches and crossings.

Tunneling with Steel Ring and Shotcrete Support
Tunneling is considered technically challenging and a significantly more expensive method of constructing the underpass. A discussion is included in this section for completeness.

The design of shallow tunnels in an urban environment involves the prediction of ground movements and the determination of lining pressures. A construction scheme using heading and benching excavation with tunnel support from steel ribs and shotcrete allows great flexibility in the tunnel size and construction operations. In situations such as the underpass, a "short heading", where the upper bench is advanced only a short distance ahead of the lower bench, is most appropriate in order to minimize the invert closure distance of the tunnel support and prevent excessive ground movements. However, the very small thickness of crown cover makes this method very technically challenging with significant structural and financial risks.

Shield Tunneling
For tunnels with horizontal and vertical curvature, the use of a tunnel boring machine (TBM) is typically adopted to construct circular tunnels. The design profile indicates that the majority of the proposed tunnel would be within the high plasticity clay unit with the tunnel crown in fill or silt and clay. However, the required tunnel is about 6 m high by 12 m wide, or an area of about 72 m^2. This configuration is not considered appropriate for conventional shield tunneling and, due to the shallow depth and soft ground, ground movements could be considerable.

Concrete Box Jacking
The horizontal and vertical curvature prevents the use of methods such as pushing or jacking concrete box sections.

Despite the high traffic volumes on the CN railway, it is considered that a staged "cut and cover" method is the most appropriate approach to construct the underpass. Outside the tunnel or bridge section, retaining walls will be required. Strip footings are recommended for the wall foundations

Some groundwater seepage will occur during construction and, as this is the lowest point of the proposed facility, long term seepage will also collect in this area. It will therefore be necessary to provide a pumped drainage system whereby groundwater and surface runoff is collected and pumped to the stormwater sewer system. Dependent on the depth of the groundwater collection system at this location, insulation may also be necessary to prevent frost penetrating below the water table.

Further recommendations are provided in Section 7.

5.4 BRT Test Section Roadway

The proposed grade for the test section is about elevation 233 m. The test holes in this area, AH03-09 to AH03-15 inclusive, indicate the subsurface stratigraphy is comprised of about 2 m to 3 m of clay and silt fill with occasional sand and gravel over high plasticity clay. Groundwater, where observed, was about 1 m to 4 m below the ground surface.

Road materials and construction is to be in accordance with the City of Winnipeg Standard Construction Specifications, Division 4, CW3110-R6, CW3310-R7 and CW3410-R5.

A concrete pavement thickness of 250 mm is recommended on 450 mm of compacted A-Base over a prepared subgrade. The upper 75 mm of A-Base can be replaced with a porous asphalt to provide added stability and reduce the A-Base thickness to 300mm. All old basements and services, organic and unsuitable fill materials should be removed from the roadway alignment before placing fill. The upper 150 mm of existing sub-grade soil shall be scarified and then recompacted to 98% of the standard Proctor maximum dry density (ASTM D698). Additional fill is to be placed in lifts no thicker than 150 mm and compacted to a minimum of 98% of the standard Proctor maximum dry density. The upper 300 mm of fill below the base course is to be compacted to a minimum of 100% of the standard Proctor maximum dry density.

5.5 Underground Utilities

Underground utilities exist throughout the BRT extension site. Water mains, high-pressure gas pipelines, stormwater conduits and buried electrical lines are present within the footprints of the proposed extension. Additional utilities may also be present. The designer and/or contractor must confirm the existence and location of underground utilities prior to any construction, including excavation and piling.

Utilities are to be installed in accordance with the City of Winnipeg Standard Construction Specifications, Division 3, CW 2030-R5.

6. SITE PREPARATION AND GENERAL FILL REQUIREMENTS

6.1 Excavation

Perform excavation in accordance with Province of Manitoba "W210 The Workplace Safety and Health Act" and "Guidelines for Excavation Work". All excavations greater than 1.5 m should be sloped or shored for worker protection. Local experience indicates that temporary slopes of 1H:1V or flatter for excavations up to 5 m deep are acceptable. This angle is considered to be adequately stable for temporary purposes, assuming favourable subsurface conditions. For steeper slopes, a shoring and anchor design prepared by a structural and Geotechnical engineer must be provided. Unfavourable groundwater or soil conditions may require flatter slopes. The safe angles of the excavation slopes should be re-evaluated by a geotechnical engineer during detailed design and construction. Excavations that intercept the upper water table and will tend to drain the more permeable silt layer in this zone. If seepage persists for extended periods of time, measures for control of the groundwater seepage may have to be implemented to ensure adequate stability of temporary slopes.

6.2 Granular Backfill

The granular backfill should be placed in conformance with the following specifications:

- Granular backfill in non-structural support areas should be well watered and compacted to 95% standard Proctor maximum dry density. For structural supporting backfill, the compaction requirements should vary from 98% to 100% depending on the allowable deformation. Compaction of granular fill should be performed with a smooth drum vibratory roller.
- Backfill material should be placed and compacted in lifts not exceeding 200 mm compacted thickness.
- Placing and spreading of material should ensure that segregation or nesting of larger rock sizes does not occur.

- Lift thicknesses should be reduced to 150 mm adjacent to the concrete walls. The fill placed in contact with the structures should have a maximum particle size of 25 mm.
- Hand compaction equipment should be used within 1000 mm of concrete walls.
- Fill should not be placed in a frozen state, or placed on a frozen subgrade.
- The granular backfill should meet the gradation requirements listed in Table 8.

Table 8 Gradation Requirements for Structural Granular Backfill

Sieve Size	Percent Passing by Weight
75 mm	100
19 mm	85-100
4.75 mm	35-70
0.425 mm	15-30
0.075 mm	0-12

6.3 Cohesive Backfill

Cohesive backfill should be compacted with at least six passes of a heavy duty sheepsfoot compactor (10,000 kg or greater) to 97% standard Proctor maximum dry density at -2% to +2% of optimum moisture content for general site fill applications. Higher degrees of compaction will be required for structural fills. Backfill may consist of soil with a maximum size of 100 mm, except topsoil and clays with a liquid limit great than 50%.

Prior to placing fill, the subgrade shall be stripped of organic material and the subgrade shall be proof rolled to identify any soft areas. All soft areas shall be removed and replaced with well compacted clay fill. All water shall be removed from depressions and the subgrade shall be properly moistened and sufficiently clean to obtain a suitable bond with the placed fill. The fill shall be spread evenly across the full width of the section and be bladed smooth in successive layers not exceeding 150 mm in depth when compacted. Placing and spreading of material should ensure that segregation or nesting of larger rock sizes does not occur.

It should be noted that the high plasticity lacustrine clay encountered at the site has a natural moisture content (typically about 50%) significantly above the optimum moisture content for compaction (about 25%). It is considered that the lacustrine clay will have to be removed from the site and wasted. Additionally, the mixing of wet zones from the upper materials will affect the usability of the materials.

7. PRELIMINARY FOUNDATION RECOMMENDATIONS

7.1 Introduction

This section outlines foundation support options, construction and other geotechnical issues that are common to various components of the BRT project. Preliminary foundation recommendations are presented. During detailed design, additional data and structure specific foundation analyses will be required to confirm or modify the recommendations in this report, including any additional site investigations that may be required.

7.2 Frost Action Considerations

Frost action may give rise to frost heaving and uplift forces on foundation elements. The severity of frost action depends on the exposure to cold temperatures, the type of soil, the variability of the soil strata and the position of the groundwater table. Frost action effects arise from two processes:

- Freezing of the water in the soil voids, where the 9% volumetric expansion of the water typically results in an expansion of saturated soil of about 2.5% to 5%, depending on the initial void ratio.
- Growth of ice lenses in fine grained soil, which can cause heave several times the height of the freezing soil column. Ice lenses form at the freezing front, and can occur above the groundwater table where water is drawn towards the freezing front by capillary action.

The latter condition is the more serious and soils that are prone to this are termed "frost susceptible".

The qualitative frost susceptibility of a soil is typically assessed using guidelines developed by Casagrande (1932) on the basis of the percentage by weight of the soil finer than 0.02 mm. This classification system has been adopted by the U.S. Army Corps of Engineering and the Canadian Foundation Engineering Manual (1992). Soils are classed as F1 through F4, in order of increasing frost susceptibility. Silts, silty sands and very low plastic clays are the most frost susceptible, and are rated F4. All of the soil within the depth of frost penetration at the site is potentially frost susceptible. Frost action will occur if groundwater is available within the frost zone.

Frost penetration into frost susceptible soils can cause damage to structures by two mechanisms. Where shallow foundation elements are used, formation of ice lenses and volumetric expansion of saturated soil can cause heave of the overlying foundation elements and the structure. When the soil becomes frozen to a vertical surface on either a shallow foundation or a pile foundation, heave of the surrounding soil will impart uplift forces onto the foundation element, causing "frost jacking". The adfreeze shear strength of soil frozen to concrete or steel is sufficient to generate large uplift loads. The rule-of-thumb is that to resist frost jacking by friction along the surface of a pile in uniform soil conditions, the total pile length must be three times the depth of frost penetration. Penner (1974) and Penner and Goodrich (1983) performed field experiments on adfreeze bond stresses, and suggest design values ranging from 65 kPa for fine-grained soils frozen to concrete, 100 kPa for fine-grained soils frozen to steel to 150 kPa for gravel frozen to steel. These values are considered to be appropriate for calculating uplift forces at this site.

Frost penetration can also reduce the strength of frost-susceptible road or building sub-grade materials upon thawing in the spring.

Isolated exterior footings in unheated portions of structures should have a minimum soil cover of 2.1 m unless provided with equivalent insulation.

7.3 Foundation Types

7.3.1 Piles

Driven piles founded in the till are recommended for all structures on site where significant total and differential settlements cannot be tolerated. It is understood that pre-cast concrete piles are commonly used in the Winnipeg area, although steel pipe piles and H-piles are also suitable.

The allowable axial capacities for driven, pre-cast concrete piles are listed in Table 9 and are based on local experience and data derived from pile load testing. It has been assumed that the piles are about 15 m long and have been driven to practical refusal in the underlying till. The dead weight of the pile should be included when calculating the total load applied to the pile. If piles are installed in areas of significant fill or adjacent to shallow foundations, the effect of downdrag due to settlement should also be included when calculating the total load applied to the pile.

Table 9 Allowable Axial Capacity of Driven Pre-Cast Concrete Piles*

Pile Diameter (mm)	**Axial Capacity (includes a factor of safety of 3) (kN)**	**Final Set Blows/25mm for a hammer delivering at least 40 kJ/blow**
300	445 50 Tons	8
360	620 70 Tons	10
410	800 90 Tons	12

* structural capacity of pile section must be checked by structural designer.

All piles should have a minimum centre to centre spacing of three pile diameters. At this spacing, no axial load reduction factor is required for pile groups.

Lateral load analyses have been performed for free and fixed headed concrete piles, installed in the clay using the program COM624. The analyses assume that the structural capacity of the pile has not been exceeded, and are based on an uncracked moment of inertia for the concrete piles, and a concrete compressive strength of 50 MPa. For conservatism, the subgrade was assumed to comprise of the high plasticity clay with no contribution from the stiffer upper clay and fill. Piles were assumed to be 15 m long.

The allowable lateral loads of the concrete piles at given deflections of 6 mm and 12 mm are listed in Table 10 and Table 11 for free and fixed headed piles, respectively. The analyses reported in these tables are for a lateral load applied at ground surface with zero vertical load. The structural designer must check the stresses in the pile section from combined axial load and bending.

Table 10 Allowable Lateral Load of Free Headed Concrete Piles

Pile Diameter (mm)	Allowable Lateral Load		Resulting Bending Moment	
	6 mm Deflection (kN)	12 mm Deflection (kN)	6 mm Deflection kN.m	12 mm Deflection kN.m
300	17	25	17	27
360	22	33	26	41
410	28	41	36	58

Table 11 Allowable Lateral Load of Fixed Headed Concrete Piles

Pile Diameter (mm)	Allowable Lateral Load		Resulting Bending Moment	
	6 mm Deflection (kN)	12 mm Deflection (kN)	6 mm Deflection kN.m	12 mm Deflection kN.m
300	35	51	44	70
360	46	67	66	106
410	57	83	92	148

Where piles are installed in groups, the reduction factors listed in Table 12 should be applied to the allowable lateral loads of individual piles as listed in Tables 10 and 11.

Table 12 Lateral Load Reduction Factors for Pile Groups

Pile Spacing / Pile Diameter	Reduction Factor
8	1.00
6	0.70
4	0.40
3	0.25

The following recommendations apply to installation of pre-cast driven concrete piles.

- The structural design and manufacture of concrete piles must conform to the requirements of the National Building Code and should utilize a concrete with a minimum 28-day strength of 50 MPa.

- To allow the installation of long piles, special mechanical splices have been developed. In general, the strength of the splice must be comparable to that of the pile in compression, tension and bending; the splice must be designed and positioned to maintain the alignment of the joined pile segments (maximum permissible deviation in squareness of a pile segment end is 1:100); and the splice must be designed so that the play or slack between two pile segments is less than 0.5 mm in either compression or tension. We understand that pile lengths are available up to 21 m long in the Winnipeg area and so mechanical splices may only be required for special cases.

- Temporary pile stresses resulting from handling and driving may be significant factors in the structural design. It is recommended that the pile size be selected with an adequate factor of safety under service loads, and to select the driving equipment on the basis of the structural capacity of the selected pile.

- The concrete cover for high-quality piles should be as thin as possible and about equal to 1.5 times the size of the largest reinforcing bar, or equal to the largest concrete aggregate size, whichever value is largest.

- The longitudinal reinforcing bars should have a minimum cross-sectional area determined by the condition that the maximum axial tension stress in the pile, when calculated on the steel area alone, must not exceed the value of 0.6 times the steel yield strength. This value is adequate against tension failure including the forces induced during driving.

- The driving of pre-cast concrete piles must be exercised with care. Significant tension stresses will occur in the pile when driven into the high plasticity soft clay. The piles should be pre-bored for a minimum distance of 5 m before driving. The pile head and toe should be protected with a steel plate and steel pile shoe respectively.

The disadvantage of the pre-cast pile approach is that the required pile length must be known with some degree of accuracy before piling otherwise the pile head may end up too low or too high depending on the refusal conditions. In practice, precast piles are usually ordered about 2 m longer than necessary and cut off. This is considered more economical than splicing or designing segmental piles lengths.

7.3.2 Footings and Rafts

Lightly loaded structures that are insensitive to settlement may be supported by strip or spread footings. Minimum footing dimensions in plan should be 0.6 m and 0.9 m for strip and square footings respectively. Following excavation to grade, the sub-grade soils should be proof rolled and any soft spots excavated and replaced with compacted impervious fill.

(~2000 psf)

For design, the allowable net bearing pressure can be taken as 100 kPa for the foundation soils. The weight of the footing and backfill above the footing should be included in the calculation of bearing pressure at the footing base. The stated allowable bearing capacities are based on limiting the settlement of the footings to about 25 mm.

For assessment of structural requirements, a modulus of subgrade reaction, k_s, is often used to represent the soil stiffness. It has been found that bending moments and the computed soil pressure are not very sensitive to the k_s value because the structural member is usually 10 or more times as stiff as the soil stiffness. Structural analyses using the recommended modulus of subgrade reaction will not predict the correct amount of settlement for the structure. A design k_s value of 3 MN/m³ is recommended for the high plasticity clays (Hunt, 1986).

7.3.3 Retaining Walls

7.3.3.1 General

The lateral pressure distribution against the structural walls should be estimated by applying lateral earth coefficients to the effective soil stresses and as appropriate, adding the water pressure to the resultant lateral earth loads, as follows:

$$\sigma_h = K\ [(\gamma_m\ (h - h_w) + \gamma_b . h_w] + \gamma_w h_w$$

σ_h = unit horizontal pressure (kPa)
K = lateral earth pressure coefficient
γ_b = Buoyant unit weight of backfill (kN/m^3)
γ_m = Moist unit weight of backfill (kN/m^3)
h = height of fill above base of wall (m)
h_w = height of water above base of wall (m)

The value of lateral earth coefficient depends on a variety of factors, including backfill type, degree of compaction, geometry of the wall backfill slopes and the amount of wall movement that can occur.

It is recommended that the minimum thickness of wall and slabs of earth retaining structures shall be 600 mm.

7.3.3.2 Granular Backfill

Backfill placed adjacent to exterior walls should be granular, permeable material, to allow drainage around the exterior walls of structures. Any debris, clay or organic materials present in the fill should be removed prior to placement. Backfill should be compacted to a minimum of 95% standard Proctor maximum dry density. Only hand operated compaction equipment should be employed within 600 mm of concrete walls. A minimum thickness of 450 mm of granular backfill is required for drainage purposes. However, to adopt the lateral pressure coefficient for granular backfill, a minimum thickness equal to the height of the wall must be considered behind the wall.

For preliminary design, the lateral pressure coefficient for granular backfill may be taken as K = 0.5. The saturated and moist unit weights of granular backfill may be assumed to be 21.8 kN/m^3 and 19.8 kN/m^3, respectively. This assumes that appropriate restrictions are placed on the compactive effort immediately adjacent to the walls, and that there is a sufficient thickness of granular fill behind the structure.

It is not necessary to add hydrostatic water pressure to the lateral earth pressures if positive drainage and proper backfilling are achieved around the perimeter of underground structures, through the use of clean granular backfill and pumping of the subdrainage system. The upper 0.6 m of backfill around the perimeter of any structure should comprise low permeability clayey soil and be graded to drain away from the structure at a minimum 3% slope.

Compaction of the granular backfill will induce higher lateral earth pressures in the upper wall section, which will exceed the pressures due to self weight of the fill. The walls should therefore be designed for lateral earth pressures whereby the horizontal earth pressure at any given depth (z) in metres is as shown below. Surface surcharge loads and groundwater must be added to these pressures, if applicable, using the lateral earth pressure coefficient noted above.

Depth (z)	0 – 1 m	Horizontal earth pressure	40.z kPa
Depth (z)	1 – 4 m	Horizontal earth pressure	40 kPa (constant)
Depth (z)	> 4 m	Horizontal earth pressure	9.9.z kPa

7.3.3.3 Impervious Backfill

For the selection of appropriate coefficients for cohesive backfill materials, it is important to review the effects of potential swelling, creep and/or frost penetration. The following parameters are proposed:

$K = 0.8$

$\gamma_b = 18 \text{ kN/m}^3$

This assumes that high plasticity clays will not be used as backfill behind the structure, and that appropriate restrictions will be specified to limit the compactive effort immediately adjacent to the walls.

Compaction of the backfill will induce higher lateral earth pressures in the upper wall sections, which will exceed the pressure due to the self weight of the fill. The walls should therefore be designed for lateral earth pressure whereby the horizontal earth pressure at any given depth (z) in metres is as follows:

Depth (z)	0 – 1 m	Horizontal earth pressure	40.z kPa
Depth (z)	1 – 2.78 m	Horizontal earth pressure	40 kPa (constant)
Depth (z)	> 2.78 m	Horizontal earth pressure	14.4.z kPa

Surface surcharge loads and groundwater must be added to these pressures, if applicable, using the lateral earth pressure coefficient noted above. It is also assumed that the surface of the backfill will be graded away from the structure to promote surface runoff away from the walls.

7.4 Embankment Fills

Embankment fills will be required up to a fill thickness of 3 m high. Embankments should be constructed from well-compacted clay with side slopes of 4H:1V or flatter.

In general, the fill shall be as specified in Section 6.3. Due to the low height of the fill, settlements are not expected to be significant. For design, a settlement allowance of about 0.5% to 1% of the fill height and foundation thickness can be assumed.

Earthwork construction is to be in accordance with the City of Winnipeg Standard Construction Specifications, Division 4, CW 3170-R3.

7.5 Concrete Types

Measured soluble sulphate concentrations will produce negligible to severe degree of sulphate attack. It is recommended that Type 50 sulphate resistant cement be used in all concrete in contact with the clay. The specified concrete strength and maximum water/cementing materials ratio should be in accordance with CAN/CSA-A23.1-94. Air entrainment of 4% to 7% by volume is recommended for all concrete exposed to freezing temperatures, soil or groundwater.

8. REVIEW OF DETAILED DESIGN

This report was prepared for preliminary design prior to the final selection of the foundation support methods and assessment of structural loads. Once these details have been determined, Klohn Crippen should be given the opportunity to input into detailed foundation design and specifications related to geotechnical aspects of this project.

Additional structure specific drilling may be required for detailed design, however, rig access is limited at the present time. Although, the drilled test holes did not indicate a large difference in refusal elevation, some variability may exist in the subsurface conditions.

All preliminary design recommendations presented in this report are based on the assumption that an adequate level of geotechnical monitoring will be provided during construction and that construction will be carried out by qualified contractors, experienced in earthworks and foundation construction. Quality control and quality assurance monitoring should be carried out by suitably qualified persons, independent of the contractor. One of the purposes of providing an adequate level of monitoring is to check that recommendations, based on data obtained at discrete borehole locations, are relevant to other areas of the site.

9. LIMITATIONS

This report is an instrument of service of Klohn Crippen Consultants Ltd. The report has been prepared for the exclusive use of Dillon Consulting Ltd. for specific application to the City of Winnipeg Bus Rapid Transit System – Southwestern Corridor. The material in it reflects Klohn Crippen's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Klohn Crippen accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. In this report, Klohn Crippen has endeavoured to comply with generally accepted geotechnical practice common to the local area. Klohn Crippen makes no other warranty, expressed or implied.

The analyses, conclusions and recommendations contained in this report are based on data derived from a limited number of test holes obtained from widely spaced subsurface explorations. The methods used indicate subsurface conditions only at the specific locations where samples were obtained or where in-situ tests would infer, only at the time they were obtained, and only to the depths penetrated. The samples and tests cannot be relied on to accurately reflect the nature and extent of strata variations that usually exist between sampling or testing locations.

The recommendations included in this report have been based in part on assumptions about strata variations between test holes that will not become evident until construction or further investigation. Accordingly, Klohn Crippen should be retained to perform construction observation and thereby provide a complete professional geotechnical engineering service through the observational method. If variations or other latent conditions become evident during construction, Klohn Crippen will re-evaluate this report's recommendations. Klohn Crippen cannot assume responsibility or liability for the adequacy of its recommendations when they are used in the field without Klohn Crippen being retained to observe construction.

The conclusions and recommendations in this report are prepared on the assumption that any and all information supplied to Klohn Crippen by Dillon Consulting Ltd., or by others on behalf of or on the instructions of Dillon Consulting Ltd, is correct, complete and accurate, and Klohn Crippen shall not be liable for any loss, cost, expense or damage arising from or as a result of the incorrectness or inaccuracy of such information. Dillon Consulting Ltd shall, upon such incorrectness or inaccuracy coming to its attention, notify Klohn Crippen thereof and allow Klohn Crippen to make any revisions or changes to the recommendations in this report.

Although Klohn Crippen has explored subsurface conditions as part of this program, Klohn Crippen has not conducted analytical laboratory testing of samples obtained, and has not evaluated the site for potential presence of contaminated soil or groundwater.

10. CLOSURE

We trust this information satisfies your present requirements. Should you have any questions, please contact the undersigned.

This report was reviewed by Steven R. Ahlfield, P.Eng.

Yours truly,

KLOHN CRIPPEN CONSULTANTS LTD.

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May 10/04

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APEGGA Permit to Practice No. 433

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City of Winnipeg Standard Construction Specifications:

- Division 3, CW 2030-R5 "Excavation Bedding and Backfill"
- Division 4, CW3110-R6 "Subgrade, Subbase and Base Course Construction"
- Division 4, CW3120 "Installation of Subdrains"
- Division 4, CW3170-R3 "Earthwork and Grading"
- Division 4, CW3310-R7 "Portland Cement Concrete Pavement Works"
- Division 4, CW3410-R5 "Asphaltic Concrete Pavement Works"

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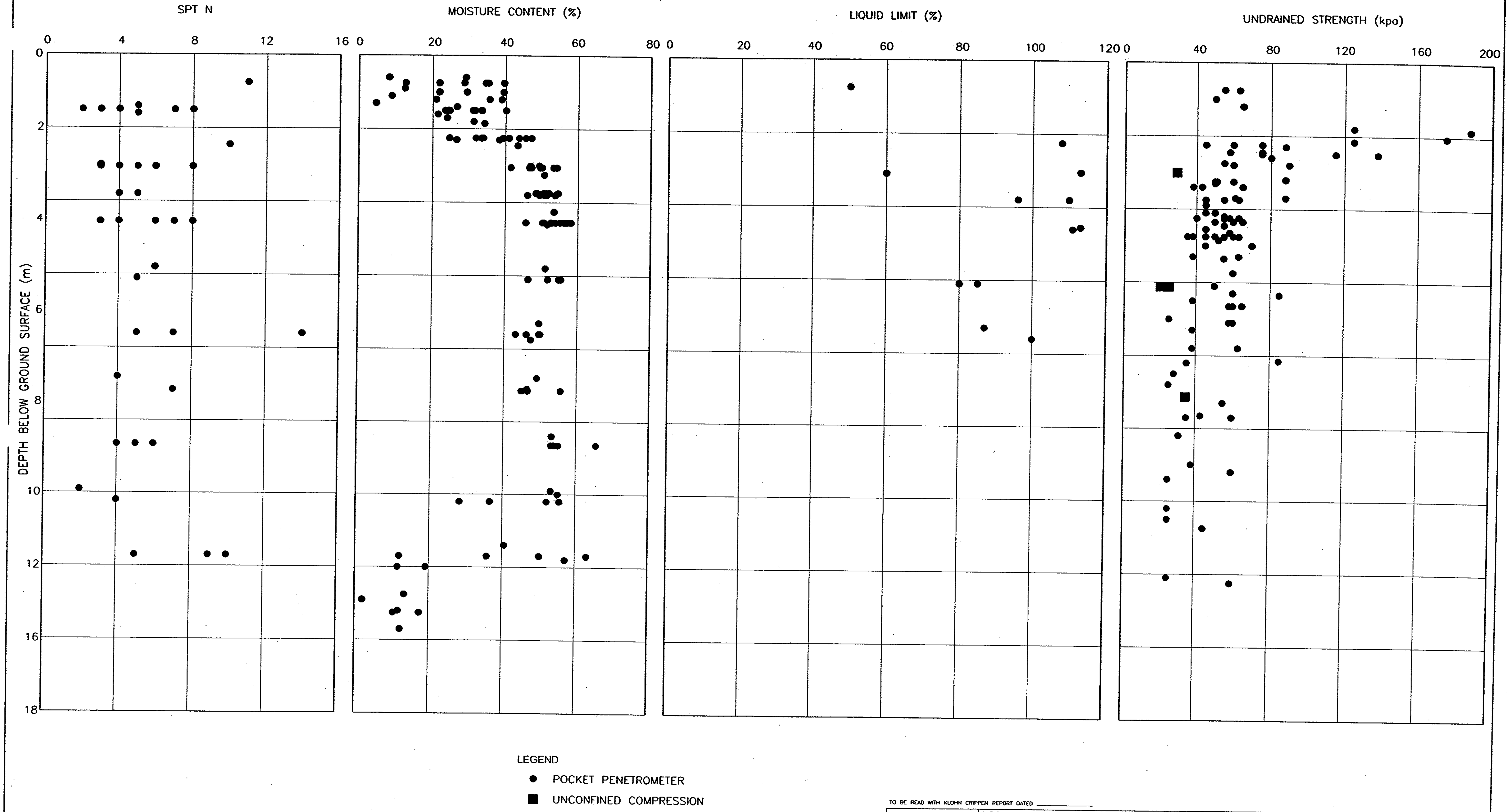
FIGURES



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TRANSIT DEPARTMENT
BUS RAPID TRANSIT SYSTEM

KLOHN CRIPPEN

PROJECT
WINNIPEG BRT

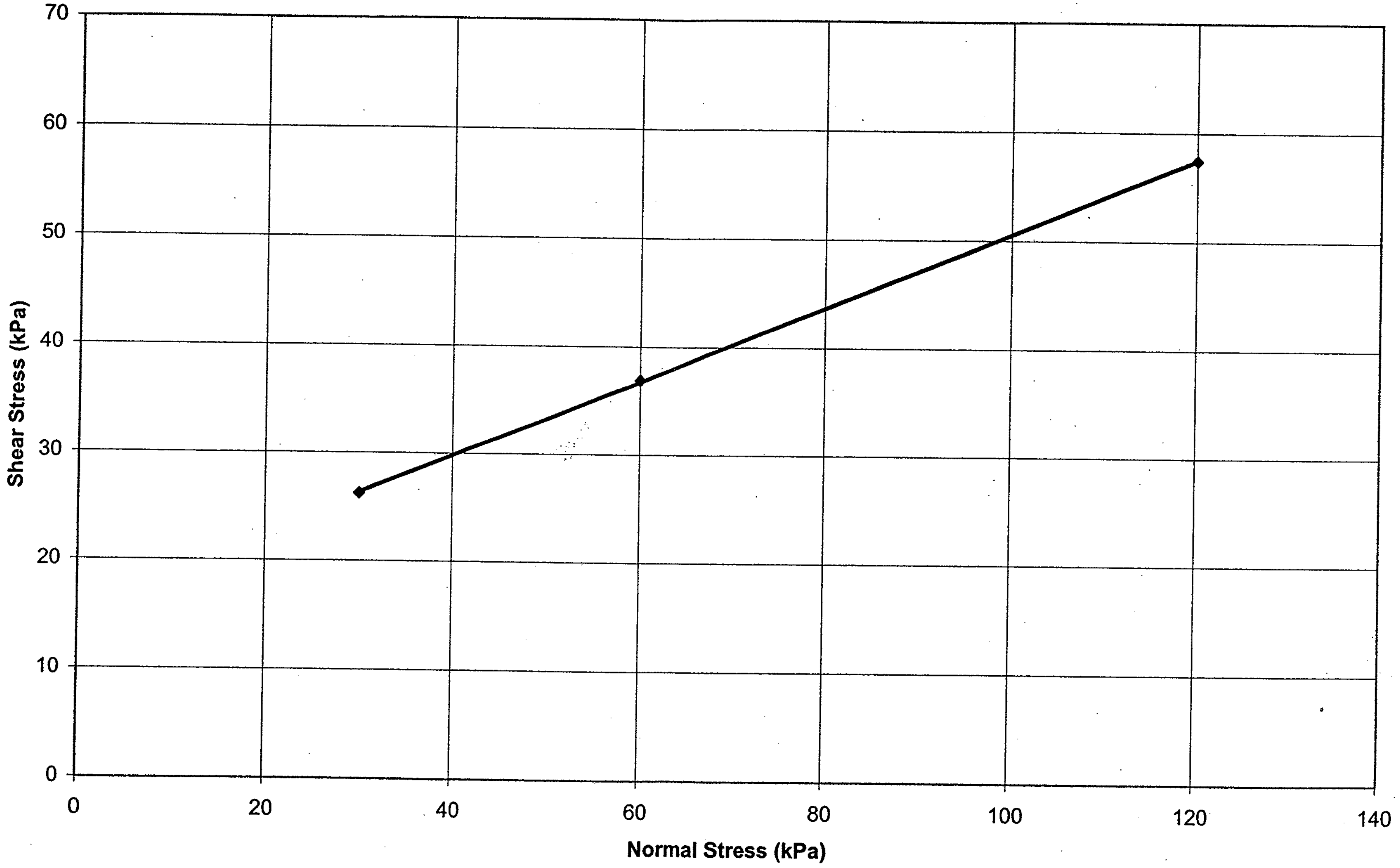
TITLE
SUMMARY OF SOIL PARAMETERS

PROJECT No.
A3023A01

FIG. No.
FIGURE 1

THE
NATIONAL
TESTING
LABORATORIES
LIMITED
Established in 1923

WINNIPEG BRTS
SAMPLE AH03-06-9



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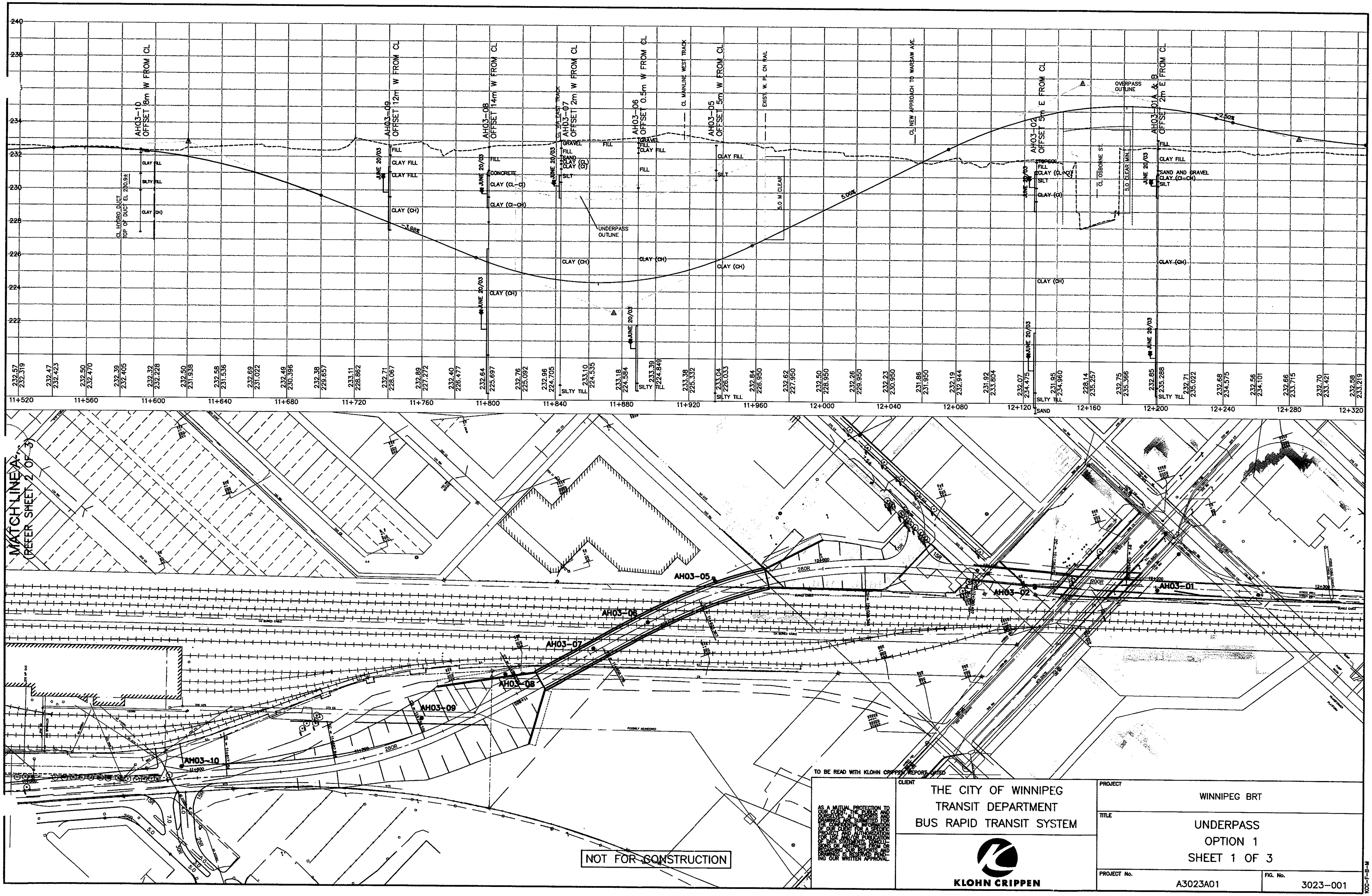
PROJECT
WINNIPEG BRT

TITLE
DIRECT SHEAR TEST
RESULT

PROJECT No.
A3023A01

FIG. No.
FIGURE 2

DRAWINGS



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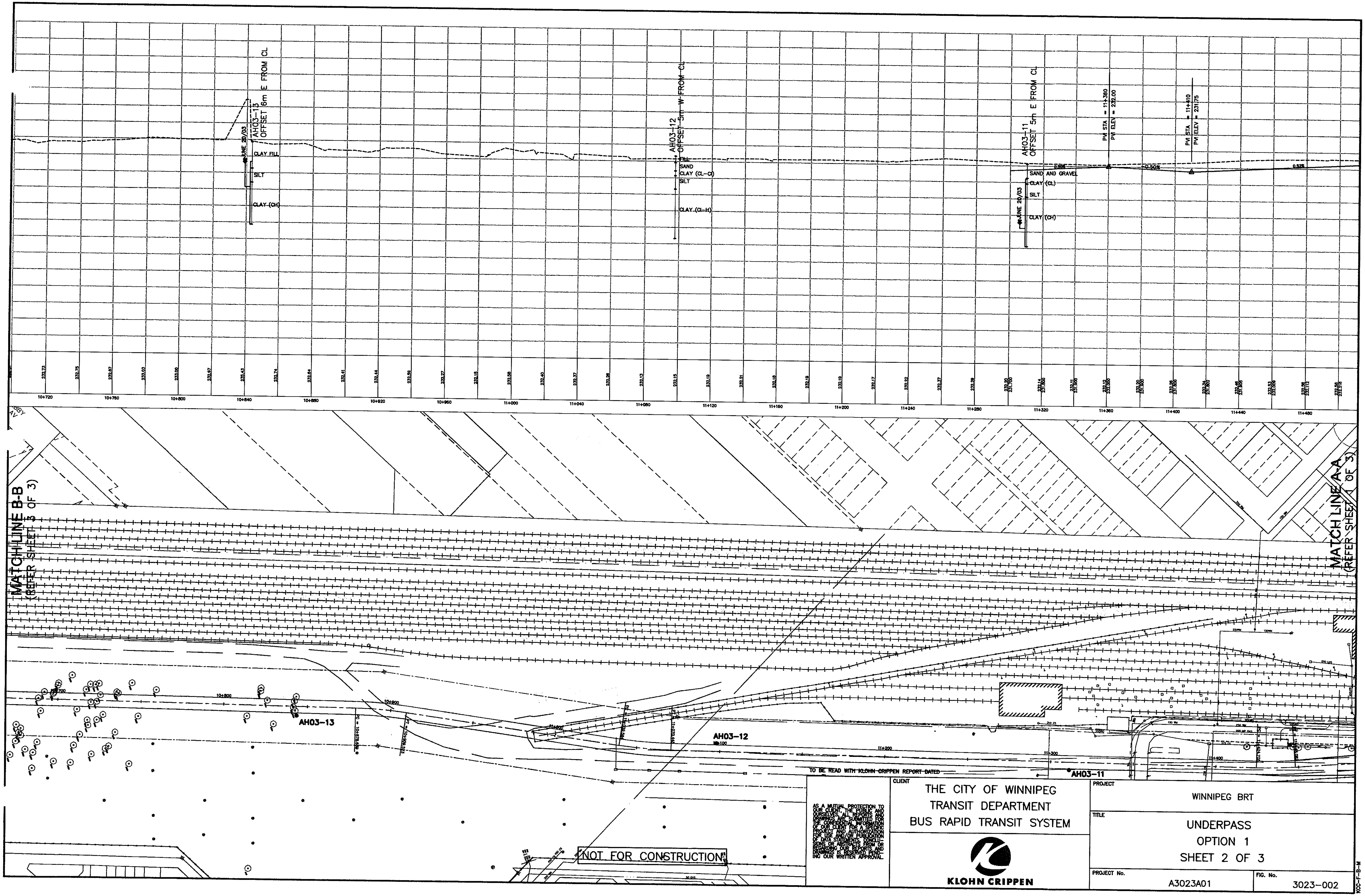
	KLOHN CRIPPEN
PROJECT	WINNIPEG BRT
TITLE	UNDERPASS OPTION 1 SHEET 1 OF 3
PROJECT No.	A3023A01
FIG. No.	3023-001

KCC-F-B-M



TO BE READ WITH KLOHN CRIPPEN REPORT DATED

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

CLIENT
THE CITY OF WINNIPEG
TRANSIT DEPARTMENT
BUS RAPID TRANSIT SYSTEM

KLOHN CRIPPEN

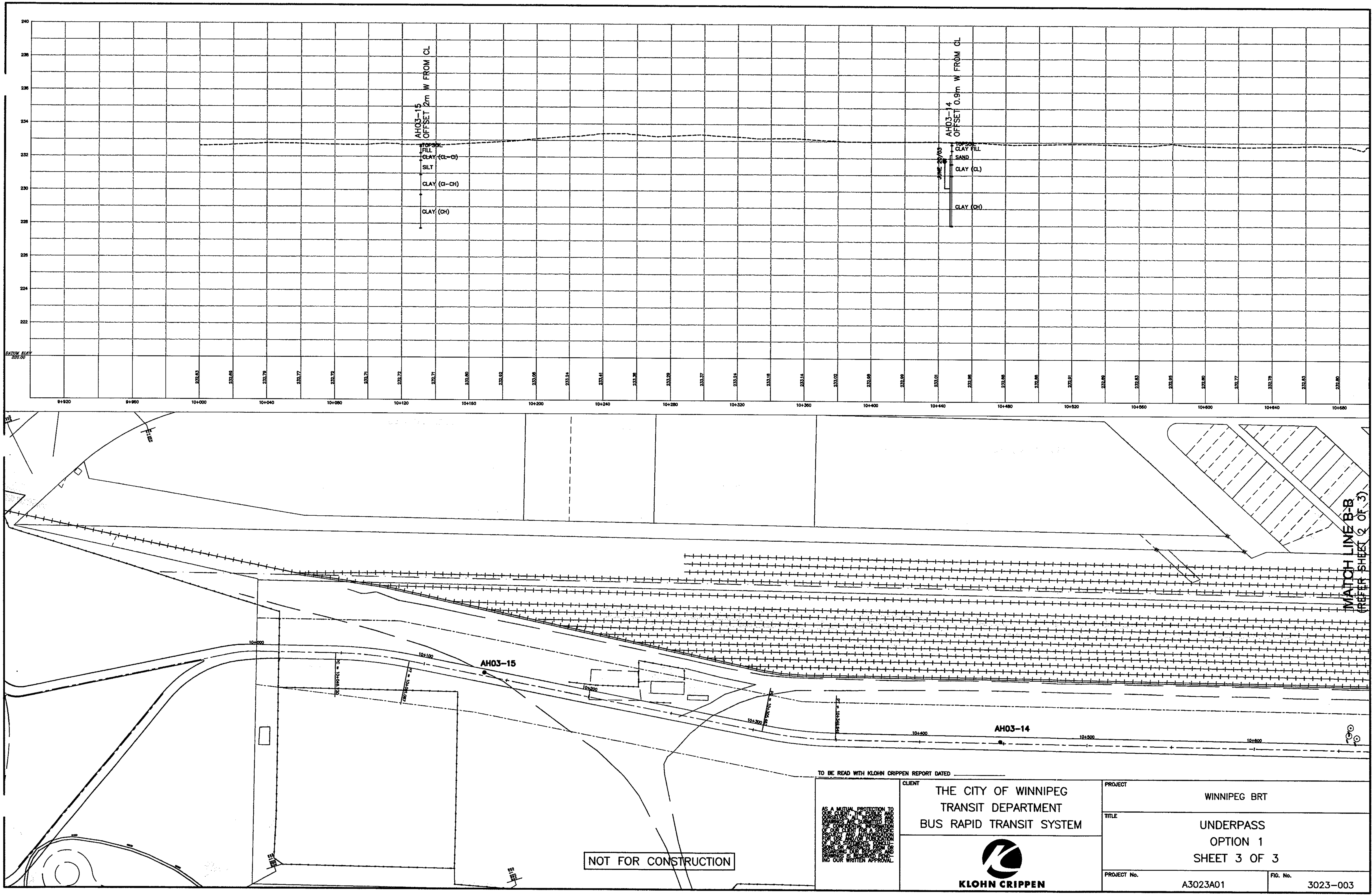
PROJECT
WINNIPEG BRT

TITLE
UNDERPASS
OPTION 1
SHEET 2 OF 3

PROJECT No. A3023A01

FIG. No. 3023-002

KCC-F-B-M



NOT FOR CONSTRUCTION

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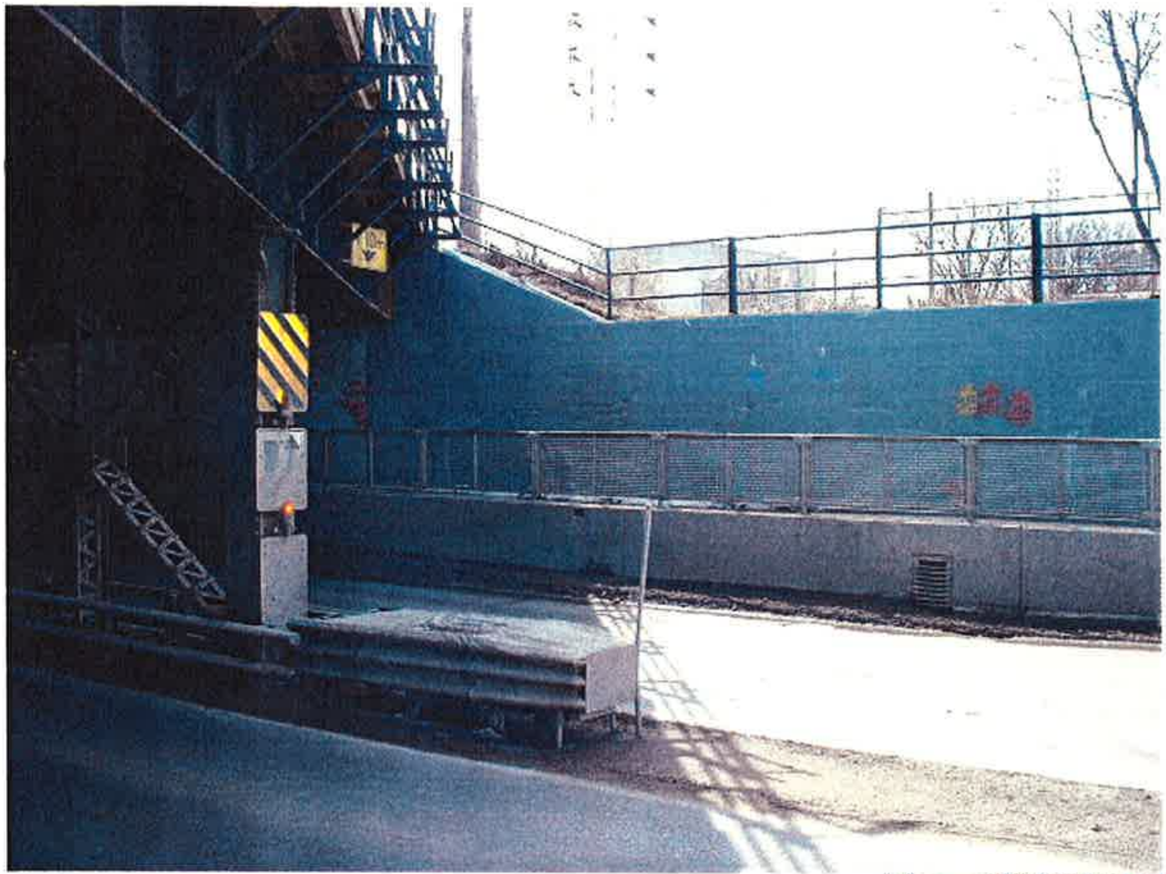
CLIENT THE CITY OF WINNIPEG TRANSIT DEPARTMENT BUS RAPID TRANSIT SYSTEM	PROJECT WINNIPEG BRT
KLOHN CRIPPEN	TITLE UNDERPASS OPTION 1 SHEET 3 OF 3
	PROJECT No. A3023A01 FIG. No. 3023-003

APPENDIX I

Site Photographs


1-2
CN Subway


1-24

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APPENDIX II

Test Hole Logs

TEST HOLE LOG

STARTED: June 16, 2003 **FINISHED:** June 16, 2003

DRILL METHOD: Solid Stem Auger

GROUND ELEV. (m): 233.32

COORDINATES (m): N 5526235.4 E 633589.4

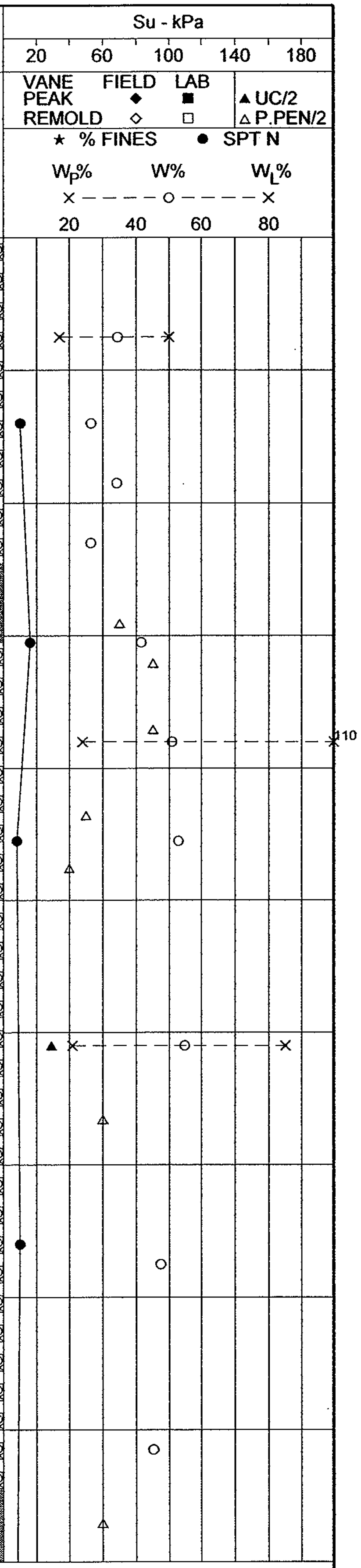
DESCRIPTION OF MATERIALS

Depth (m) / Elev.	Description of Materials
	FILL Cinders, trace gravel, trace sand, black, dry, upper 10cm is silty with rootlets, sparse grass coverage
0.50 232.82	CLAY (CI) Silty, medium plasticity, trace fine gravel, mottled light brown to dark grey, some rusting, moist (FILL)
1.80 231.52	SAND AND GRAVEL (SW-GW) Fine to coarse sand, fine to medium gravel, moist (FILL)
2.05 231.27	CLAY (CI-CH) Medium to high plasticity, firm to stiff, light greyish brown, moist
2.45 230.87	SILT (ML) Trace clay, non-plastic to low plasticity, soft, light brown, wet 2.45 m: first appearance of water in hole
2.75 230.57	CLAY (CH) Trace to some silt, high plasticity, firm to stiff, moist, olive grey mottled with brown, oxidized in spots 3.0 - 3.8 m: occasional pebbles 3.8 m: Sample 5 = 24% silt, 76% clay 4.5m: occasional gypsum inclusions (white, powdery) Unconfined Compressive Strength = 57.4 kPa 7.6 m: no recovery in split-spoon, grab sample taken 9.1 m: occasional inclusions of sandy silt, trace gravel, becoming grey to olive grey

Continued Next Page

SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.
	Grab	1
4 3 2	SPT	2
	Grab	3
	SY	3b
3 4 4	SPT	4
	SY	5
2 2 2	SPT	6
	SY	7
3 2 3	SPT Grab	8
	SY	9

DEPTH (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10



PROJECT NO.: A03023A01

PROJECT: Winnipeg BRT

LOCATION: Southwest Corridor - Overpass

LOGGED BY: JNH **CHECKED BY:** DWR

SHEET 1 **OF** 2 **HOLE NO.:** AH03-01A

KLOHN CRIPPEN

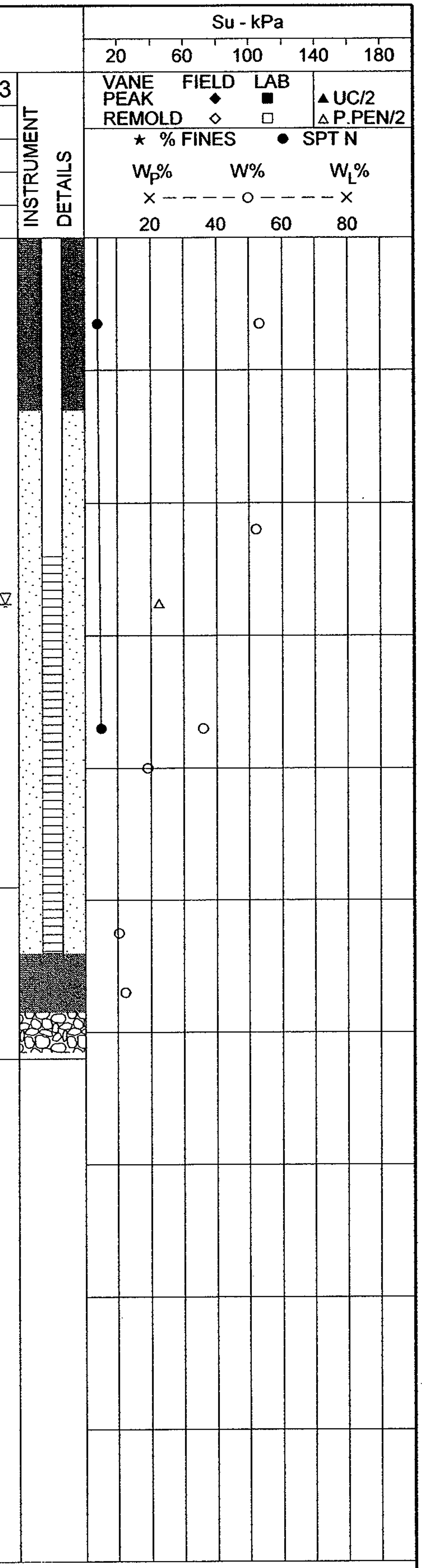
TEST HOLE LOG

STARTED: June 16, 2003 **FINISHED:** June 16, 2003
DRILL METHOD: Solid Stem Auger
GROUND ELEV. (m): 233.32
COORDINATES (m): N 5526235.4 E 633589.4

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	DESCRIPTION OF MATERIALS
11	2 2 2	SPT	10	10.7 m: trace gravel
12		SY	10b	
13				
14	2 2 3	SPT SPT	11 12	13.7 m: frequent inclusions / lenses of TILL - Samples 11 & 12 from same SPT test but split based on material type 14.0 - 14.15: TILL inclusion (silt, trace sand, trace gravel, light greyish brown)
14.90 218.42				SILT (ML) Gravely (fine to medium), some sand (fine to coarse), light brown to reddish brown, wet (TILL-LIKE)
15		SY	13	
16		Grab	14	16.20 m: Auger refusal
16.20 217.12				

End of Hole at: 16.2 m

25 mm standpipe installed in lockable steel casing
Stick-up = 0.94 m
Initial water level = 9.4 m bgl
June 17/03 water level = 12.41 m bgl
June 20/03 water level = 12.76 m bgl



KLOHN CRIPPEN

PROJECT NO.: A03023A01
PROJECT: Winnipeg BRT
LOCATION: Southwest Corridor - Overpass
LOGGED BY: JNH **CHECKED BY:** DWR
SHEET 2 **OF** 2 **HOLE NO.:** AH03-01A

KC_TEST_HOLE-SI SW_U ROCK_006.GDT 24/10/03

TEST HOLE LOG

STARTED: June 16, 2003 **FINISHED:** June 16, 2003

DRILL METHOD: Solid Stem Auger

GROUND ELEV. (m): 233.32

COORDINATES (m): N 5526234 E 633589

DEPTH (m) | SPT BLOWS PER 0.15m | SAMPLE TYPE | SAMPLE No. | SYMBOL | **DESCRIPTION OF MATERIALS** | INSTRUMENT DETAILS

Su - kPa: 20 60 100 140 180

VANE PEAK: FIELD ◆ LAB ■

REMOLD: FIELD ◇ LAB □

▲ UC/2

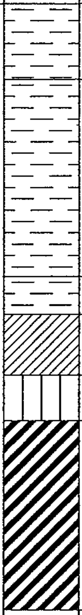
△ P.PEN/2

★ % FINES ● SPT N

W_P% W% W_L%

× – – – – ○ – – – – ×

20 40 60 80



FILL
Cinders, trace gravel, trace sand, black, dry, upper 10cm is silty with rootlets, sparse grass coverage

0.50
232.82

CLAY (CL-CI)
Silty, low to medium plasticity, trace fine gravel, mottled light brown to dark grey, some rusting, moist (FILL)

1.80
231.52

SAND AND GRAVEL (SW-GW)
Fine to coarse sand, fine to medium gravel, moist (FILL)

2.05
231.27

CLAY (CI)
Medium plasticity, firm to stiff, light greyish brown, moist

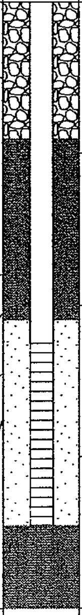
2.45
230.87

SILT (ML)
Trace clay, non-plastic to low plasticity, soft, light brown, wet
2.45 m: first appearance of water in hole

2.75
230.57

CLAY (CI-CH)
Medium to high plasticity, firm to stiff, moist, olive grey mottled with brown, oxidized in spots

4.00
229.32



End of Hole at: 4.0 m

New hole drilled for AH03-01B due to bridging in AH03-1A (unable to install shallow standpipe)

Located ~1 m South of AH03-1A. No logging or sampling performed on hole.

25 mm standpipe installed in lockable steel casing
Stick-up = 0.94 m
Initial water level estimated from drilling = 2.44 m bgl
June 17/03 water level = 2.77 m bgl
June 20/03 water level = 2.63 m bgl

DEPTH (m): 1 2 3 4 5 6 7 8 9 10

KLOHN CRIPPEN

PROJECT NO.: A03023A01

PROJECT: Winnipeg BRT

LOCATION: Southwest Corridor - Overpass

LOGGED BY: JNH **CHECKED BY:** DWR

SHEET 1 **OF** 1 **HOLE NO.:** AH03-01B

TEST HOLE LOG

STARTED: June 18, 2003 **FINISHED:** June 18, 2003

DRILL METHOD: Solid Stem Auger

GROUND ELEV. (m): 232.10

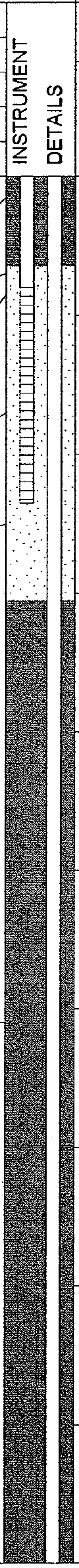
COORDINATES (m): N 5526165.9 E 633565.1

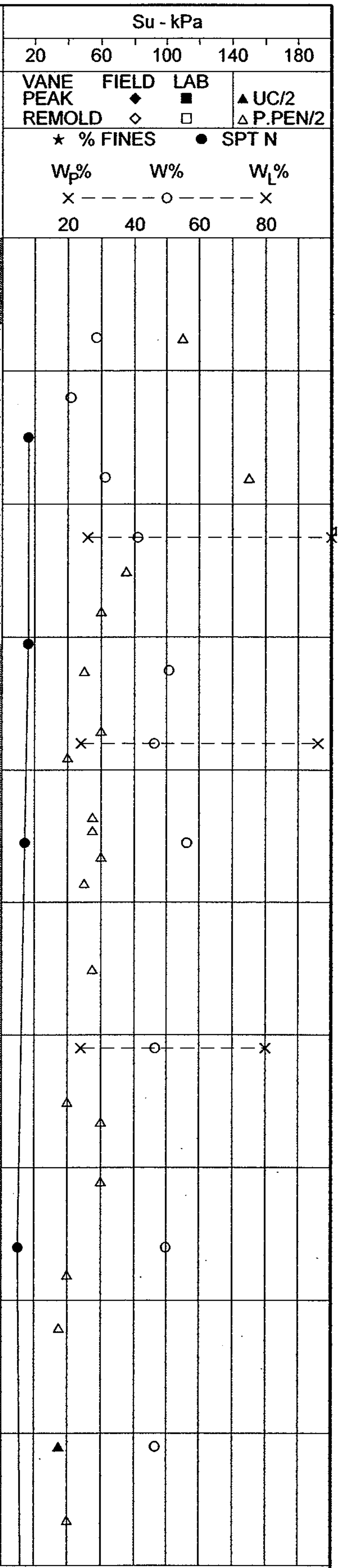
DESCRIPTION OF MATERIALS

DEPTH (m)	ELEV. (m)	DESCRIPTION OF MATERIALS
0.15	231.95	TOPSOIL - Silty, black, dry, rootlets, dense vegetation cover
0.70	231.40	FILL Silty, some cinders, some gravel (fine to coarse), black, dry
0.85	231.25	CLAY (CL-CI) Low to medium plasticity, stiff, dark grey
1.70	230.40	SILT (ML) Non-plastic to low plasticity, soft, light brown to light brownish yellow, moist PP/2 < 25 kPa 1.5m: SPT picked up slough only, no sample recovery ▼
2.50	229.60	CLAY (CI-CH) Trace silt, medium to high plasticity, stiff to very stiff, brown to olive grey mottled with some dark grey, dry to moist 2.25 m: Sample 4 = 12% silt, 88% clay
6.10	226.00	CLAY (CH) Trace silt, high plasticity, firm to stiff, brown to olive grey, moist, gypsum deposits 3.05 m: SPT numbers are too high - pushing rock, no sample 3.25 m: some rusty brown spots Sample 6: 0.01% sulphate by weight Consolidation test performed
		CLAY (CH) High plasticity, firm to stiff, olive grey, moist, gypsum deposits 6.1m: some small flecks of silt beginning to appear 7.6m: becoming olive grey to grey, some rusty seams, frequent flecks of silt 9.1m: beginning of occasional pebbles (subangular to angular, 2-15mm dia.) Unconfined Compressive Strength = 69.4 kPa

SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.
	Grab	1
	Grab	2
3 3 5	SPT	
	Grab	3
	SY	4
4 4 4	SPT Grab	5
	SY	6
3 3 4	SPT	7
	SY	8
2 2 3	SPT	9
	SY	10

DEPTH (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10





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PROJECT NO.: A03023A01

PROJECT: Winnipeg BRT

LOCATION: Southwest Corridor - Overpass

LOGGED BY: JNH **CHECKED BY:** DWR

SHEET 1 **OF** 2 **HOLE NO.:** AH03-02

KLOHN CRIPPEN

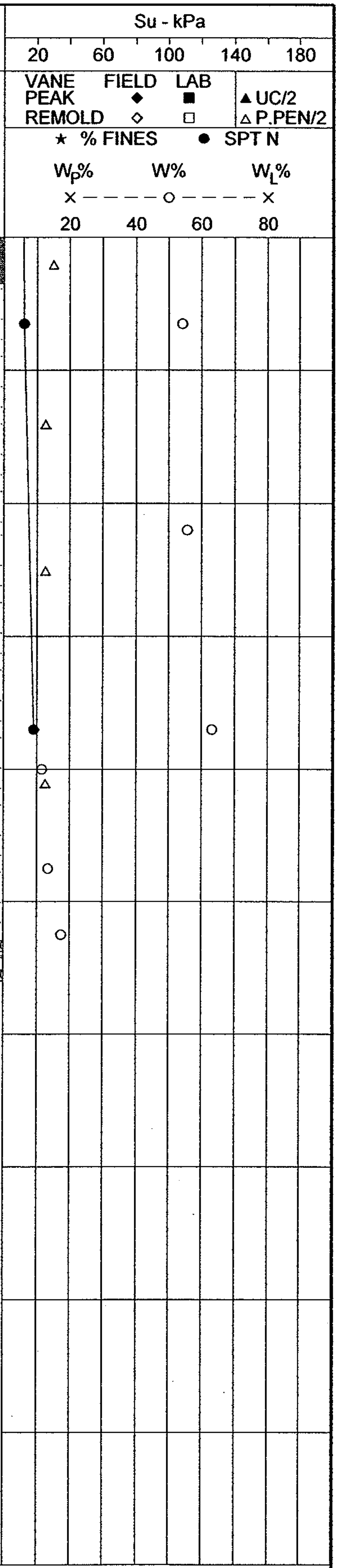
TEST HOLE LOG

STARTED: June 18, 2003 **FINISHED:** June 18, 2003
DRILL METHOD: Solid Stem Auger
GROUND ELEV. (m): 232.10
COORDINATES (m): N 5526165.9 E 633565.1

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	DESCRIPTION OF MATERIALS
11	2 3 3	SPT	11	10.65 - 14.0m: becoming soft to firm PP/2 < 25 kPa
12		SY	12	
13				
14	6 5 4	SPT	13a	13.7m: SPT sample split
			13b	14.00 218.10 **SILT (ML)** Some gravel (fine to coarse, subangular to angular), trace coarse sand, trace clay, non-plastic to low plasticity, soft to firm, pinkish brown becoming light brown, wet (TILL-LIKE) 14.75 m: becoming gravely, firm
15		Grab	14	
		Grab	15	15.25 216.85 **SAND (SM)** Fine, silty, light brown, wet 15.60 216.50 15.60 m: Auger refusal
16				End of Hole at: 15.6 m

End of Hole at: 15.6 m

2 x 25 mm standpipes installed in lockable steel casing
Stick-up = 0.90 m for both
AH03-02A: Initial water level = 12.34 m bgl
June 20/03 water level = 12.03 m bgl
AH03-02B: Initial water level = 0.73 m bgl
June 20/03 water level = 1.71 m bgl



PROJECT NO.: A03023A01
PROJECT: Winnipeg BRT
LOCATION: Southwest Corridor - Overpass
LOGGED BY: JNH **CHECKED BY:** DWR
SHEET 2 **OF** 2 **HOLE NO.:** AH03-02

KLOHN CRIPPEN

TEST HOLE LOG

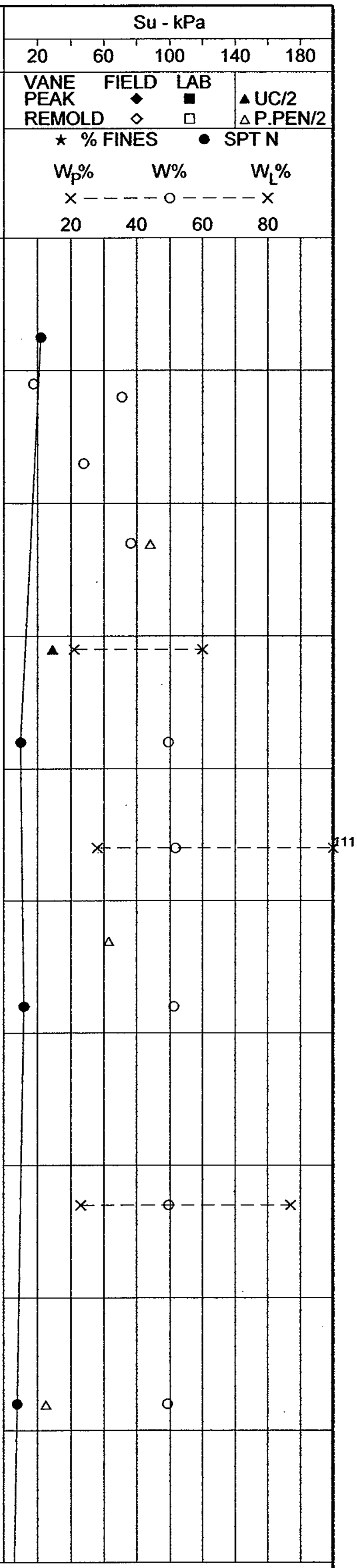
STARTED: June 27, 2003 **FINISHED:** June 27, 2003

DRILL METHOD: Solid Stem Auger

GROUND ELEV. (m): 232.84

COORDINATES (m): N 5525985.5 E 633502.1

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					CLAY FILL Silty, trace to some fine gravel, low plasticity, firm, black, moist, surface covered by 50 mm of crushed limestone (20mm diam)	
1					0.9 - 1.2 m: sand seam, wet	
		Bag	1			
		Bag	2			
1.50 231.34					SILT (ML) Low plasticity, soft, light brown, moist	
		Bag	3			
2						
2.10 230.74					CLAY (CH) High plasticity, firm, mottled brown with olive grey, trace silt inclusions	
		Bag	4			
3					Unconfined Compressive Strength = 57.0 kPa	
		Shelby	5			
					Some silt inclusions below 3.8 m	
4	2 2 3	SPT	6			
					Trace sulphates below 4.6 m	
5		Shelby	7			
					Trace oxidation below 5.8 m	
6	2 2 4	SPT	8			
7						
		Shelby	9			
8					8.20 m: becoming grey	
9	1 1 3	SPT	10			
10					Continued Next Page	



PROJECT NO.: A03023A01

PROJECT: Winnipeg BRT

LOCATION: Southwest Corridor - CNR Underpass

LOGGED BY: NTL **CHECKED BY:** DWR

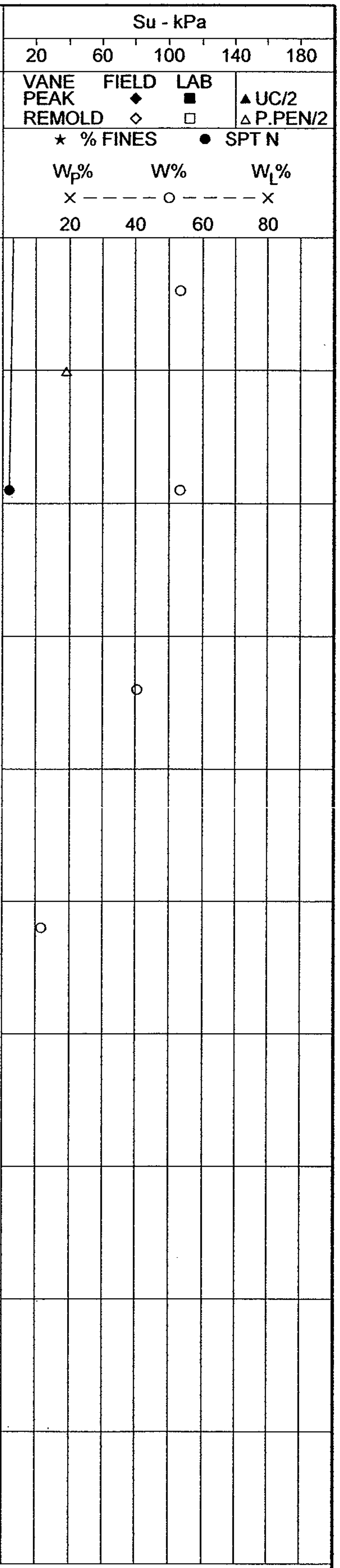
SHEET 1 OF 2 **HOLE NO.:** AH03-05

KLOHN CRIPPEN

TEST HOLE LOG

STARTED: June 27, 2003**FINISHED:** June 27, 2003
DRILL METHOD: Solid Stem Auger
GROUND ELEV. (m): 232.84
COORDINATES (m): N 5525985.5 E 633502.1

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
		Shelby	11	▨		
11				▨		
12	1 1 1	SPT	12	▨		
13		Shelby	13	▨	13.7 m: trace till inclusions	
14				▨		
15	4 DNF	SPT	14		14.90 217.94 SILT (ML) Gravely (fine to coarse), dense, light reddish brown, wet (TILL-LIKE)	
					15.40 217.44 15.4 m: auger refusal, suspect boulder on bedrock	
16					End of Hole at: 15.4 m Hole drilled under supervision of National Test Labs	
17						
18						
19						
20						



J ROCK_006.GDT 24/10/03

KC_TEST_HOLE-SI SW_

KLOHN CRIPPEN

PROJECT NO.: A03023A01
PROJECT: Winnipeg BRT
LOCATION: Southwest Corridor - CNR Underpass
LOGGED BY: NTL **CHECKED BY:** DWR
SHEET 2 **OF** 2 **HOLE NO.:** AH03-05

TEST HOLE LOG

STARTED: June 18, 2003 **FINISHED:** June 18, 2003
DRILL METHOD: Hollow Stem Auger
GROUND ELEV. (m): 233.24
COORDINATES (m): N 5525939.3 E 633513.3

SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.
	Grab	1
6 16 DNF	SPT	2
3 5 5	SPT	3
	Bulk	14
	SY	4&5
2 2 2	SPT	6
	Bulk	15
	SY	7
2 2 3	SPT	8
	SY	9
3 3 4	SPT	10

DESCRIPTION OF MATERIALS

GRAVEL / CRUSHED ROCK (GP)
Coarse, trace cobbles, poorly graded, track bed

0.30
232.94
FILL
Cinders, some sand, trace gravel, trace silt, black, moist

0.60
232.64
CLAY FILL (CL)
Silty, low plasticity, stiff, dark grey, dry to moist

0.90
232.34
FILL
Sand, silty, some cinders, some gravel, light brown, black in some zones, moist

1.50
231.74
CLAY, SAND and GRAVEL (FILL)
- no quality samples obtained with Shelby tubes or SPT
- no auger flight samples with hollow stem

1.5 m: poor sample recovery (SPT on top of rock)
~1.5 - 2.2 m: appear to have drilled through an abandoned wooden sewer - wood fragments in samples 3,4&5; visible cavern on side of borehole, trickling water, surrounded by sand.
No recovery in Shelby tubes pushed at 2.25 m and 2.45 m.

3.00
230.24
2.45 m: Clay in SPT sample (possibly native but highly disturbed by a sloughed rock caught in shoe - explains high SPT N)

CLAY (CH)
High plasticity, firm to stiff, brown mottled with olive grey, occasional salt/silt inclusions (light brown, powdery)
3.00 m: Standard Proctor Results -
Maximum Dry Density = 1400 kg/m3
Optimum Moisture Content = 23.5%

3.05 m: Sample 5 repushed over same depth as Sample 4
4.25 m: Standard Proctor Results -
Maximum Dry Denstiy = 1390 kg/m3
Optimum Moisture Content = 28.0%
4.55 m: becoming spotted with rusty brown
Sample 7: 1.63% sulphate by weight

6.10 m: occasional salt deposits (white crystals), mottling of olive grey and brown in horizontal seams.

Sample 9: Consolidation test performed
Direct shear test performed

8.15 m - becoming drier

9.15 m: becoming trace spots of silt (light brown), trace gravel (fine - coarse, subangular)

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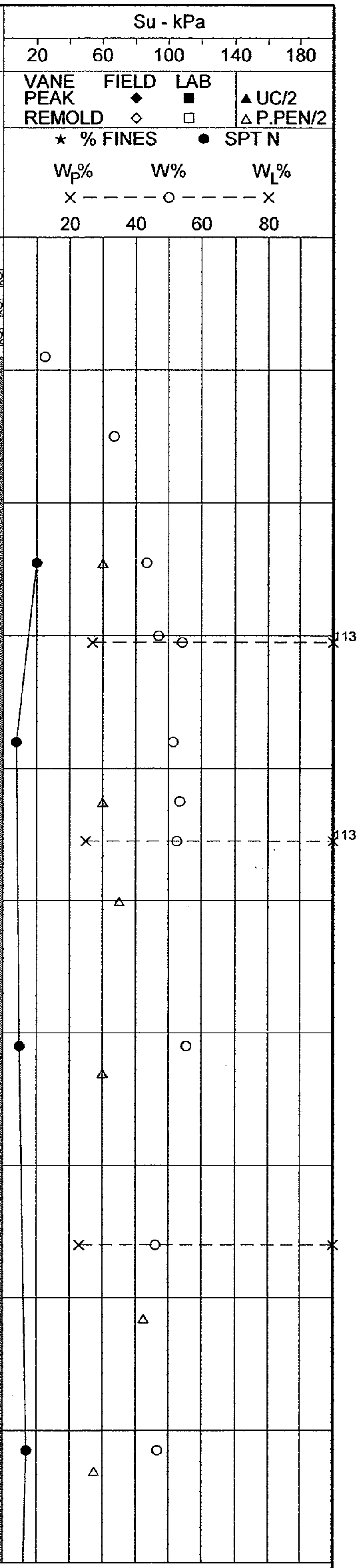


DEPTH (m) 1 2 3 4 5 6 7 8 9 10

KLOHN CRIPPEN

PROJECT NO.: A03023A01
PROJECT: Winnipeg BRT
LOCATION: Southwest Corridor - CNR Underpass
LOGGED BY: JNH **CHECKED BY:** DWR
SHEET 1 OF 2 **HOLE NO.:** AH03-06

TEST HOLE LOG

STARTED: June 18, 2003 **FINISHED:** June 18, 2003
DRILL METHOD: Hollow Stem Auger
GROUND ELEV. (m): 233.24
COORDINATES (m): N 5525939.3 E 633513.3

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.
11		SY	11
12	2 2 2	SPT	12
13			
14		SY	13
15			
16			
17			
18			
19			
20			

DESCRIPTION OF MATERIALS

10.65 m: frequent spots of silt

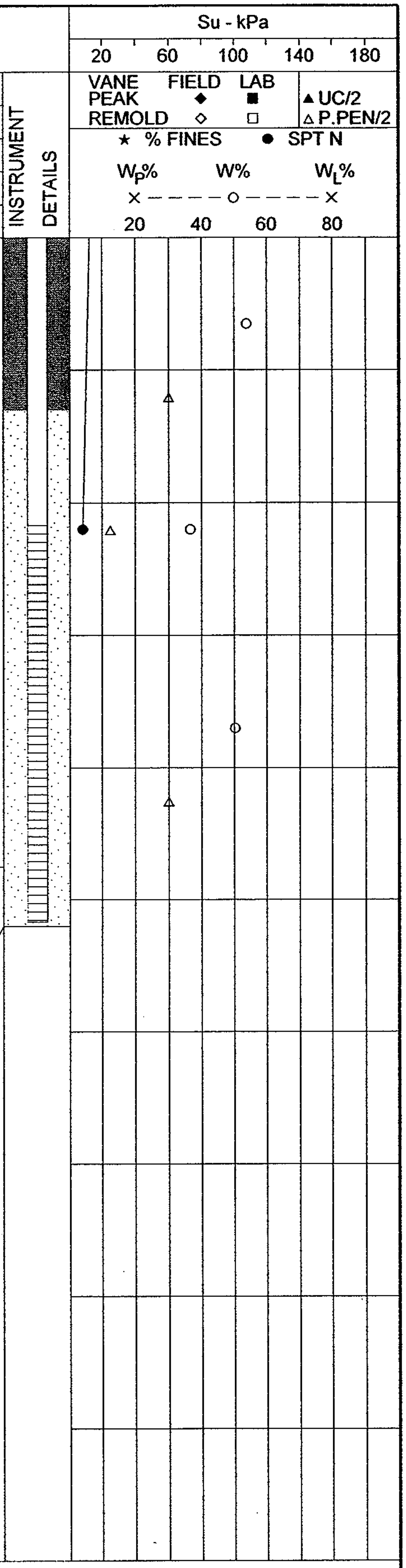
12.20 m: more frequent spots of silt ⊽

14.75
218.49 SILT (ML)
- No sample retrieved, assumed to be gravelly from SPT (TILL-LIKE, inferred from drill action)

15.20
218.04 15.20 m: Auger refusal
15.25 m: SPT bouncing on rock

End of Hole at: 15.2 m

25 mm standpipe installed with flush mount cover
Recess = 0.20 m
Initial water level = 12.34 m bgl



KLOHN CRIPPEN

PROJECT NO.: A03023A01
PROJECT: Winnipeg BRT
LOCATION: Southwest Corridor - CNR Underpass
LOGGED BY: JNH **CHECKED BY:** DWR
SHEET 2 **OF** 2 **HOLE NO.:** AH03-06

TEST HOLE LOG

STARTED: June 17, 2003 **FINISHED:** June 17, 2003
DRILL METHOD: Solid Stem Auger
GROUND ELEV. (m): 233.05
COORDINATES (m): N 5525903.1 E 633518.1

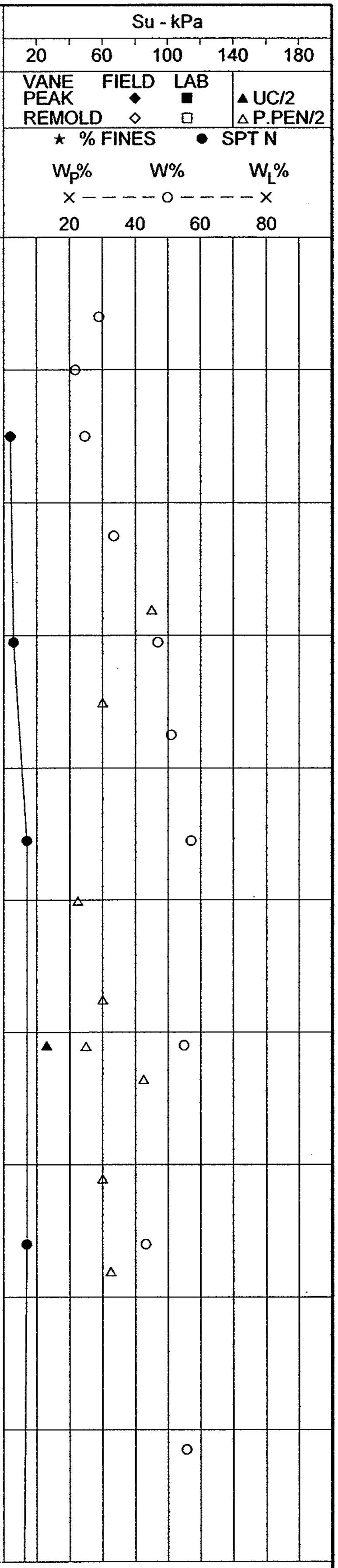
DEPTH (m): 1 2 3 4 5 6 7 8 9 10

SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.
	Grab	1
	Grab	2
2 1 1	SPT	3
	SY	4
3 1 2	SPT	5
	Grab	6
2 3 4	SPT	8
	SY	9
3 3 4	SPT	10
	SY	11

DESCRIPTION OF MATERIALS

	GRAVEL / CRUSHED ROCK (GM) Coarse, silty, trace cobbles, subrounded, track bed
0.45 232.60	FILL Cinders, sandy, black, saturated
0.90 232.15	SAND (SW) Fine to medium, trace fine gravel, trace silt, brown, saturated (FILL)
1.20 231.85	CLAY (CL) Organic, black, rootlets, soft, wet
1.40 231.65	CLAY (CI) Medium plasticity, firm to stiff, grey mottled with some rusty brown, moist
1.70 231.35	SILT (ML) Nonplastic to low plasticity, soft, light brown, saturated - bottom contact is somewhere between 2.25 and 2.8 (within Shelby tube)
2.50 230.55	CLAY (CH) High plasticity, firm to stiff, mottled brown and grey, moist 3.00 m: major gypsum deposits and rusty zones 3.75 m: no recovery in Shelby tube (hole is wet - making clay slick) Unconfined Compressive Strength = 52.1 7.60 m: becoming medium plasticity, trace silt 9.15 m: becoming medium to high plasticity, soft to firm, wetter (possibly from seepage above)

INSTRUMENT DETAILS



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KLOHN CRIPPEN

PROJECT NO.: A03023A01
PROJECT: Winnipeg BRT
LOCATION: Southwest Corridor - CNR Underpass
LOGGED BY: JNH **CHECKED BY:** DWR
SHEET 1 OF 2 **HOLE NO.:** AH03-07

TEST HOLE LOG

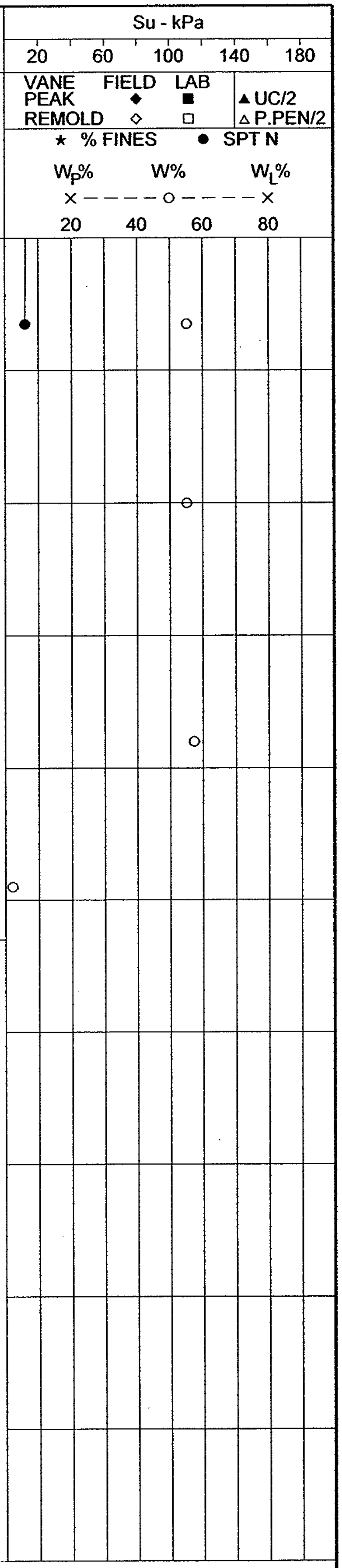
STARTED: June 17, 2003 **FINISHED:** June 17, 2003

DRILL METHOD: Solid Stem Auger

GROUND ELEV. (m): 233.05

COORDINATES (m): N 5525903.1 E 633518.1

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
11	2 2 2	SPT	12			
					11.40 m: Hole is squeezing in preventing retrieval of a Shelby sample	
12		Grab	13			
					12.50 m: Very soft clay (driller can push drill in without rotating) - could be due to infiltration of water from above	
13						
14		Grab	14			
					14.70 218.35	
15		Grab	15		SILT (ML) Low plasticity to non-plastic, some fine gravel, trace sand, trace clay, light pinkish brown, wet (TILL-LIKE)	
					15.30 217.75 15.30 m: Auger refusal	
16					End of Hole at: 15.3 m Hole backfilled with cuttings. Top 3.0 m sealed with bentonite chips.	
17						
18						
19						
20						



KLOHN CRIPPEN

PROJECT NO.: A03023A01

PROJECT: Winnipeg BRT

LOCATION: Southwest Corridor - CNR Underpass

LOGGED BY: JNH **CHECKED BY:** DWR

SHEET 2 **OF** 2 **HOLE NO.:** AH03-07

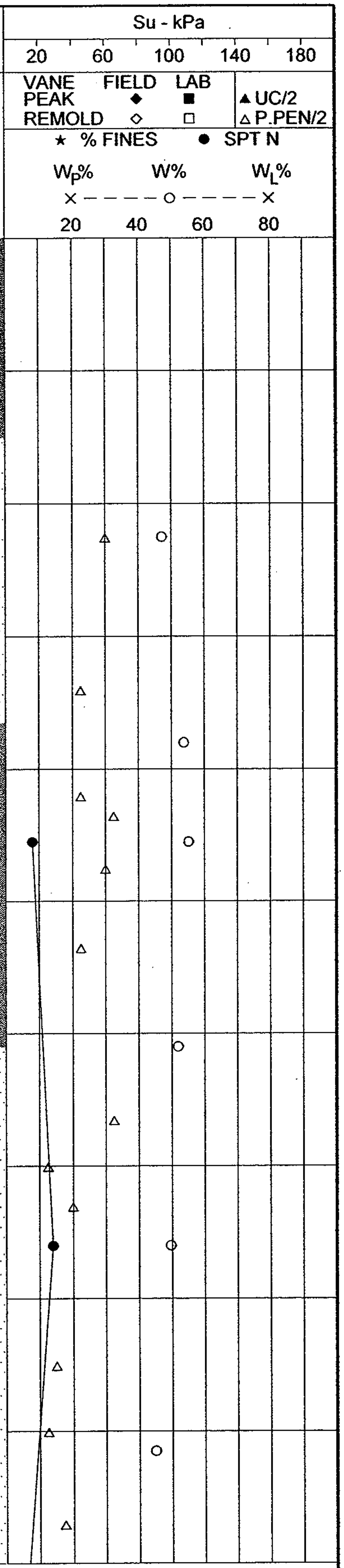
TEST HOLE LOG

STARTED: June 19, 2003 **FINISHED:** June 19, 2003
DRILL METHOD: Solid Stem Auger
GROUND ELEV. (m): 232.62
COORDINATES (m): N 5525848.3 E 633516.7

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.
0.75		Grab	1*
2.3		Grab	1
4.0		SY	2
4.7	2 4 4	SPT	3
6.4		SY	4
7.8	4 7 7	SPT	5
9.4		SY	6

DESCRIPTION OF MATERIALS

Depth / Elev. (m)	Description
0.00	FILL Silt, clay, some gravel, trace sand, low plasticity to non-plastic, dry to moist 0.75 m: sample of fill was taken from a failed hole ~ 13m NEE of AH03-08
1.40 231.22	CONCRETE - probably a basement foundation, surface and basement foundations prevalent to the east of AH03-08
1.70 230.92	CLAY (CL-CI) Low to medium plasticity, trace gravel, trace silt, firm, grey mottled with brown, moist (POSSIBLY FILL)
3.00 229.62	CLAY (CI-CH) Medium to high plasticity, firm to stiff, brown mottled with olive grey, moist to wet
4.50 228.12	CLAY (CH) High plasticity, firm to stiff, mottled brown and olive grey, moist, occasional salt inclusions 7.60 m: SPT N high due to sloughed rock (sample showed rock fragments, clay was twisted) 8.00 m: more frequent silt inclusions 9.00 m: becoming soft to firm, ocassional pebbles PP/2 < 25 kPa



Continued Next Page

PROJECT NO.: A03023A01
PROJECT: Winnipeg BRT
LOCATION: Southwest Corridor - CNR Underpass
LOGGED BY: JNH **CHECKED BY:** DWR
SHEET 1 OF 2 **HOLE NO.:** AH03-08

KLOHN CRIPPEN

TEST HOLE LOG

STARTED: June 19, 2003 **FINISHED:** June 19, 2003

DRILL METHOD: Solid Stem Auger

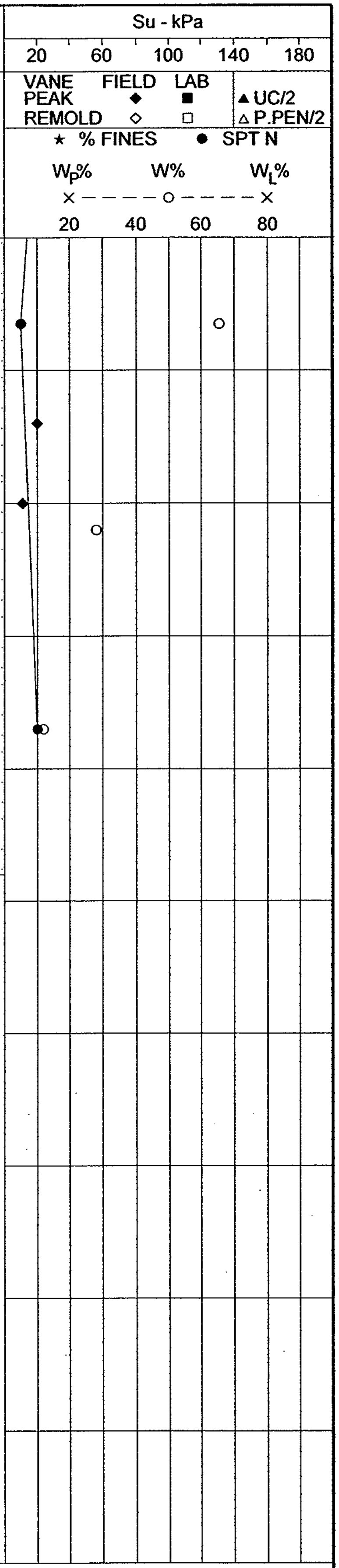
GROUND ELEV. (m): 232.62

COORDINATES (m): N 5525848.3 E 633516.7

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.		DESCRIPTION OF MATERIALS
11	3 2 3	SPT	7		
12		SY	8	12.50 220.12	SILT (ML) Non-plastic to low plasticity, some gravel, trace sand, trace clay, soft, light grey, wet (TILL-LIKE)
13					
14	3 5 5	SPT	9		13.90 m: becoming gravely, trace to some sand, light pinkish brown 14.80 m: Auger refusal
				14.80 217.82	
15					End of Hole at: 14.8 m
16					
17					
18					
19					
20					

End of Hole at: 14.8 m

2 x 25 mm standpipes installed in one lockable steel casing
Stick-up = 0.87 m for both
AH03-08A: Initial water level = 7.84 m bgl
June 20/03 water level = 9.87 m bgl
AH03-08B: Initial water level = 3.17 m bgl
June 20/03 water level = 2.70 m bgl



KLOHN CRIPPEN

PROJECT NO.: A03023A01

PROJECT: Winnipeg BRT

LOCATION: Southwest Corridor - CNR Underpass

LOGGED BY: JNH **CHECKED BY:** DWR

SHEET 2 **OF** 2 **HOLE NO.:** AH03-08

KC_TEST_HOLE-SI SW. PJ ROCK_008.GDT 24/10/03

TEST HOLE LOG

STARTED: June 17, 2003 **FINISHED:** June 17, 2003

DRILL METHOD: Solid Stem Auger

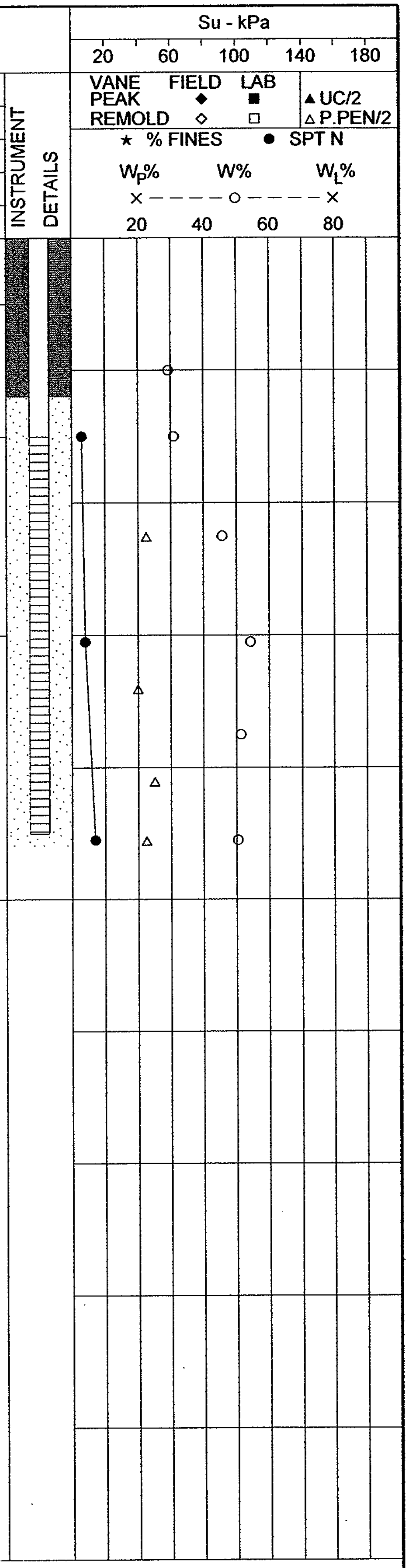
GROUND ELEV. (m): 232.60

COORDINATES (m): N 5525792.1 E 633526.2

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	DESCRIPTION OF MATERIALS
0.00				FILL Silty clay and coarse gravel, low plasticity, firm to stiff, dark brown, moist, rootlets
0.50 232.10				CLAY (CL) Silty, low plasticity, trace gravel, trace cinders, trace organic clay (black), firm to stiff, brown, fragments of wood (probably old lumber) (FILL)
		Grab	1	
1.50 231.10				CLAY (CL) Clay (as above) mixed with silt (light brown, soft, wet), ∇ low plasticity, trace coarse gravel, light brown mottled with brown, moist (FILL)
	2 2 1	SPT	2	
		Grab	3	
3.00 229.60				CLAY (CH) High plasticity, firm to stiff, brown to olive grey mottled with grey, moist, occasional gypsum deposits, occasional deposits (possibly organic, dark brown, angular)
	2 1 3	SPT	4	
		Grab	5	
				4.50 m: more frequent salt inclusions, occasional rust spots, occasional spots of silt (thin seams, near vertical)
	3 3 4	SPT	6	
5.00 227.60				

End of Hole at: 5.0 m

25 mm standpipe installed in lockable steel casing
Stick-up = 0.91 m
Initial water level = no water
June 20/03 water level = 1.73 m bgl



PROJECT NO.: A03023A01

PROJECT: Winnipeg BRT

LOCATION: Southwest Corridor - Test Section

LOGGED BY: JNH **CHECKED BY:** DWR

SHEET 1 OF 1 **HOLE NO.:** AH03-09

KLOHN CRIPPEN

TEST HOLE LOG

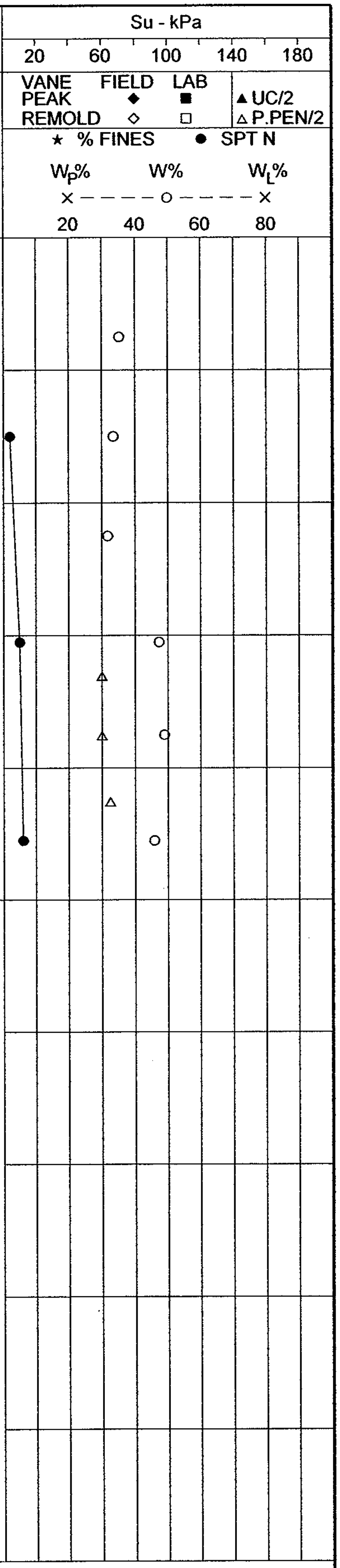
STARTED: June 17, 2003 **FINISHED:** June 17, 2003

DRILL METHOD: Solid Stem Auger

GROUND ELEV. (m): 232.40

COORDINATES (m): N 5525647 E 633509.5

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					FILL Clay, sand, cinders, black, moist	
					0.25 232.15 FILL Clay and silt, low plasticity, trace gravel, firm to stiff, grey mottled with light grey and brown, moist, rootlets	
1		Grab	1			
					1.50 230.90 FILL Silt (light grey, nonplastic to low plastic) mixed with clay (grey, medium to high plasticity), soft, wet	
2	2 1 1	SPT	2			
		Grab	3		2.25 m: some organic clay mixed in	
					2.50 229.90 CLAY (CH) High plasticity, firm to stiff, olive grey mottled brown, moist, gypsum deposits	
3	2 1 4	SPT	4			
4		Grab	5			
5	2 3 3	SPT	6			
					5.00 227.40	
6					End of Hole at: 5.0 m Hole backfilled with cuttings to 2.5 m and sealed with bentonite chips from 0 to 2.5 m. Survey coordinates are approximate. Hole was moved 10m NNE prior to drilling.	
7						
8						
9						
10						



KLOHN CRIPPEN

PROJECT NO.: A03023A01

PROJECT: Winnipeg BRT

LOCATION: Southwest Corridor - Test Section

LOGGED BY: JNH **CHECKED BY:** DWR

SHEET 1 **OF** 1 **HOLE NO.:** AH03-10

TEST HOLE LOG

STARTED: June 17, 2003 **FINISHED:** June 17, 2003

DRILL METHOD: Solid Stem Auger

GROUND ELEV. (m): 232.10

COORDINATES (m): N 5525375.8 E 633442

DESCRIPTION OF MATERIALS

0.10 / 232.00 Topsoil - Dry, grey, rootlets

SAND and GRAVEL
Fine to coarse, trace silt, trace cobbles, well graded, moist (FILL)

0.85 / 231.25 CLAY (CL)
Low plasticity, firm, black, moist, organic

1.00 / 231.10 CLAY (CL)
Low plasticity, firm to stiff, dark grey mottled with olive grey, moist

1.50 / 230.60 SILT (ML)
Low plasticity, soft, light brown, wet
1.50 m: attempted SPT - sloughing problems with sand and gravel above

2.00 / 230.10 CLAY (CI-CH)
Medium to high plasticity, firm to stiff, olive grey mottled with brown, moist

3.00 m: frequent salt deposits

4.50 m: becoming medium to high plasticity

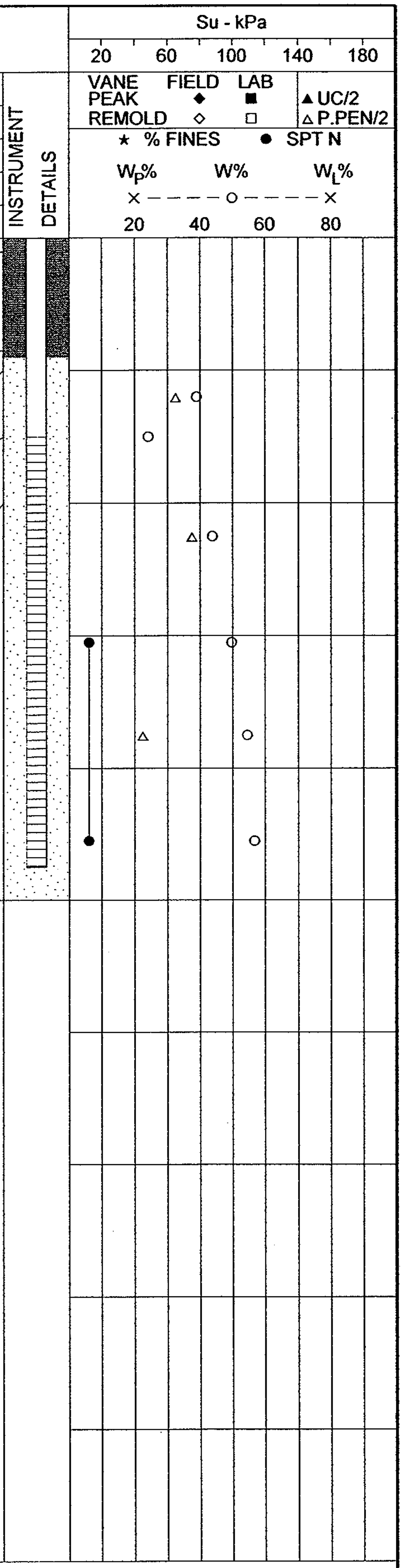
5.00 / 227.10

End of Hole at: 5.0 m

25 mm standpipe installed in lockable steel casing
Stick-up = 0.84 m
Initial water level = no water
June 20/03 water level = 3.54 m bgl (slow recovery)

SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.
	Grab	1
	Grab	2
	Grab	3
2 3 3	SPT	4
	Grab	5
2 3 3	SPT	6

DEPTH (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10



PROJECT NO.: A03023A01

PROJECT: Winnipeg BRT

LOCATION: Southwest Corridor - Test Section

LOGGED BY: JNH **CHECKED BY:** DWR

SHEET 1 **OF** 1 **HOLE NO.:** AH03-11

KLOHN CRIPPEN

TEST HOLE LOG

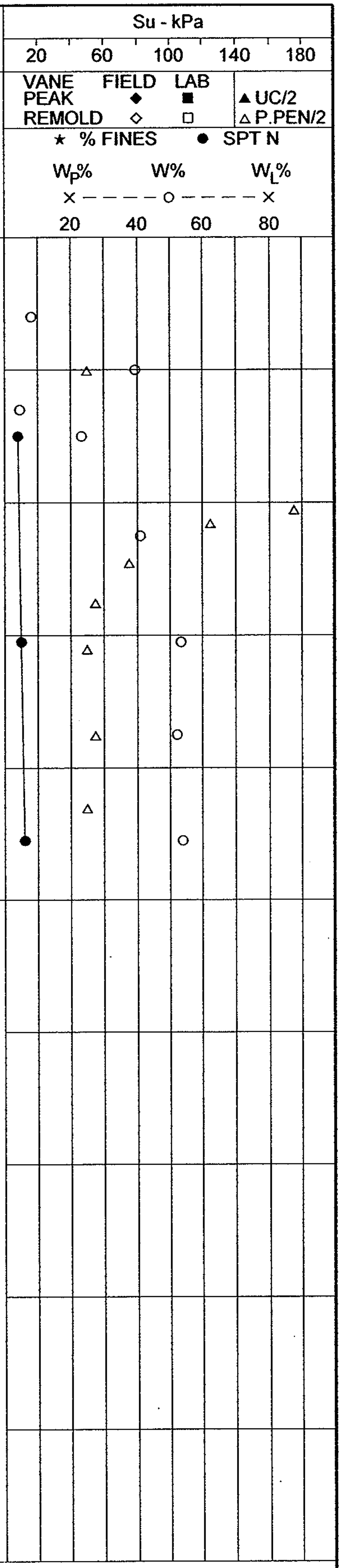
STARTED: June 17, 2003 **FINISHED:** June 17, 2003

DRILL METHOD: Solid Stem Auger

GROUND ELEV. (m): 232.32

COORDINATES (m): N 5525177.8 E 633361.7

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					FILL Cinders, granular, black, moist	
					0.40 231.92	
		Grab	1		SAND Fine to medium, trace gravel (fine to coarse, subrounded), trace clay (organic, black), well graded, brown, wet, trace rootlets	
					0.90 231.42	
1		Grab	2		CLAY (CL-CI) Low to medium plasticity, silty, stiff, dark grey mottled with light grey and reddish brown, moist	
					1.20 231.12	
		Grab	3		SILT (ML) Low plasticity, trace to some clay, soft to firm, light grey mottled with grey, moist to wet	
	2 1 3	SPT	4			
2					2.00 230.32	
		Grab	5		CLAY (CI-CH) Medium to high plasticity, stiff, mottled brown with olive grey, moist 2.25 m: becoming firm to stiff, frequent and large gypsum deposits (dry, light grey)	
3	2 2 3	SPT	6			
		Grab	7		3.75 m: becoming medium to high plasticity	
4					4.50 m: frequent white salt deposits	
5	2 2 4	SPT	8		5.00 227.32	
6					End of Hole at: 5.0 m Hole backfilled with cuttings. Sealed with bentonite chips from 0.9 to 2.5 m.	
7						
8						
9						
10						



KLOHN CRIPPEN

PROJECT NO.: A03023A01

PROJECT: Winnipeg BRT

LOCATION: Southwest Corridor - Test Section

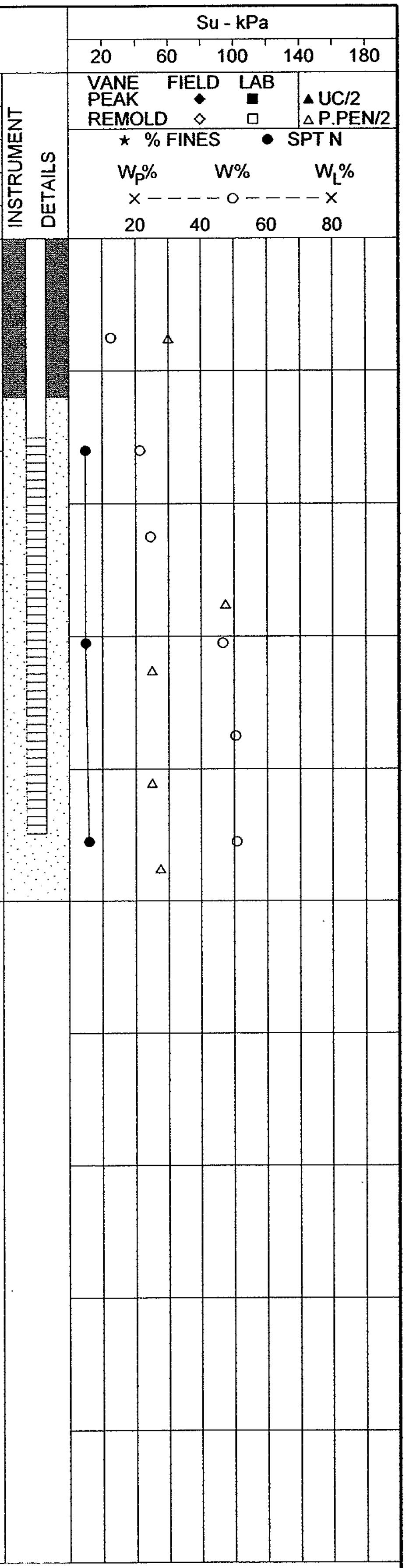
LOGGED BY: JNH **CHECKED BY:** DWR

SHEET 1 **OF** 1 **HOLE NO.:** AH03-12

TEST HOLE LOG

STARTED: June 17, 2003**FINISHED:** June 17, 2003
DRILL METHOD: Solid Stem Auger
GROUND ELEV. (m): 232.87
COORDINATES (m): N 5524942.1 E 633268.7

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL		DESCRIPTION OF MATERIALS
						CLAY (CL-CI) Silty, low to medium plasticity, trace to some gravel (fine to coarse, subrounded), trace sand, brown with some organic black clay, rootlets in top 50 cm, grass covered surface (FILL)
1		Grab	1			
					1.60 231.27	SILT (ML) Low plasticity, trace clay, very soft to soft, light grey, wet, trace rootlets
2	2 2 3	SPT	2			
		Grab	3			
					2.45 230.42	CLAY (CH) High plasticity, firm to stiff, brown to olive grey mottled with some dark grey, trace salt inclusions, trace rootlets
3	2 2 3	SPT	4			
4		Grab	5			
5	3 3 3	SPT	6			
					5.00 227.87	End of Hole at: 5.0 m 25 mm standpipe installed in lockable steel casing Stick-up = 0.91 m Initial water level = no water June 20/03 water level = 1.19 m bgl
6						
7						
8						
9						
10						



KLOHN CRIPPEN

PROJECT NO.: A03023A01
PROJECT: Winnipeg BRT
LOCATION: Southwest Corridor - Test Section
LOGGED BY: JNH **CHECKED BY:** DWR
SHEET 1 OF 1 **HOLE NO.:** AH03-13

TEST HOLE LOG

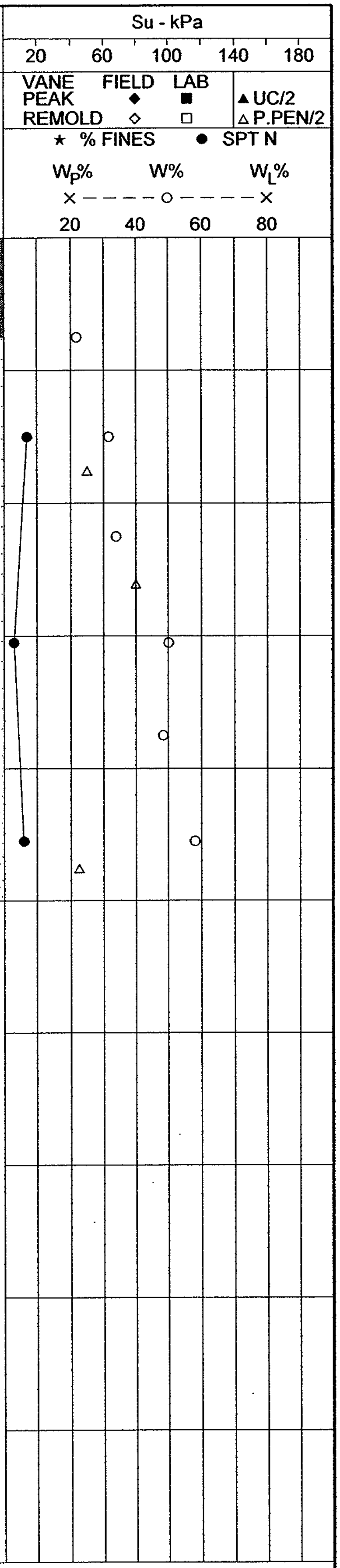
STARTED: June 16, 2003**FINISHED:** June 16, 2003
DRILL METHOD: Solid Stem Auger
GROUND ELEV. (m): 232.97
COORDINATES (m): N 5524571.2 E 633130.7

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.		DESCRIPTION OF MATERIALS
				0.15 232.82	Topsoil - dark grey, dry, rootlets
				0.50 232.47	CLAY (CL) Low plasticity, silty, trace to some sand and fine gravel, stiff, mottled light grey and olive grey, grass covered surface (FILL)
1		Grab	1	1.30 231.67	SAND (SM) Fine to medium, silty, wet (FILL) ∇
				1.50 231.47	CLAY (CL) Low plasticity, soft, black, moist, organic, rootlets
2	3 3 4	SPT	2	2.00 230.97	CLAY (CL) Low plasticity, blocky in places (very fine blocks), some fine sand, firm to stiff, grey with a tinge of green,
		Grab	3		CLAY (CH) High plasticity, firm to stiff, mottled olive grey and rusty brown, moist
3	2 1 2	SPT	4		3.00 m: becoming firm to stiff
4		Grab	5		3.75 m: occasional pebbles
5	2 3 3	STP	6	5.00 227.97	4.55 m: salt inclusions
6					
7					
8					
9					
10					

End of Hole at: 5.0 m

25 mm standpipe installed in lockable steel casing
Stick-up = 0.96 m
Initial water level = 1.28 m bgl
June 20/03 water level = 1.12 m bgl

INSTRUMENT DETAILS



PJ ROCK_008.GDT 24/10/03

KC_TEST_HOLE-SI SW_

KLOHN CRIPPEN

PROJECT NO.: A03023A01
PROJECT: Winnipeg BRT
LOCATION: Southwest Corridor - Test Section
LOGGED BY: JNH **CHECKED BY:** DWR
SHEET 1 **OF** 1 **HOLE NO.:** AH03-14

TEST HOLE LOG

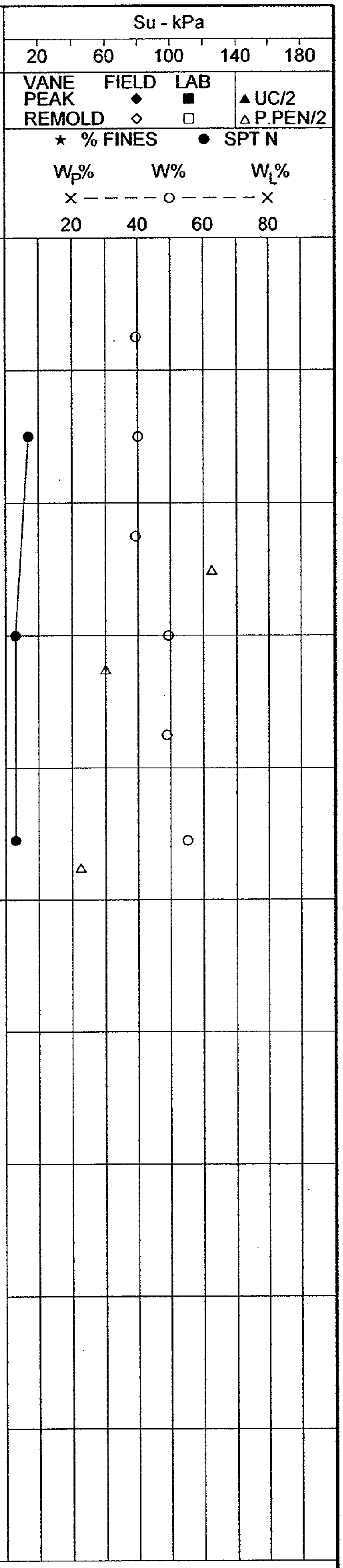
STARTED: June 16, 2003 **FINISHED:** June 16, 2003

DRILL METHOD: Solid Stem Auger

GROUND ELEV. (m): 232.72

COORDINATES (m): N 5524291.9 E 632995

DEPTH (m)	SPT BLOWS PER 0.15m	SAMPLE TYPE	SAMPLE No.	SYMBOL	DESCRIPTION OF MATERIALS	INSTRUMENT DETAILS
					0.10 / 232.62 Topsoil - Sparse grass coverage, some gravel from road	
					0.50 / 232.22 FILL Cinders, granular, black, moist	
1		Grab	1		0.95 / 231.77 CLAY (CL-CI) Low to medium plasticity, silty, firm to stiff, olive grey mottled with brown, light grey and dark grey, moist, trace rootlets (FILL?) ▽ Water level = 0.85m (measured during drilling)	
	2 3 4	SPT	2		1.80 / 230.92 SILT (ML) Low plasticity, trace clay, soft, light brown, wet	
2		Grab	3		3.00 / 229.72 CLAY (CI-CH) Medium to high plasticity, trace sand and fine gravel (in top 15 cm), stiff to very stiff, olive grey, moist	
3	2 1 2	SPT	4		CLAY (CH) High plasticity, firm to stiff, mottled olive grey and brown, rusted in some spots, trace white gypsum deposits	
4		Grab	5			
5	2 1 2	SPT	6		5.00 / 227.72	
6					End of Hole at: 5.0 m Hole backfilled with cuttings. Sealed with bentonite chips from 0.6 to 2.1 m.	
7						
8						
9						
10						



PROJECT NO.: A03023A01

PROJECT: Winnipeg BRT

LOCATION: Southwest Corridor - Test Section

LOGGED BY: JNH **CHECKED BY:** DWR

SHEET 1 **OF** 1 **HOLE NO.:** AH03-15

KLOHN CRIPPEN

KC_TEST_HOLE-SI SW_PJ ROCK_006.GDT 24/10/03

APPENDIX III

Lab Test Data

THE NATIONAL TESTING LABORATORIES LIMITED
Established in 1923

199 Henlow Bay
Winnipeg, MB R3Y 1G4
Phone (204) 488-6999
Fax (204) 488-6947
Email info@nationaltestlabs.com
www.nationaltestlabs.com

Klohn Crippen
Suite 114, 6815 - 8th Street N.E.
Calgary, AB
T2E 7H7

August 21, 2003

Project: Winnipeg BRTS

Attention: Joel Hilderman

Soil samples recovered during the drilling program for the Winnipeg BRTS were submitted to our testing laboratory. The following tests were conducted on selected samples from the drilling program:

- water content (ASTM D2216)
- particle size analysis (ASTM D422)
- plasticity index (ASTM D4318)
- unconfined compressive strength (ASTM D2166)
- sulphate content (CSA A23.2-3B)
- maximum dry density (ASTM D698)
- consolidation (ASTM D2435)
- direct shear (ASTM D3080)

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AUG 22 2003

The results for the testing program are provided in the attached tables and appended to this report. The direct shear tests were conducted with normal stresses of 30, 60 and 120 kPa. A graph showing the relationship of shear stress and normal stress is included with the direct shear test data. Two stress void ratio curves have been provided for the consolidation test. One curve has been marked to show the preconsolidation pressure to be in the range of 220 to 250 kPa. The other curve only shows the consolidation test data and it may be used to estimate the preconsolidation pressure, if required.

We appreciate the opportunity to assist you in this project. Please call me if you have any questions regarding this report.

Don Flatt

Don Flatt, M.Eng., P.Eng.
Senior Materials Engineer

TABLE 1
WATER CONTENT TEST DATA
WINNIPEG BUS RAPID TRANSIT SYSTEM

Sample ID	Water Content (%)	Sample ID	Water Content (%)	Sample ID	Water Content (%)	Sample ID	Water Content (%)	Sample ID	Water Content (%)
AH03-01-1	34.5	AH03-02-1	28.6	AH03-05-1	8.8	AH03-06-1	12.4	AH03-07-1	29.0
AH03-01-2	26.6	AH03-02-2	20.9	AH03-05-2	35.6	AH03-06-2	33.4	AH03-07-2	21.8
AH03-01-3	34.2	AH03-02-3	31.2	AH03-05-3	23.9	AH03-06-3	43.4	AH03-07-3	24.7
AH03-01-3b	26.5	AH03-02-4	41.0	AH03-05-4	38.3	AH03-06-4	35.5	AH03-07-4	33.4
AH03-01-4	41.5	AH03-02-5	50.8	AH03-05-5	50.7	AH03-06-5	54.2	AH03-07-5	46.9
AH03-01-5	50.9	AH03-02-6	46.2	AH03-05-6	49.5	AH03-06-6	51.5	AH03-07-6	51.0
AH03-01-6	52.9	AH03-02-7	56.3	AH03-05-7	51.7	AH03-06-7	52.6	AH03-07-8	57.1
AH03-01-7	54.9	AH03-02-8	46.5	AH03-05-8	51.2	AH03-06-8	55.5	AH03-07-9	54.9
AH03-01-8	47.4	AH03-02-9	49.9	AH03-05-9	49.6	AH03-06-9	46.2	AH03-07-10	43.2
AH03-01-9	45.2	AH03-02-10	46.5	AH03-05-10	49.2	AH03-06-10	46.7	AH03-07-11	55.7
AH03-01-10	53.3	AH03-02-11	54.2	AH03-05-11	53.4	AH03-06-11	53.9	AH03-07-12	55.2
AH03-01-10b	52.2	AH03-02-12	55.7	AH03-05-12	53.3	AH03-06-12	36.6	AH03-07-13	55.2
AH03-01-11	35.9	AH03-02-13a	63.2	AH03-05-13	40.6	AH03-06-13	50.3	AH03-07-14	57.3
AH03-01-12	19.1	AH03-02-13b	11.5	AH03-05-14	11.7	AH03-06-14	47.0	AH03-07-15	2.1
AH03-01-13	10.4	AH03-02-14	13.4			AH03-06-15	53.5		
AH03-01-14	12.3	AH03-02-15	17.5						

Note: Tests conducted in acordance with ASTM D2216

TABLE 1
WATER CONTENT TEST DATA
WINNIPEG BUS RAPID TRANSIT SYSTEM

Sample ID	Water Content (%)	Sample ID	Water Content (%)	Sample ID	Water Content (%)	Sample ID	Water Content (%)
AH03-08-1	47.2	AH03-09-1	29.3	AH03-10-1	35.3	AH03-11-1	38.9
AH03-08-2	53.8	AH03-09-2	31.0	AH03-10-2	33.5	AH03-11-2	24.2
AH03-08-3	55.2	AH03-09-3	45.7	AH03-10-3	31.8	AH03-11-3	43.8
AH03-08-4	51.9	AH03-09-4	54.3	AH03-10-4	47.3	AH03-11-4	49.7
AH03-08-5	49.6	AH03-09-5	51.4	AH03-10-5	48.9	AH03-11-5	54.6
AH03-08-6	44.9	AH03-09-6	50.4	AH03-10-6	45.8	AH03-11-6	65.8
AH03-08-7	65.6						
AH03-08-8	28.2						
AH03-08-9	11.9						
Sample ID	**Water Content (%)**	**Sample ID**	**Water Content (%)**	**Sample ID**	**Water Content (%)**	**Sample ID**	**Water Content (%)**
AH03-12-1	8.1	AH03-13-1	12.6	AH03-14-1	21.8	AH03-15-1	39.5
AH03-12-2	39.4	AH03-13-2	21.4	AH03-14-2	31.6	AH03-15-2	40.1
AH03-12-3	21.9	AH03-13-3	24.6	AH03-14-3	33.9	AH03-15-3	39.3
AH03-12-4	23.4	AH03-13-4	46.7	AH03-14-4	50.2	AH03-15-4	49.4
AH03-12-5	40.9	AH03-13-5	50.5	AH03-14-5	48.5	AH03-15-5	48.9
AH03-12-6	53.4	AH03-13-6	50.8	AH03-14-6	58.1	AH03-15-6	55.2
AH03-12-7	52.2						
AH03-12-8	53.9						

Note: Tests conducted in accordance with ASTM D2216

THE
NATIONAL
TESTING
LABORATORIES
LIMITED

TABLE 2
PARTICLE SIZE ANALYSIS TEST DATA
WINNIPEG BUS RAPID TRANSIT SYSTEM

Sample Identification	Gravel 75 to 4.75 mm	Sand			Silt <0.075 to 0.005 mm	Clay <0.005 mm	Colloids <0.001 mm (see note 3)
		Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
AH03-01-5	0	0	0.1	0.2	23.5	76.2	7.4
AH03-02-4	0	0	0	0.2	12.2	87.6	5.3
AH03-05-5	0	0	0	0.3	41.7	58.0	37.8
AH03-06-7	0	0	0	0.1	12.5	87.4	81.2

Notes
1. Tests conducted in accordance with ASTM D422.
2. A high speed stirring device was used for 1 minute to disperse the test samples.
3. The percentage of colloids is also included in the clay size fraction.

TABLE 3
PLASTICITY INDEX TEST DATA
WINNIPEG BUS RAPID TRANSIT SYSTEM

Sample Identification	% Retained on 0.425 mm Sieve	Liquid Limit	Plastic Limit	Plasticity Index
AH03-01-1	0.5	50	17	33
AH03-01-5	0.1	110	24	86
AH03-01-7	0.1	85	21	64
AH03-02-4	>0.1	108	26	82
AH03-02-6	0.1	96	24	72
AH03-02-8	0.1	80	24	56
AH03-05-5	>0.1	60	21	39
AH03-05-7	0.1	111	28	82
AH03-05-9	0.1	87	23	64
AH03-06-5	0.1	113	27	86
AH03-06-7	>0.1	113	25	88
AH03-06-9	0.1	100	23	77

Notes
1. Tests conducted in accordance with ASTM D4318 Method B (one-point liquid limit).
2. Samples were air-dried during sample preparation.

TABLE 4
UNCONFINED COMPRESSIVE STRENGTH TEST DATA
WINNIPEG BUS RAPID TRANSIT SYSTEM

Sample Identification	Initial Dry Density (g/cm^3)	Water Content (%)	Shear Strength (kPa)	Unconfined Compressive Strength (kPa)
AH03-01-7	1.090	54.9	28.71	57.42
AH03-02-10	1.178	46.5	34.69	69.38
AH03-05-5	1.144	50.1	28.51	57.02
AH03-07-9	1.092	54.9	26.06	52.12

Notes
1. Tests conducted in accordance with ASTM D2166.
2. The stress vs. strain curves for the test samples are attached.
3. All samples failed on a partial slickensided surface.

TABLE 5
SOIL SULPHATE CONTENT TEST DATA WINNIPEG BUS RAPID TRANSIT SYSTEM

Sample Identification	Sulphate Content (% by Weight)
AH03-02-6	0.01
AH03-06-7	1.63

Notes

1. Tests conducted in accordance with CSA A23.2-3B.
2. Sample AH03-02-06 tested for total sulphate and sample AH03-06-7 tested for water-soluble sulphate. The test method requires samples with a total sulphate content greater than 0.2% to be tested for water-soluble sulphate content.

TABLE 6
MOISTURE - DENSITY RELATIONSHIP TEST DATA WINNIPEG BUS RAPID TRANSIT SYSTEM

Sample Identification	Maximum Dry Density (kg/m3)	Optimum Moisture Content (%)
AH03-06-14	1400	23.5
AH03-06-15	1390	28.0

Note

1. Tests conducted in accordance with ASTM D698.

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MOISTURE - DENSITY RELATIONSHIP REPORT

TO
Klohn Crippen Consultants Ltd.
Suite 114, 6815- 8th Street
Calgary, Alberta
T2E 7H7

ATTN: Joel Hilderman

CLIENT Klohn Crippen Consultants Ltd.
C.C.

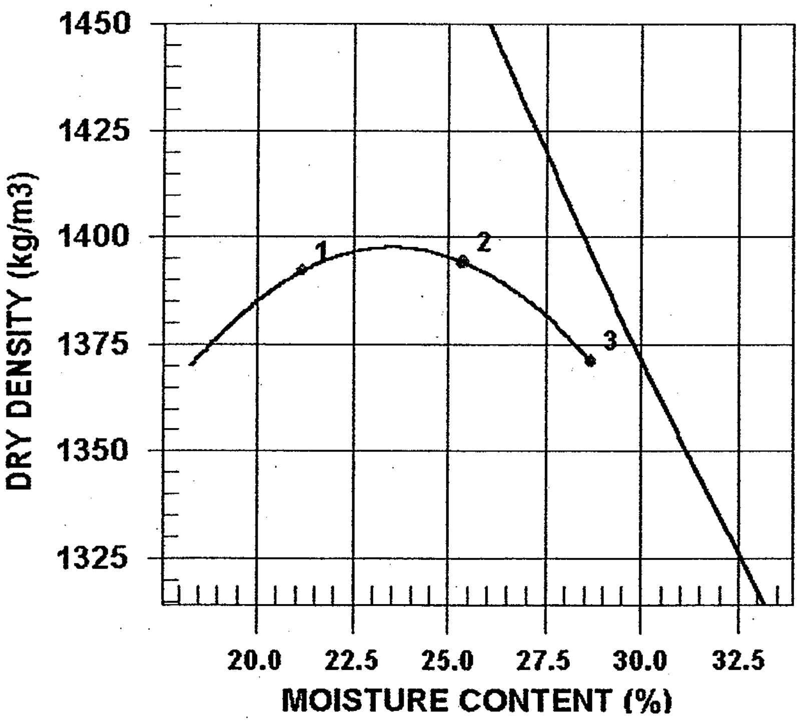
PROJECT Bus Rapid Transit System
Winnipeg

PROCTOR NO. 1

PROJECT NO. KLO-301

DATE SAMPLED 2003.Jun.18
SAMPLED BY Joel Hilderman
MATERIAL IDENTIFICATION
MATERIAL USE SUBGRADE
MAX. NOMINAL SIZE
MATERIAL TYPE Clay
SUPPLIER
SOURCE In-situ

DATE RECEIVED 2003.Jun.18
DATE TESTED 2003.Jun.24
COMPACTION STANDARD Standard Proctor, ASTM D698
COMPACTION PROCEDURE A: 101.6mm Mold, Passing 4.75mm
OVERSIZE CORRECTION METHOD None
RETAINED 4.75mm SCREEN



TRIAL NUMBER	WET DENSITY (kg/m3)	DRY DENSITY (kg/m3)	MOISTURE CONTENT (%)
1	1687	1392	21.2
2	1748	1394	25.4
3	1764	1371	28.7

	MAXIMUM DRY DENSITY (kg/m3)	OPTIMUM MOISTURE CONTENT (%)
CALCULATED OVERSIZE CORRECTED	1400	23.5

COMMENTS
ent identified the sample as AH03-06-14.

2003.Aug.14

REVIEWED BY Hermie Manalo

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Established in 1923

MOISTURE - DENSITY RELATIONSHIP REPORT

TO

Klohn Crippen Consultants Ltd.
Suite 114, 6815- 8th Street
Calgary, Alberta
T2E 7H7

ATTN: Joel Hilderman

CLIENT Klohn Crippen Consultants Ltd.
C.C.

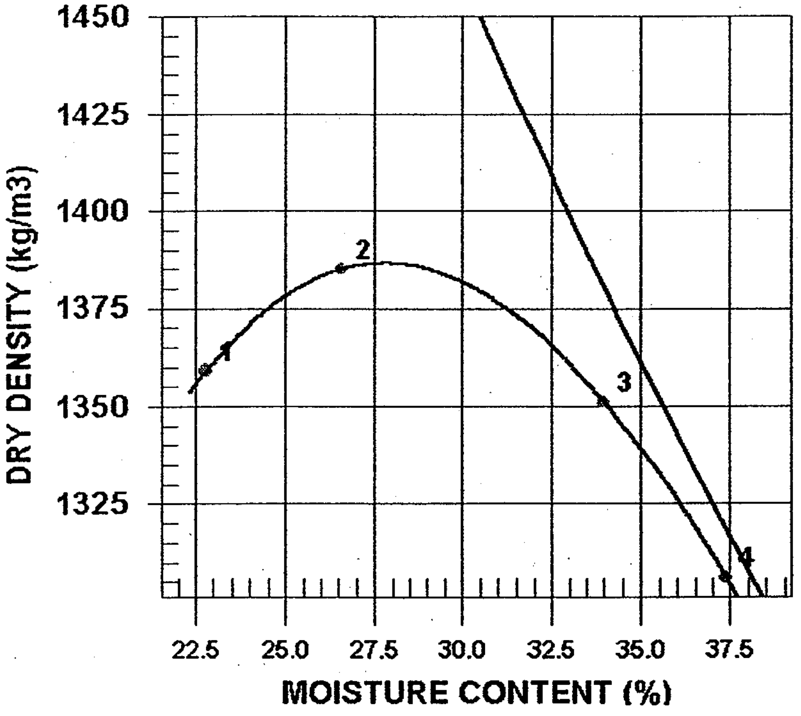
PROJECT Bus Rapid Transit System
Winnipeg

PROCTOR NO. 2

PROJECT NO. KLO-301

DATE SAMPLED 2003.Jun.18
SAMPLED BY Joel Hilderman
MATERIAL IDENTIFICATION
MATERIAL USE SUBGRADE
MAX. NOMINAL SIZE
MATERIAL TYPE Clay
SUPPLIER
SOURCE In-situ

DATE RECEIVED 2003.Jun.18
DATE TESTED 2003.Jun.24
COMPACTION STANDARD Standard Proctor, ASTM D698
COMPACTION PROCEDURE C: 152.4mm Mold, Passing 19mm
OVERSIZE CORRECTION METHOD None
RETAINED 19mm SCREEN



TRIAL NUMBER	WET DENSITY (kg/m3)	DRY DENSITY (kg/m3)	MOISTURE CONTENT (%)
1	1669	1359	22.8
2	1754	1385	26.6
3	1811	1351	34.0
4	1795	1306	37.4

	MAXIMUM DRY DENSITY (kg/m3)	OPTIMUM MOISTURE CONTENT (%)
CALCULATED	1390	28.0
OVERSIZE CORRECTED		

COMMENTS
ient identified the sample as AH03-06-15.

Page 1 of 1 2003.Aug.14

REVIEWED BY Hermie Manalo

Manitoba Hydro

Power Supply
Civil Engineering Department
Concrete & Materials Testing Section

NATIONAL TESTING AO23A01

Sample No	Hole No	Depth
9	AH 03 - 06	7.60 - 8.15m

DIRECT SHEAR TEST
PEAK SHEAR @ 30 kPa
03 07 23 By - HM
DIR - SHEARS FILE - 30kPaSRL DATA - 30kPaSRLONG

SAMPLE SIZE: ROUND (63.5 mm Diam)
INITIAL HEIGHT: 20 mm
STRAIN RATE: 0.0058mm/min
INITIAL SEATING STRESS: 6 kPa
TOTAL NORMAL STRESS: 30 kPa

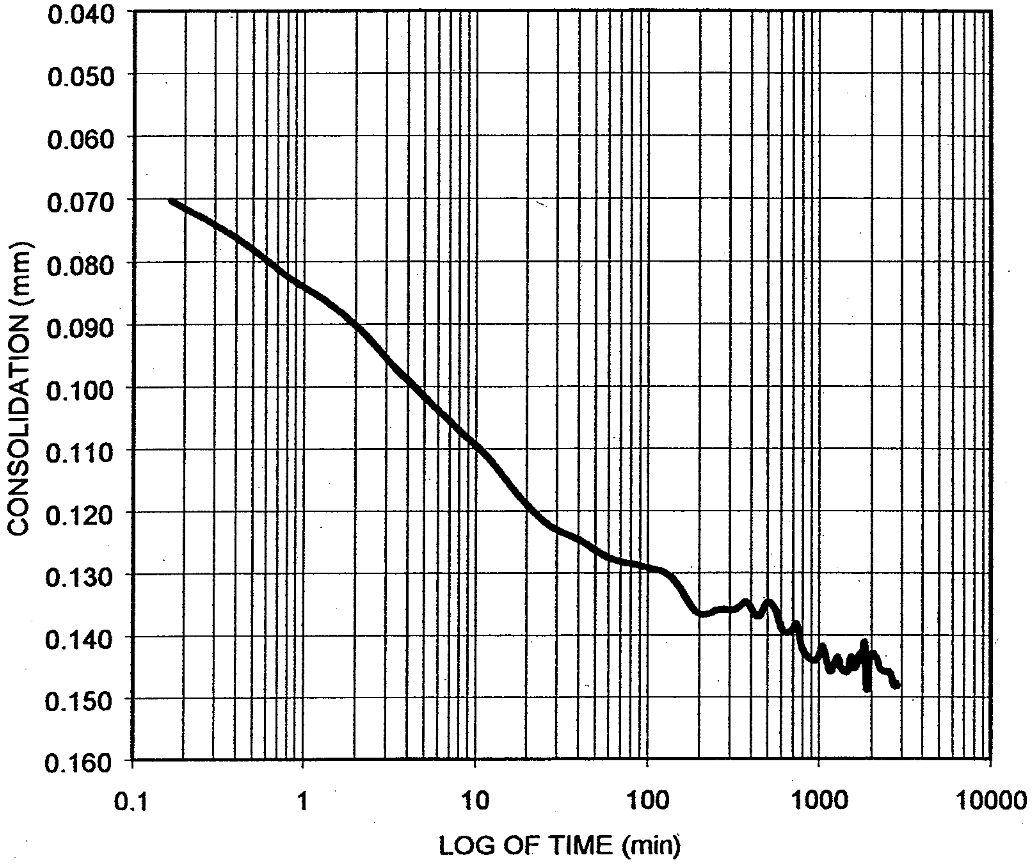
MOISTURE: 42.4 %
SATURATION: 94.6 %
VOID RATIO: 1.24
WET DENSITY: 1754 kg/m³
DRY DENSITY: 1232 kg/m³

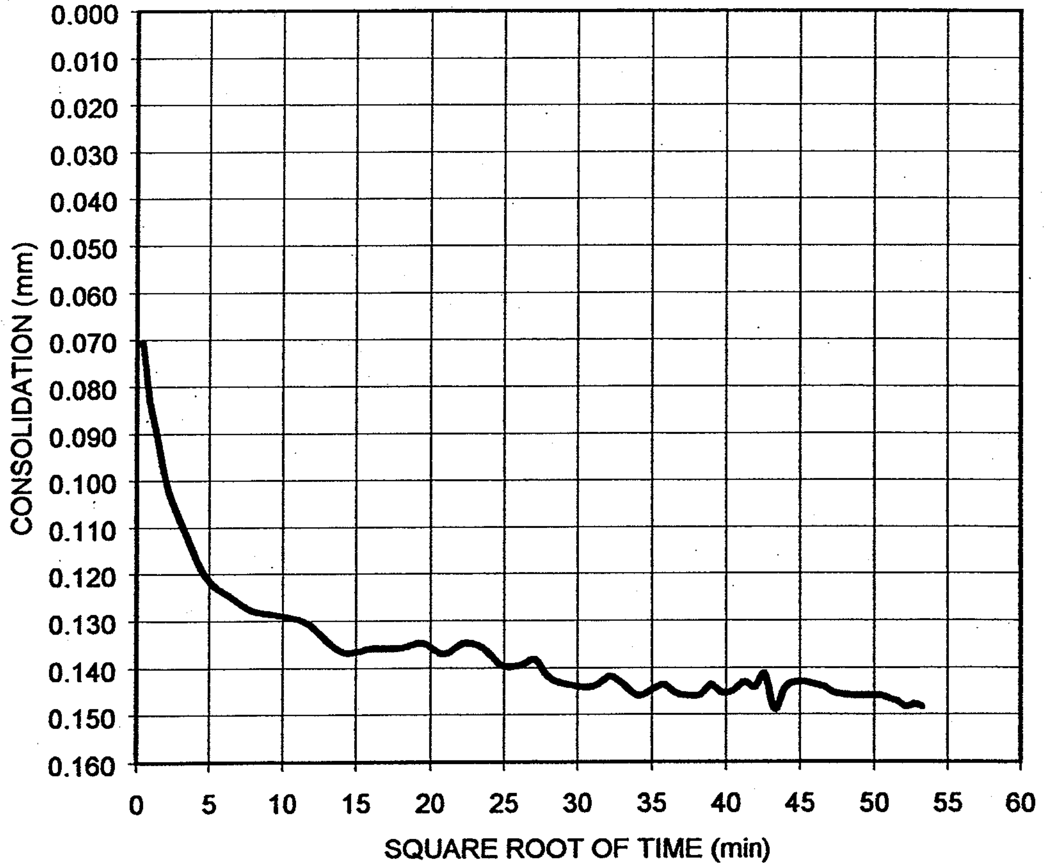
DIRECTORY: SHEARS
FILE: 30kPaSRL
TEST: PEAK
TEST DATE: 03 07 23
TESTED BY: HM

COMMENTS: Initial shear. Seating load and swelling at 6.2kPa. Consolidated to 30kPa.

SHEAR STRAIN (mm)	VERTICAL DISPLACEMENT (mm)	SHEAR STRESS (kPa)	SHEAR STRAIN (mm)	VERTICAL DISPLACEMENT (mm)	SHEAR STRESS (kPa)
0.00	0.000	0.00	7.91	0.095	8.85
0.19	-0.010	7.71	8.13	0.097	8.71
0.40	-0.018	20.20	8.34	0.100	8.50
0.61	-0.021	25.06	8.53	0.102	8.50
0.82	-0.018	26.20	8.76	0.109	8.42
1.02	-0.012	25.27	8.99	0.109	8.28
1.23	-0.009	22.42	9.21	0.112	8.21
1.44	-0.007	19.42	9.44	0.114	8.14
1.65	-0.004	17.63	9.66	0.117	8.14
1.86	0.000	16.49	9.89	0.122	8.07
2.06	0.002	15.56	10.11	0.122	8.00
2.27	0.004	14.78	10.34	0.125	7.85
2.48	0.008	13.99	10.56	0.128	7.85
2.69	0.010	13.49	10.78	0.131	7.78
2.90	0.015	13.06	11.00	0.134	7.64
3.10	0.016	12.71	11.22	0.136	7.64
3.32	0.022	12.28	11.45	0.138	7.64
3.53	0.026	11.92	11.67	0.141	7.57
3.73	0.030	11.57	11.90	0.144	7.57
3.94	0.035	11.28	12.13	0.145	7.57
4.15	0.038	11.14	12.35	0.147	7.64
4.35	0.040	10.85	12.58	0.150	7.64
4.56	0.043	10.64	12.80	0.151	7.64
4.78	0.047	10.49	13.04	0.155	7.57
4.99	0.048	10.28	13.26	0.155	7.71
5.20	0.054	10.07	13.49	0.157	7.71
5.40	0.058	9.99	13.72	0.161	7.78
5.61	0.058	9.92	13.94	0.161	7.85
5.82	0.063	9.85	14.15	0.165	7.78
6.03	0.066	9.78	14.38	0.163	7.85
6.24	0.071	9.64	14.61	0.168	7.71
6.45	0.073	9.57	14.83	0.168	7.78
6.66	0.076	9.35	15.05	0.167	8.00
6.87	0.078	9.28	15.28	0.167	8.00
7.08	0.083	9.21	15.50	0.167	7.92
7.28	0.086	9.00	15.72	0.168	7.92
7.49	0.088	8.92	15.93	0.172	7.92
7.70	0.090	8.85	16.16	0.173	7.85

DATAFILE - 30kPaSRLONG





0.233 mm SWELLING

DIRECT SHEAR TEST
CONSOLIDATION @ 30 kPa
03 07 23 By - HM

DIR - SHEARS FILE - 30kPaSRL DATA - 30kPaSRLONG

NATIONAL TESTING AO23A01

Sample No	*Hole No*	*Depth*
9	AH 03 - 06	7.60 - 8.15m

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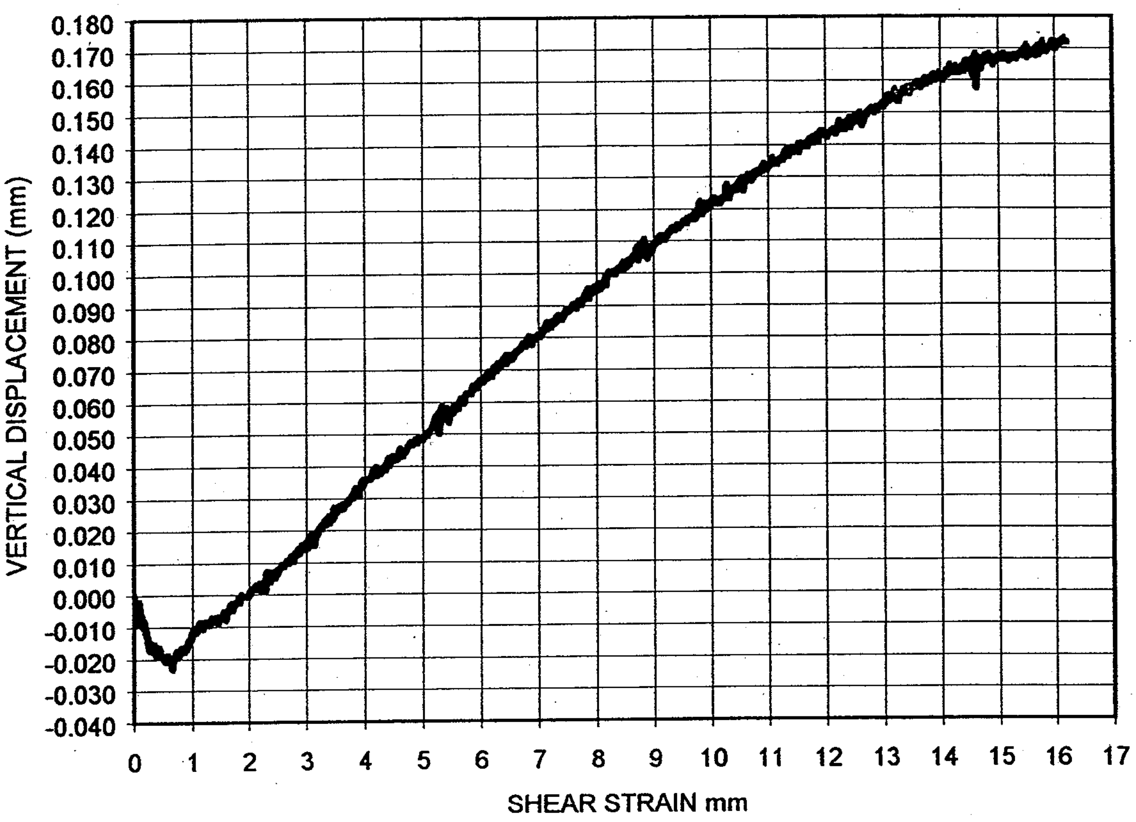
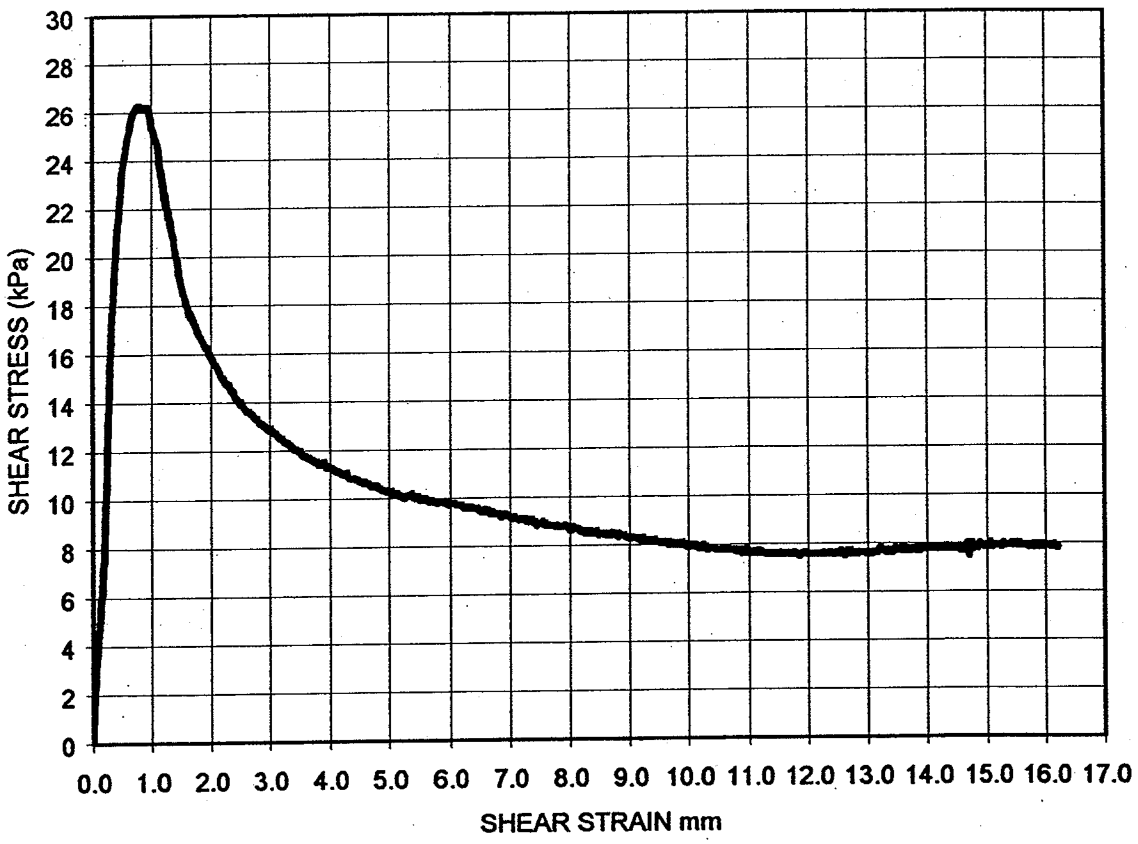
Concrete & Materials Testing
Section





DIRECT SHEAR TEST

PEAK SHEAR @ 30 kPa

03 07 23 By - HM

D/R - SHEARS FILE - 30kPaSRL DATA - 30kPaSRLONG

NATIONAL TESTING AO23A01

Sample No	*Hole No*	*Depth*
9	AH 03 - 06	7.60 - 8.15m

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Civil Engineering Department
Concrete & Materials Testing Section

NATIONAL TESTING AO23A01

Sample No	*Hole No*	*Depth*
9	AH 03 - 06	7.60 - 8.15m

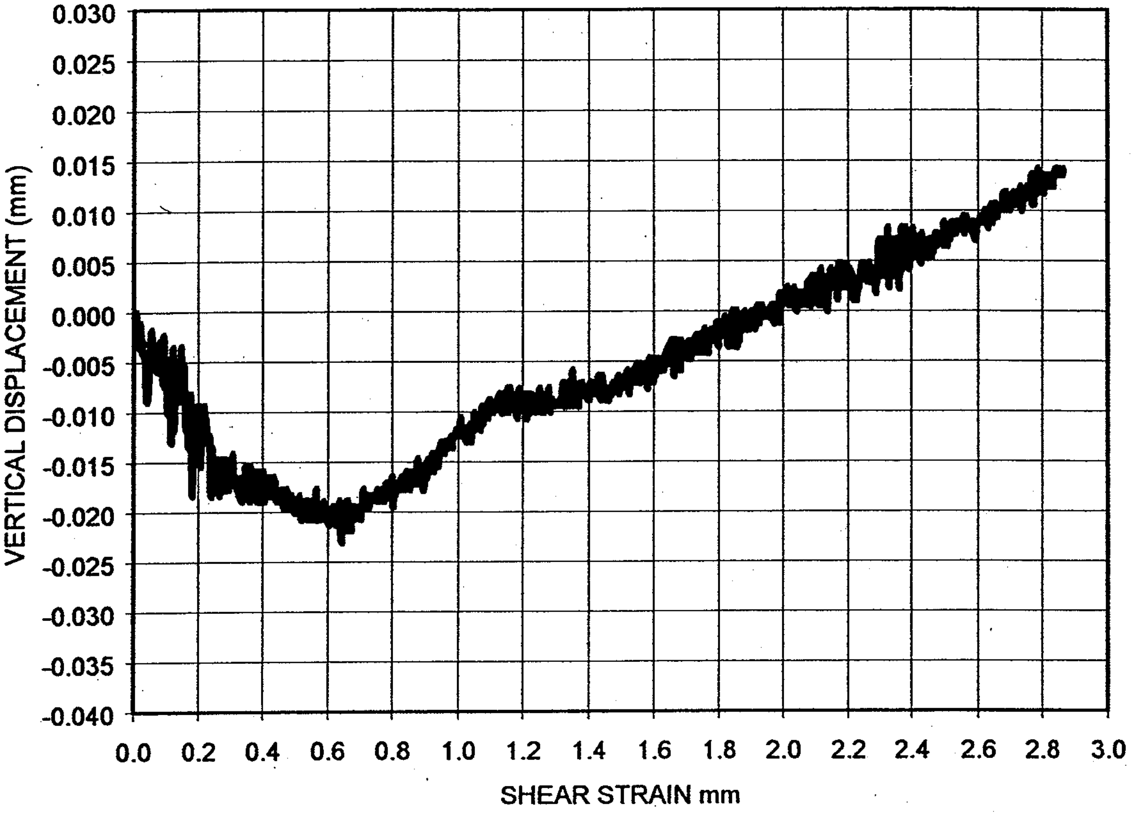
DIRECT SHEAR TEST
PEAK SHEAR @ 30 kPa
03 07 23 By - HM
DIR - SHEARS FILE - 30kPaSRS DATA - 30kPaSR

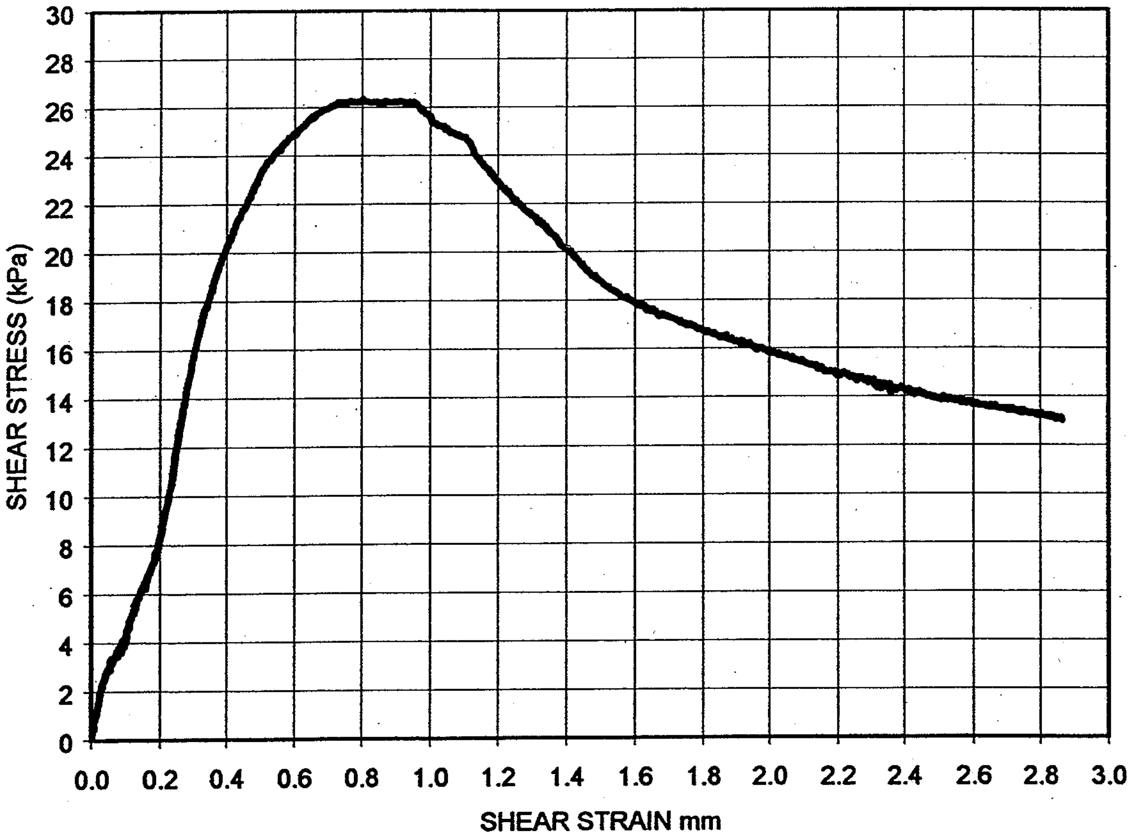
SAMPLE SIZE:	ROUND (63.5 mm Diam)	MOISTURE:	42.4 %	DIRECTORY:	SHEARS
INITIAL HEIGHT:	20 mm	SATURATION:	94.6 %	FILE:	30kPaSRS
STRAIN RATE:	0.0058mm/min	VOID RATIO:	1.24	TEST:	PEAK
INITIAL SEATING STRESS:	6 kPa	WET DENSITY:	1754 kg/m³	TEST DATE:	03 07 23
TOTAL NORMAL STRESS:	30 kPa	DRY DENSITY:	1232 kg/m³	TESTED BY:	HM

COMMENTS: INITIAL SHEAR. VALUES TO 2.85mm STRAIN.

SHEAR STRAIN (mm)	VERTICAL DISPLACEMENT (mm)	SHEAR STRESS (kPa)	SHEAR STRAIN (mm)	VERTICAL DISPLACEMENT (mm)	SHEAR STRESS (kPa)
0.00	0.000	0.00	1.39	-0.008	20.20
0.03	-0.003	1.86	1.43	-0.006	19.70
0.06	-0.004	3.14	1.46	-0.009	19.28
0.10	-0.008	3.93	1.49	-0.007	18.85
0.13	-0.006	5.85	1.53	-0.006	18.42
0.17	-0.013	6.85	1.57	-0.005	18.06
0.21	-0.013	8.64	1.61	-0.006	17.78
0.24	-0.018	11.07	1.65	-0.003	17.49
0.28	-0.017	14.21	1.69	-0.004	17.35
0.31	-0.017	16.56	1.73	-0.003	17.06
0.35	-0.015	18.20	1.77	-0.003	16.92
0.39	-0.019	19.85	1.81	-0.002	16.63
0.42	-0.017	21.06	1.85	-0.001	16.42
0.46	-0.019	22.13	1.89	-0.001	16.28
0.50	-0.020	23.27	1.93	0.001	16.13
0.53	-0.021	23.99	1.97	0.001	15.99
0.57	-0.019	24.56	2.01	0.001	15.78
0.61	-0.019	25.06	2.05	0.002	15.63
0.65	-0.021	25.63	2.09	0.004	15.49
0.69	-0.020	25.91	2.13	0.003	15.28
0.72	-0.018	26.13	2.17	0.001	15.06
0.76	-0.018	26.20	2.21	0.004	14.92
0.80	-0.017	26.20	2.25	0.004	14.85
0.83	-0.018	26.20	2.29	0.002	14.71
0.87	-0.017	26.27	2.33	0.005	14.28
0.91	-0.015	26.20	2.37	0.008	14.35
0.94	-0.014	26.20	2.41	0.006	14.21
0.98	-0.012	25.84	2.44	0.006	14.21
1.02	-0.012	25.27	2.49	0.007	13.99
1.06	-0.011	24.99	2.53	0.008	13.85
1.09	-0.011	24.77	2.57	0.009	13.78
1.13	-0.009	24.06	2.61	0.009	13.64
1.17	-0.008	23.42	2.65	0.009	13.56
1.21	-0.008	22.77	2.69	0.010	13.49
1.24	-0.009	22.20	2.73	0.011	13.42
1.28	-0.008	21.77	2.77	0.011	13.35
1.31	-0.009	21.27	2.81	0.012	13.21
1.35	-0.008	20.77	2.85	0.014	13.14

DATAFILE - 30kPaSR





DIRECT SHEAR TEST
PEAK SHEAR @ 30 kPa
03 07 23 By - HM
DIR - SHEARS FILE - 30kPaSRS DATA - 30kPaSR

NATIONAL TESTING AO23A01

Sample No	*Hole No*	*Depth*
9	AH 03 - 06	7.60 - 8.15m

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NATIONAL TESTING AO23A01

Sample No	*Hole No*	*Depth*
9	AH 03 - 06	7.60 - 8.15m

DIRECT SHEAR TEST
PEAK SHEAR @ 60 kPa
03 07 23 By - HM
DIR - SHEARS FILE - 60kPaSRL DATA - 60kPaSRLONG

SAMPLE SIZE: ROUND (63.5 mm Diam)
INITIAL HEIGHT: 20 mm
STRAIN RATE: 0.0058mm/min
INITIAL SEATING STRESS: 6 kPa
TOTAL NORMAL STRESS: 60 kPa

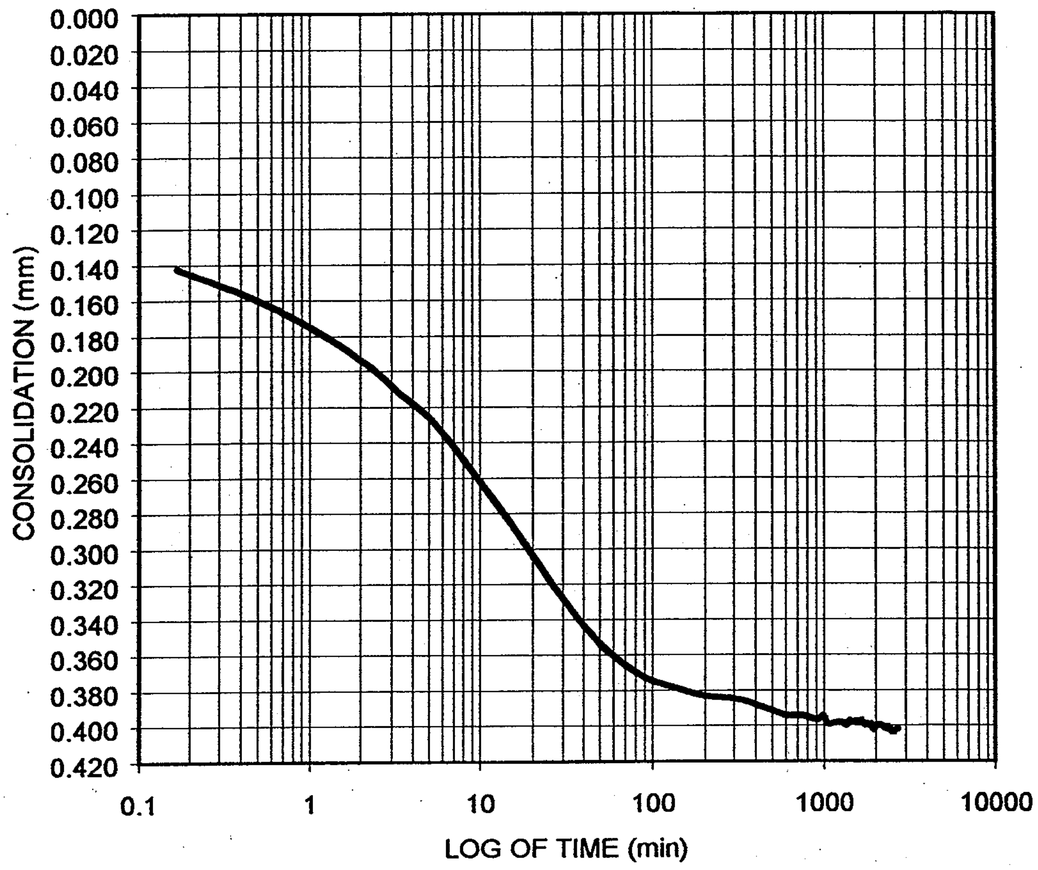
MOISTURE: 46.6 %
SATURATION: 97.4 %
VOID RATIO: 1.32
WET DENSITY: 1740 kg/m³
DRY DENSITY: 1187 kg/m³

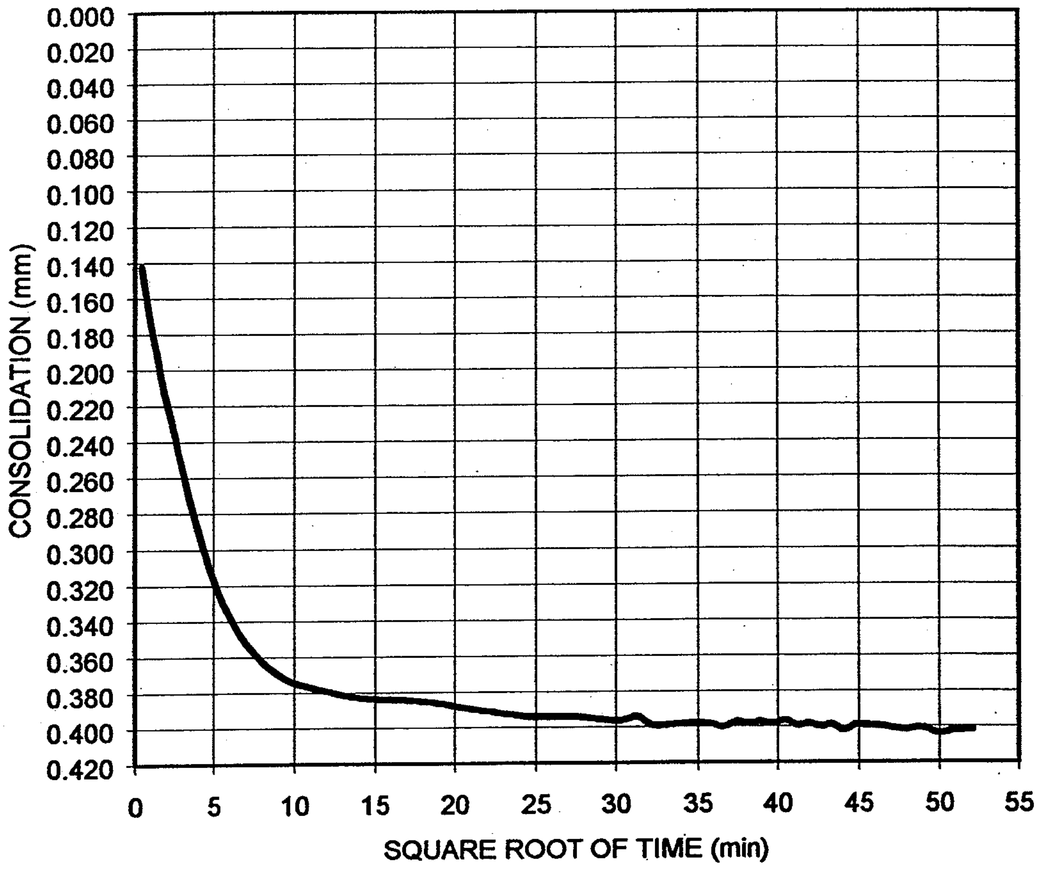
DIRECTORY: SHEARS
FILE: 60kPaSRL
TEST: PEAK
TEST DATE: 03 07 23
TESTED BY: HM

COMMENTS: Initial shear. Seating load and swelling at 6.2kPa. Consolidated to 60kPa.

SHEAR STRAIN (mm)	VERTICAL DISPLACEMENT (mm)	SHEAR STRESS (kPa)	SHEAR STRAIN (mm)	VERTICAL DISPLACEMENT (mm)	SHEAR STRESS (kPa)
0.00	0.000	0.00	6.85	-0.092	15.99
0.16	-0.009	7.42	7.04	-0.092	15.78
0.33	-0.019	20.70	7.21	-0.093	15.63
0.52	-0.031	28.70	7.40	-0.093	15.56
0.69	-0.043	33.98	7.61	-0.091	15.35
0.88	-0.051	36.48	7.80	-0.090	15.28
1.05	-0.058	36.41	8.01	-0.089	15.21
1.24	-0.068	34.62	8.20	-0.087	15.13
1.41	-0.073	33.34	8.39	-0.088	15.13
1.58	-0.080	29.63	8.60	-0.086	14.99
1.77	-0.081	27.63	8.79	-0.086	14.92
1.94	-0.083	26.41	9.00	-0.086	14.71
2.13	-0.085	25.34	9.20	-0.083	14.63
2.30	-0.086	24.56	9.40	-0.084	14.49
2.50	-0.085	23.63	9.60	-0.083	14.35
2.67	-0.087	22.99	9.79	-0.082	14.35
2.86	-0.087	22.34	9.98	-0.082	14.14
3.04	-0.090	21.92	10.17	-0.080	14.14
3.21	-0.088	21.42	10.36	-0.082	14.06
3.41	-0.091	20.85	10.55	-0.081	13.92
3.58	-0.092	20.49	10.76	-0.081	13.92
3.77	-0.092	20.06	10.94	-0.082	13.78
3.94	-0.092	19.70	11.15	-0.082	13.71
4.15	-0.092	19.35	11.34	-0.078	13.64
4.32	-0.092	19.06	11.55	-0.080	13.64
4.51	-0.093	18.78	11.74	-0.080	13.64
4.68	-0.090	18.20	11.93	-0.081	13.56
4.86	-0.093	18.28	12.14	-0.079	13.49
5.04	-0.093	17.99	12.35	-0.081	13.49
5.22	-0.093	17.85	12.56	-0.080	13.42
5.41	-0.092	17.56	12.75	-0.080	13.42
5.58	-0.093	17.35	12.95	-0.080	13.35
5.77	-0.093	17.06	13.14	-0.080	13.42
5.95	-0.093	16.85	13.34	-0.079	13.49
6.14	-0.092	16.63	13.53	-0.078	13.42
6.32	-0.093	16.42	13.72	-0.080	13.35
6.49	-0.092	16.35	13.93	-0.078	13.35
6.68	-0.092	16.13	14.12	-0.079	13.35

DATAFILE - 60kPaSRLONG





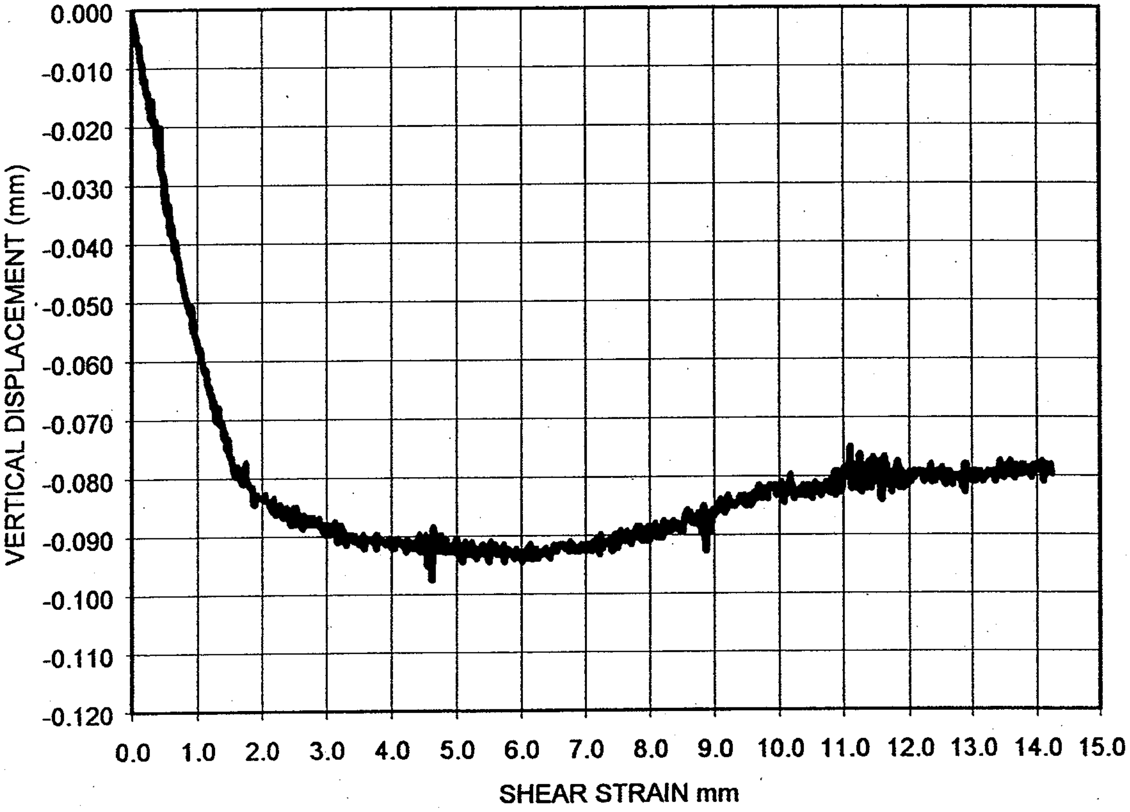
0.286 mm SWELLING

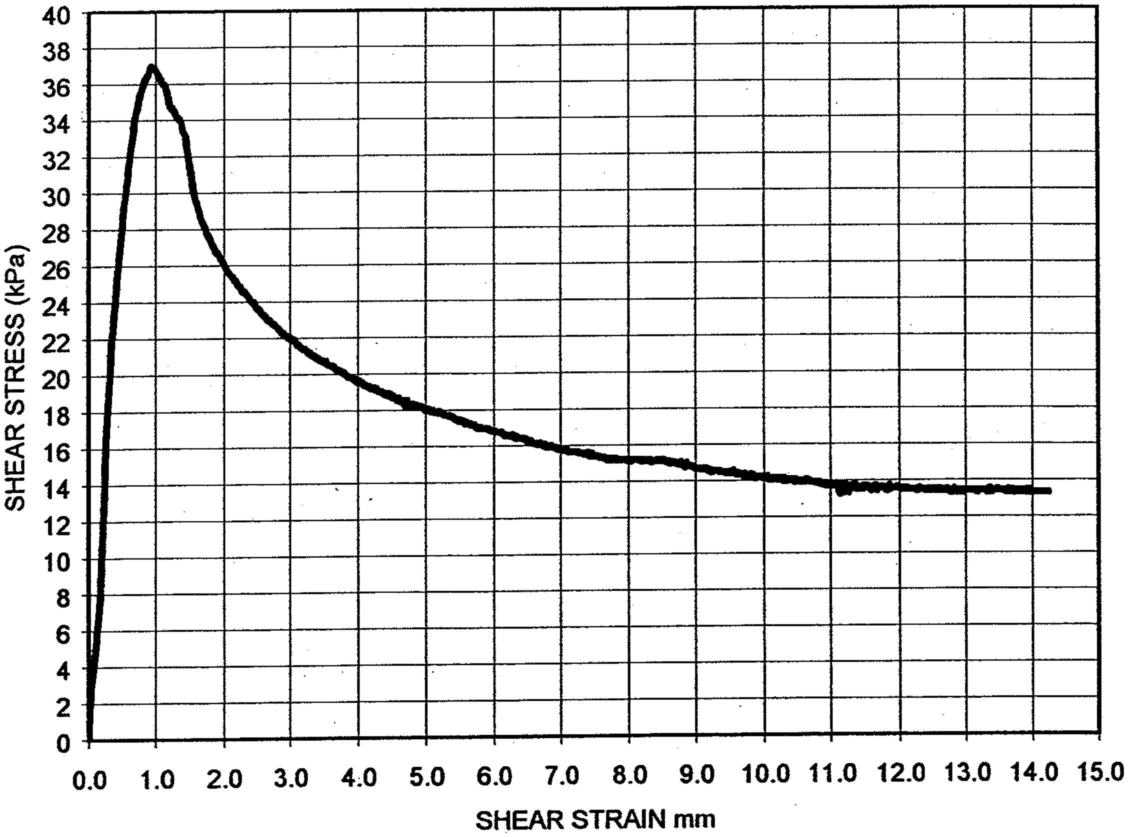
DIRECT SHEAR TEST
CONSOLIDATION @ 60 kPa
03 07 23 By - HM
DIR - SHEARS FILE - 60kPaSRL DATA - 60kPaSRLONG

NATIONAL TESTING AO23A01

Sample No	*Hole No*	*Depth*
9	AH 03 - 06	7.60 - 8.15m

Manitoba Hydro
Power Supply
Civil Engineering Department
Concrete & Materials Testing Section





DIRECT SHEAR TEST
PEAK SHEAR @ 60 kPa
03 07 23 By - HM
DIR - SHEARS FILE - 60kPaSRL DATA - 60kPaSRLONG

NATIONAL TESTING AO23A01

Sample No	*Hole No*	*Depth*
9	AH 03 - 06	7.60 - 8.15m

Manitoba Hydro
Power Supply
Civil Engineering Department
Concrete & Materials Testing
Section

Manitoba Hydro Power Supply Civil Engineering Department Concrete & Materials Testing Section	NATIONAL TESTING AO23A01		DIRECT SHEAR TEST PEAK SHEAR @ 60 kPa *03 07 23 By - HM* *DIR - SHEARS FILE - 60kPaSRS DATA - 60kPaSR*
	Sample No 9	*Hole No* AH 03 - 06	*Depth* 7.60 - 8.15m

SAMPLE SIZE: ROUND (63.5 mm Diam)
INITIAL HEIGHT: 20 mm
STRAIN RATE: 0.0058mm/min
INITIAL SEATING STRESS: 6 kPa
TOTAL NORMAL STRESS: 60 kPa

MOISTURE: 48.0 %
SATURATION: 97.4 %
VOID RATIO: 1.36
WET DENSITY: 1727 kg/m³
DRY DENSITY: 1167 kg/m³

DIRECTORY: SHEARS
FILE: 60kPaSRS
TEST: PEAK
TEST DATE: 03 07 23
TESTED BY: HM

COMMENTS: INITIAL SHEAR. VALUES TO 2.57mm STRAIN.

SHEAR STRAIN (mm)	VERTICAL DISPLACEMENT (mm)	SHEAR STRESS (kPa)	SHEAR STRAIN (mm)	VERTICAL DISPLACEMENT (mm)	SHEAR STRESS (kPa)
0.00	0.000	0.00	1.24	-0.067	34.55
0.02	-0.002	2.14	1.27	-0.069	34.41
0.06	-0.004	3.43	1.31	-0.071	34.05
0.09	-0.006	4.50	1.34	-0.071	34.05
0.12	-0.008	5.78	1.38	-0.070	33.70
0.15	-0.011	7.14	1.41	-0.073	33.41
0.19	-0.010	9.00	1.45	-0.075	32.77
0.22	-0.015	12.14	1.48	-0.074	31.84
0.25	-0.015	14.99	1.52	-0.077	30.84
0.28	-0.018	17.78	1.56	-0.077	30.13
0.32	-0.015	19.85	1.59	-0.076	29.41
0.35	-0.018	21.70	1.63	-0.079	28.98
0.38	-0.021	23.13	1.67	-0.080	28.56
0.42	-0.023	24.77	1.70	-0.080	28.20
0.45	-0.027	26.13	1.74	-0.077	27.84
0.48	-0.030	27.13	1.77	-0.082	27.63
0.51	-0.032	28.63	1.81	-0.081	27.34
0.55	-0.033	29.70	1.85	-0.082	27.06
0.58	-0.035	30.77	1.88	-0.083	26.70
0.61	-0.039	31.77	1.92	-0.082	26.56
0.65	-0.041	32.70	1.95	-0.084	26.34
0.68	-0.043	33.70	1.99	-0.083	26.13
0.71	-0.044	34.41	2.03	-0.085	25.91
0.75	-0.044	35.12	2.06	-0.085	25.63
0.78	-0.047	35.62	2.10	-0.084	25.49
0.81	-0.049	36.05	2.13	-0.085	25.34
0.85	-0.050	36.34	2.17	-0.083	25.13
0.88	-0.051	36.48	2.21	-0.084	24.99
0.91	-0.051	36.91	2.24	-0.087	24.84
0.94	-0.054	36.91	2.28	-0.085	24.63
0.98	-0.057	36.84	2.31	-0.086	24.49
1.01	-0.057	36.77	2.35	-0.086	24.34
1.04	-0.060	36.41	2.39	-0.087	24.13
1.08	-0.061	36.12	2.42	-0.085	23.99
1.11	-0.063	35.98	2.46	-0.087	23.92
1.14	-0.062	35.91	2.50	-0.085	23.63
1.17	-0.064	35.12	2.53	-0.087	23.56
1.21	-0.067	34.77	2.57	-0.087	23.42

DATAFILE - 60kPaSR

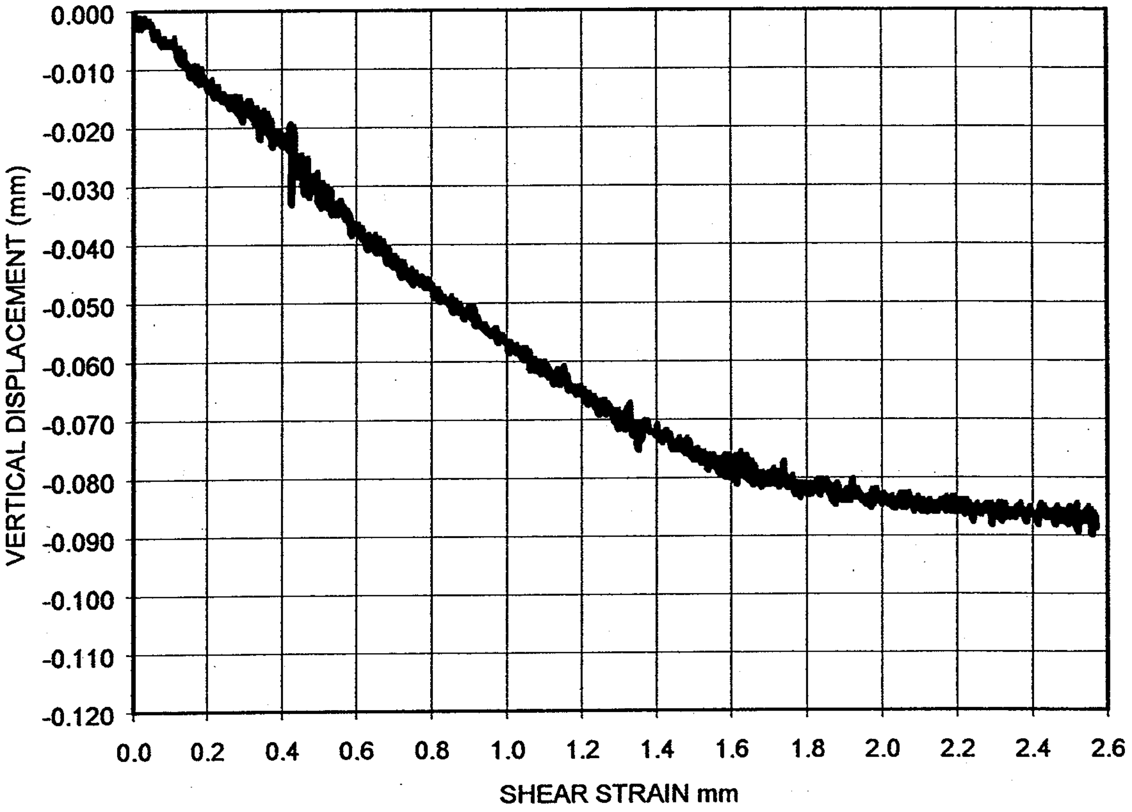
DIRECT SHEAR TEST
PEAK SHEAR @ 60 kPa
03 07 23 By - HM

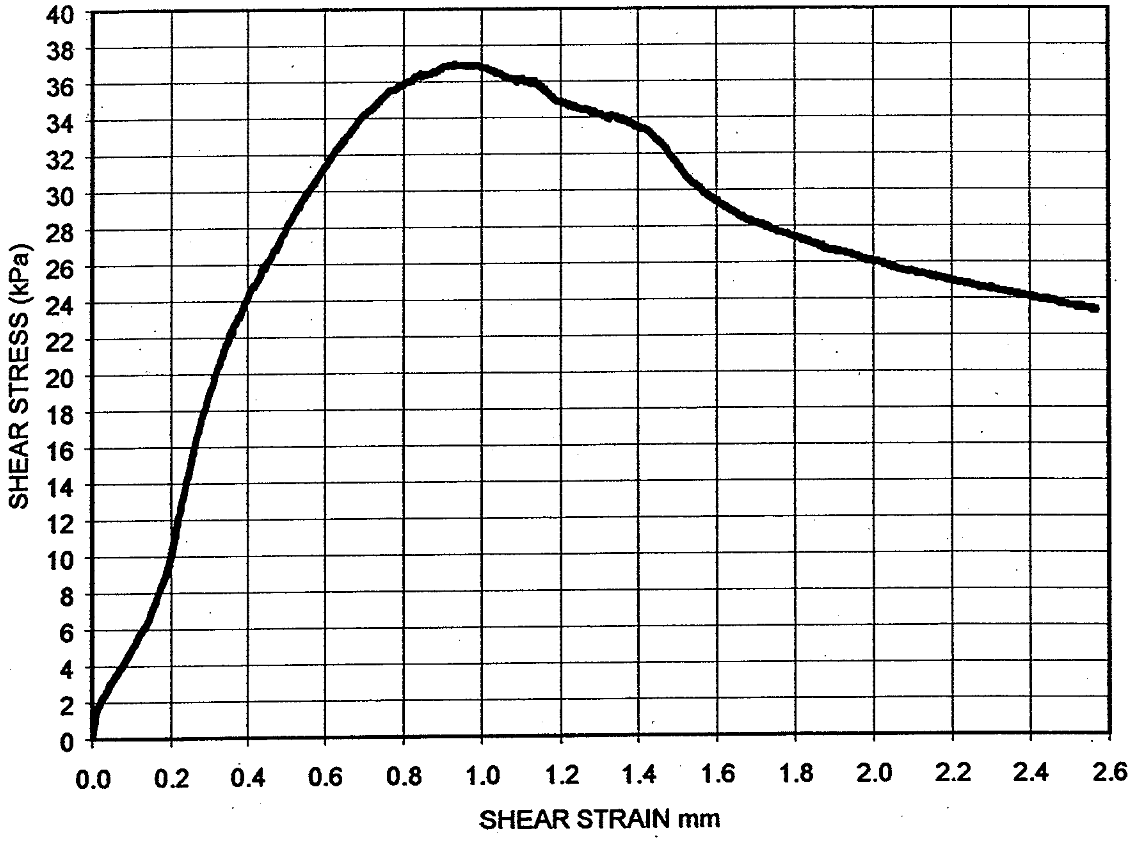
DIR - SHEARS FILE - 60kPaSRS DATA - 60kPaSR

NATIONAL TESTING AO23A01

Sample No	*Hole No*	*Depth*
9	AH 03 - 06	7.60 - 8.15m

Manitoba Hydro
Power Supply
Civil Engineering Department
Concrete & Materials Testing
Section





Manitoba Hydro

Power Supply
Civil Engineering Department
Concrete & Materials Testing
Section

NATIONAL TESTING AO23A01

Sample No	*Hole No*	*Depth*
9	AH 03 - 06	7.60 - 8.15m

DIRECT SHEAR TEST
PEAK SHEAR @ 120 kPa
03 07 24 By - HM
DIR - SHEARS FILE - 120kPaSL DATA - 120kPaSLONG

SAMPLE SIZE: SQUARE (38.1 x 38.1 mm)
INITIAL HEIGHT: 19 mm
STRAIN RATE: 0.000128in/min
INITIAL SEATING STRESS: 29 kPa
TOTAL NORMAL STRESS: 120 kPa

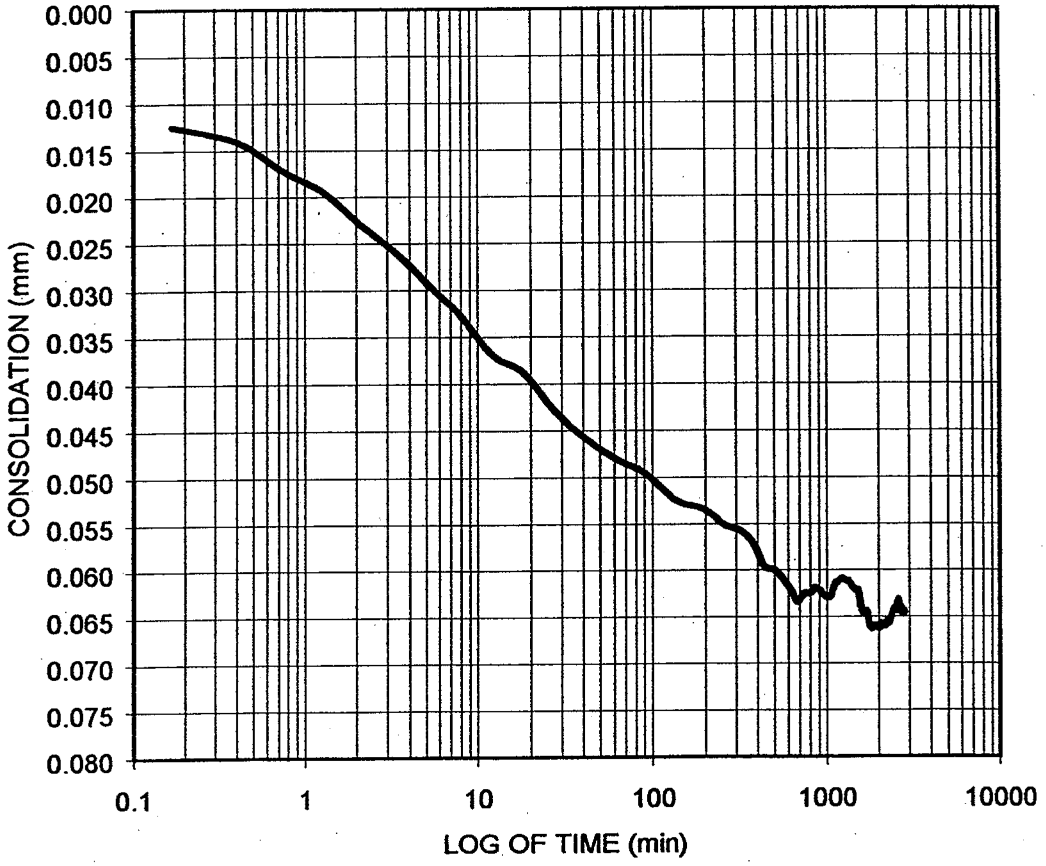
MOISTURE: 48.2 %
SATURATION: 101.9 %
VOID RATIO: 1.30
WET DENSITY: 1771 kg/m³
DRY DENSITY: 1195 kg/m³

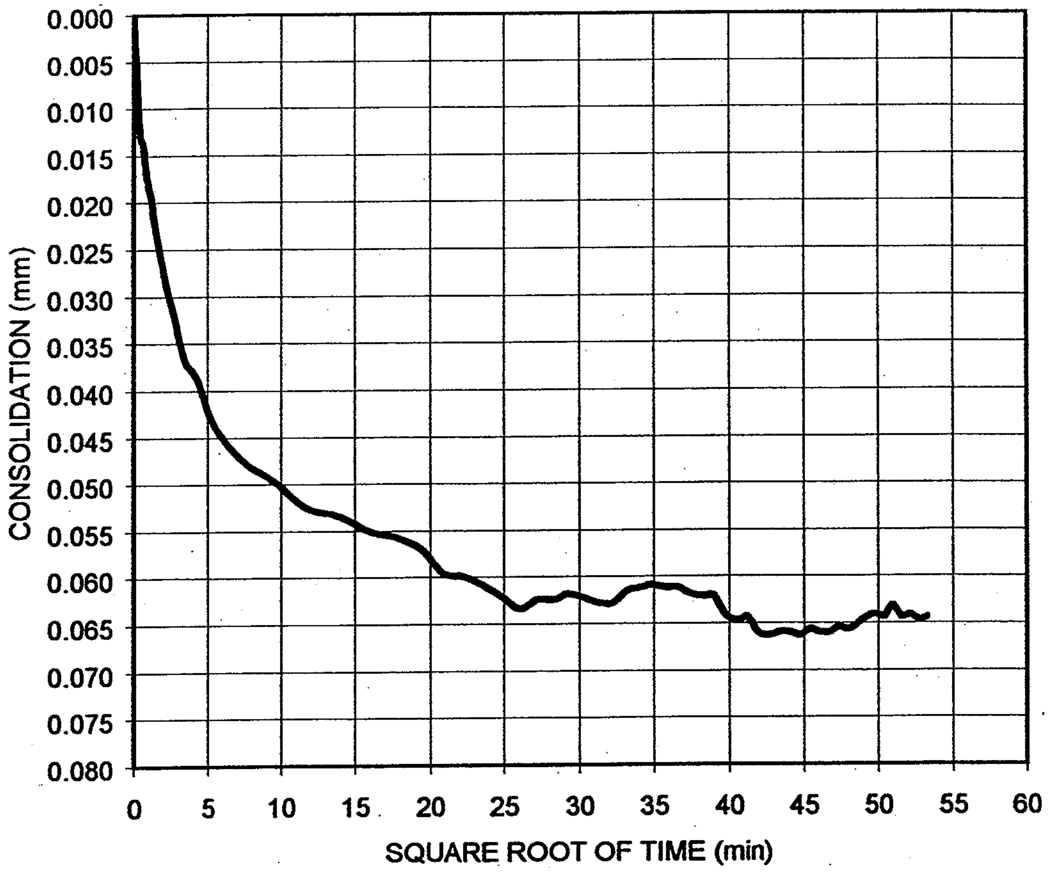
DIRECTORY: SHEARS
FILE: 120kPaSL
TEST: PEAK
TEST DATE: 03 07 24
TESTED BY: HM

COMMENTS: INITIAL SHEAR. CONSOLIDATED AT 59 kPa AND THEN ADDED FINAL CONSOLIDATION LOAD TO 120 kPa.

SHEAR STRAIN (mm)	VERTICAL DISPLACEMENT (mm)	SHEAR STRESS (kPa)
0.00	0.000	0.00
0.08	-0.060	8.78
0.18	-0.084	17.95
0.26	-0.096	25.72
0.36	-0.100	33.86
0.46	-0.110	41.33
0.55	-0.117	47.24
0.65	-0.122	52.49
0.75	-0.126	56.25
0.84	-0.133	57.20
0.94	-0.149	47.65
1.04	-0.163	42.86
1.13	-0.168	41.09
1.23	-0.174	39.52
1.33	-0.178	38.19
1.42	-0.182	37.41
1.52	-0.185	36.50
1.60	-0.188	35.84
1.70	-0.190	35.14
1.79	-0.193	34.68
1.88	-0.195	34.15
1.98	-0.197	33.69
2.08	-0.198	33.20
2.16	-0.198	32.82
2.27	-0.199	32.29
2.37	-0.200	31.96
2.45	-0.200	31.63
2.55	-0.200	31.30
2.65	-0.201	30.97
2.74	-0.201	30.72
2.84	-0.201	30.39
2.95	-0.202	29.56
3.04	-0.203	29.31
3.15	-0.205	28.94
3.24	-0.206	28.57
3.34	-0.207	28.24
3.44	-0.211	27.37
3.53	-0.212	27.25
3.63	-0.213	27.04
3.73	-0.215	26.83
3.83	-0.216	26.59
3.92	-0.216	26.50
4.03	-0.218	26.30
4.14	-0.218	26.09
4.24	-0.219	25.93
4.35	-0.223	25.51
4.46	-0.224	25.43
4.56	-0.225	25.31
4.67	-0.227	25.10
4.77	-0.227	25.02
4.88	-0.227	24.93
4.99	-0.228	24.69
5.09	-0.228	24.56
5.20	-0.230	24.36
5.31	-0.230	24.27
5.41	-0.232	24.15
5.52	-0.232	24.07
5.63	-0.230	24.03
5.72	-0.231	23.94
5.84	-0.234	23.65
5.95	-0.237	23.53
6.05	-0.237	23.49
6.16	-0.242	23.28
6.27	-0.243	23.45
6.36	-0.243	23.32
6.48	-0.243	23.20
6.57	-0.243	23.16
6.68	-0.244	23.12
6.79	-0.245	22.95
6.89	-0.247	22.99
7.00	-0.247	22.91
7.11	-0.249	22.87
7.21	-0.248	22.99
7.32	-0.250	22.87
7.43	-0.252	22.95
7.53	-0.252	22.91

DATAFILE - 120kPaSLONG





0.201 mm SWELLING

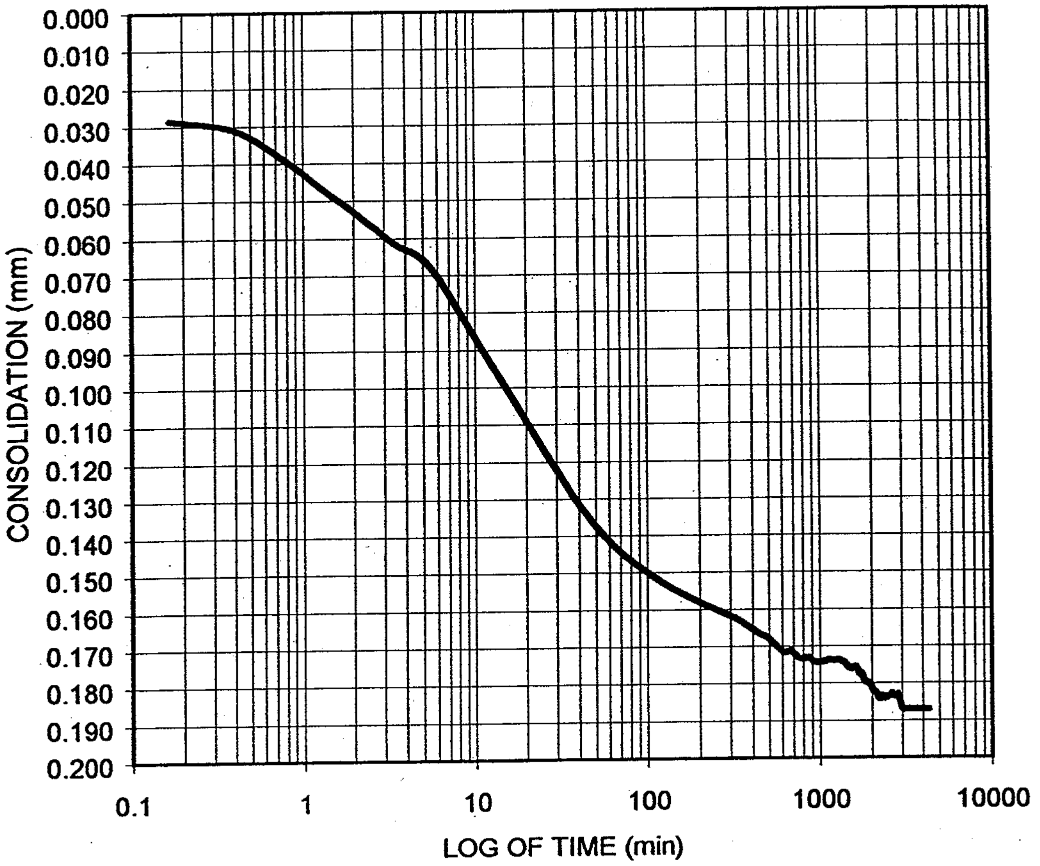
DIRECT SHEAR TEST
CONSOLIDATION #1 @ 59.035 kPa
03 07 24 By - HM
DIR - SHEARS FILE - 120kPaSL DATA - 120kPaSLONG

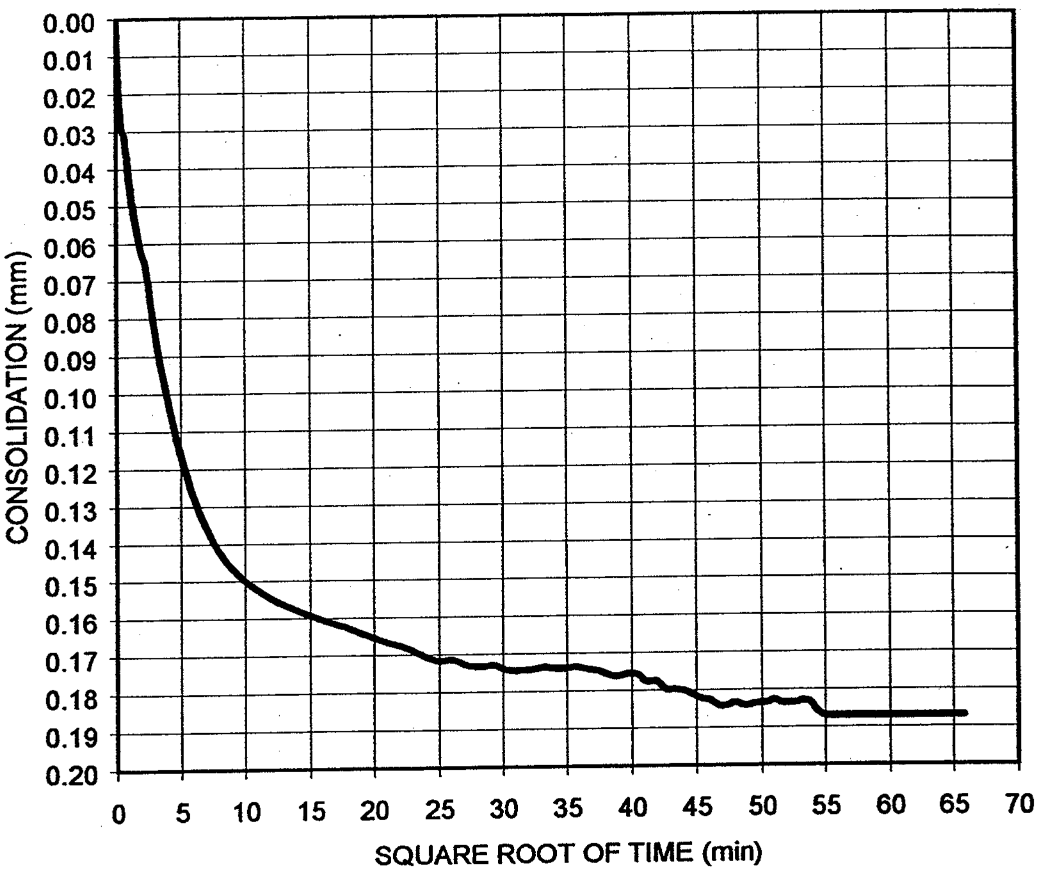
NATIONAL TESTING AO23A01

Sample No	*Hole No*	*Depth*
9	AH 03 - 06	7.60 - 8.15m

Manitoba Hydro

Power Supply
Civil Engineering Department
Concrete & Materials Testing
Section





0.000 mm SWELLING

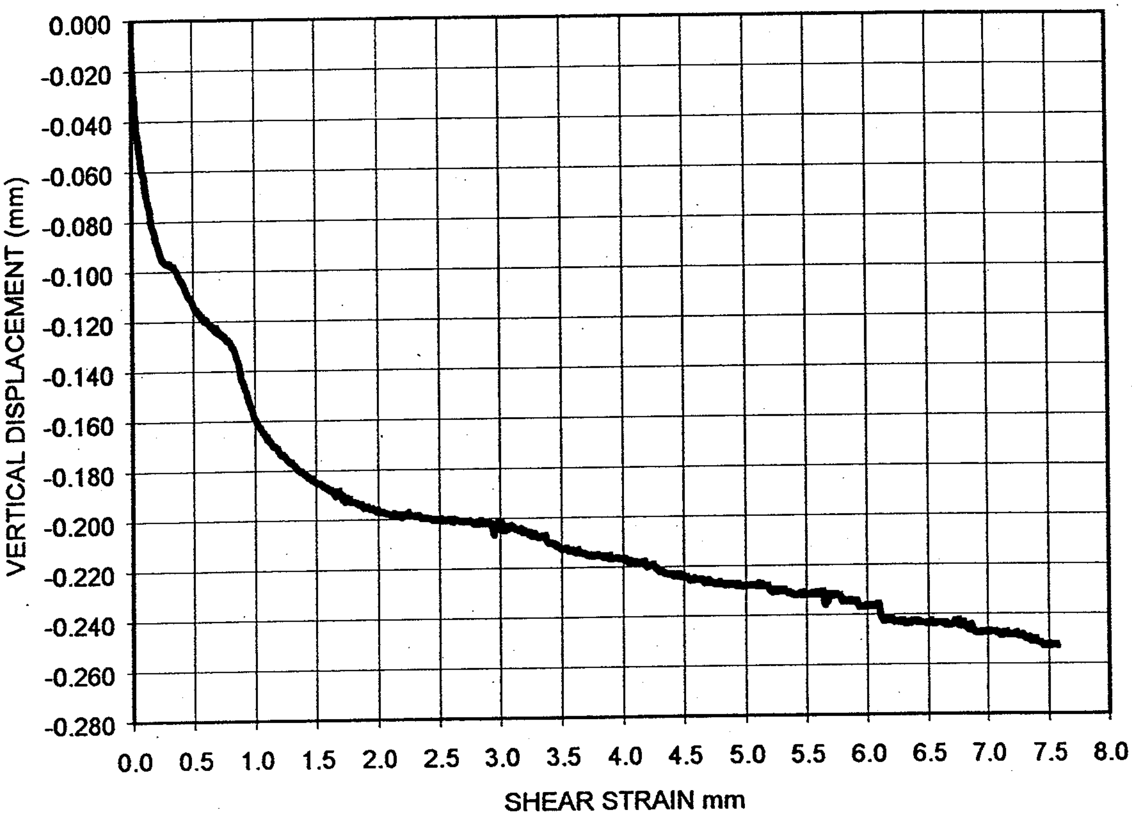
DIRECT SHEAR TEST
CONSOLIDATION #2 @ 120 kPa
03 07 24 By - HM

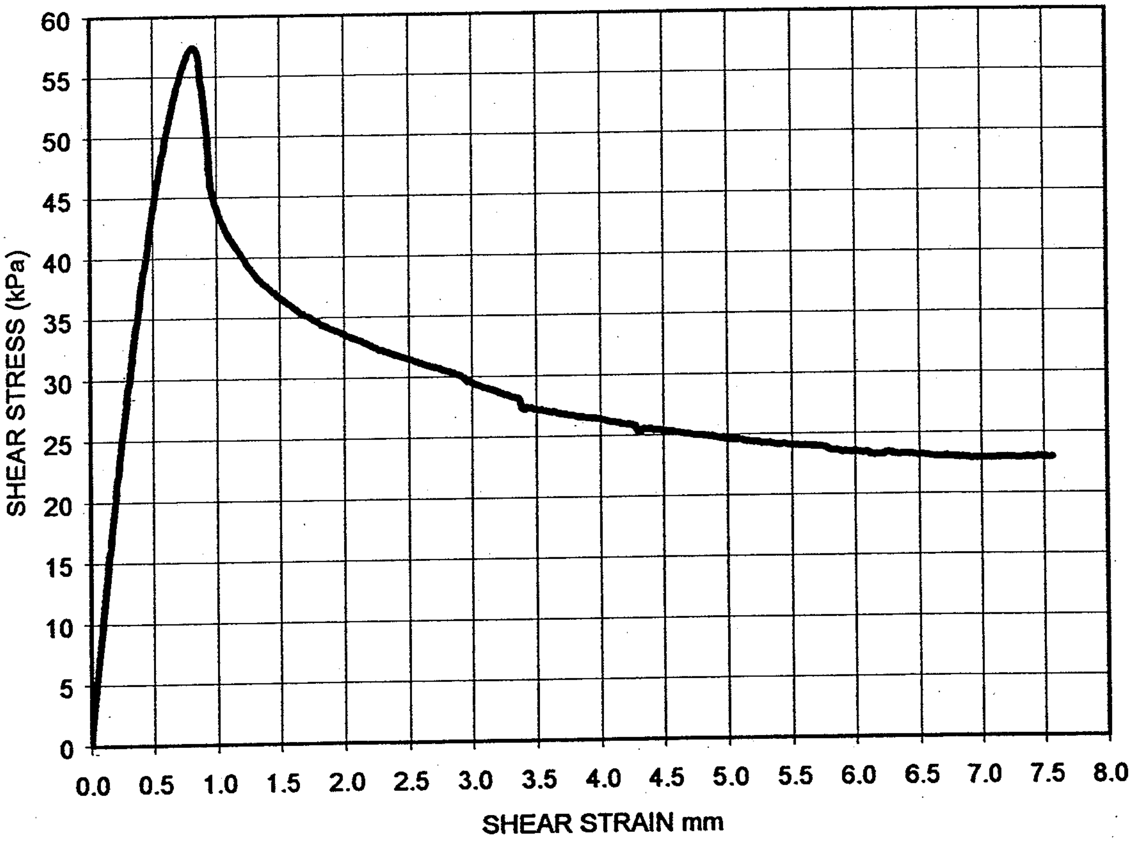
DIR - SHEARS FILE - 120kPaSL DATA - 120kPaSLONG

NATIONAL TESTING AO23A01

Sample No	*Hole No*	*Depth*
9	AH 03 - 06	7.60 - 8.15m

Manitoba Hydro
Power Supply
Civil Engineering Department
Concrete & Materials Testing Section





DIRECT SHEAR TEST
PEAK SHEAR @ 120 kPa
03 07 24 By - HM
DIR - SHEARS FILE - 120kPaSL DATA - 120kPaSLONG

NATIONAL TESTING AO23A01

Sample No	*Hole No*	*Depth*
9	AH 03 - 06	7.60 - 8.15m

Manitoba Hydro
Power Supply
Civil Engineering Department
Concrete & Materials Testing
Section

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Concrete & Materials Testing Section

NATIONAL TESTING AO23A01

Sample No	*Hole No*	*Depth*
9	AH 03 - 06	7.60 - 8.15m

DIRECT SHEAR TEST
PEAK SHEAR @ 120 kPa
03 07 24 By - HM
DIR - SHEARS FILE - 120kPaSS DATA - 120kPaS

SAMPLE SIZE: SQUARE (38.1 x 38.1 mm)
INITIAL HEIGHT: 19 mm
STRAIN RATE: 0.000128in/min
INITIAL SEATING STRESS: 29 kPa
TOTAL NORMAL STRESS: 120 kPa

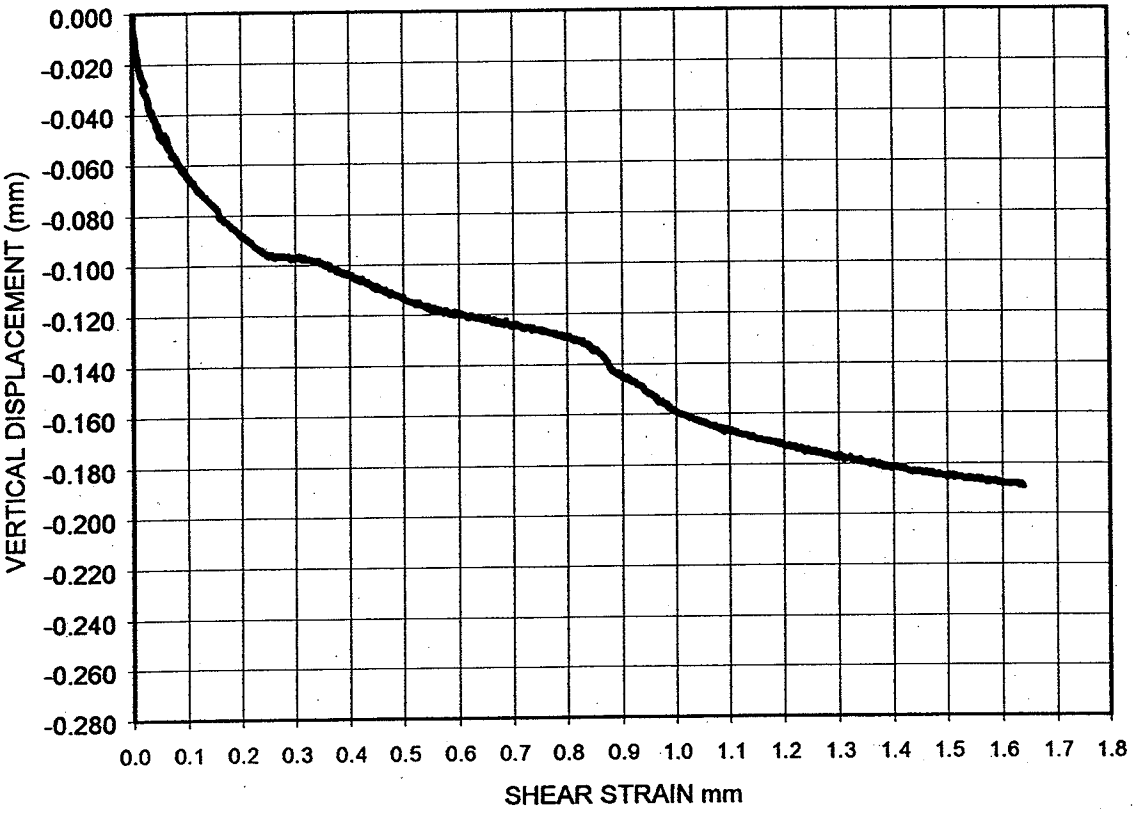
MOISTURE: 48.2 %
SATURATION: 101.9 %
VOID RATIO: 1.30
WET DENSITY: 1771 kg/m³
DRY DENSITY: 1195 kg/m³

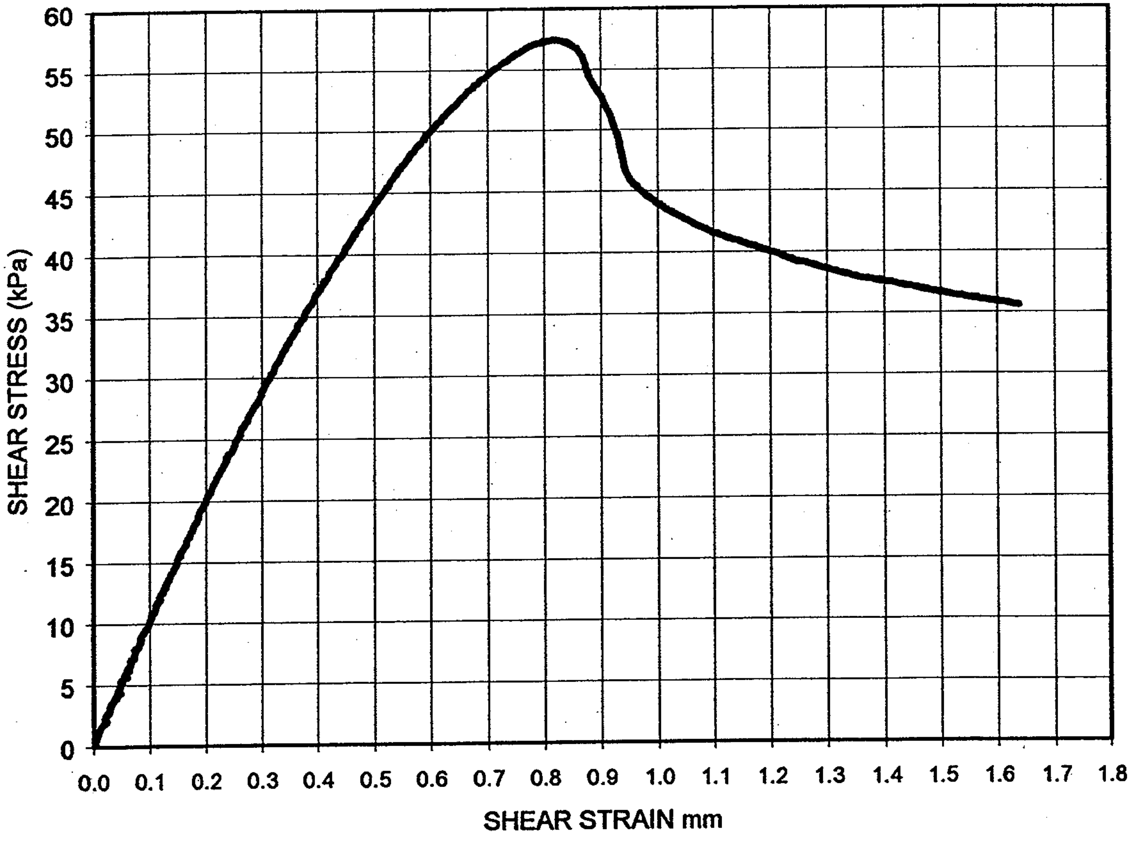
DIRECTORY: SHEARS
FILE: 120kPaSS
TEST: PEAK
TEST DATE: 03 07 24
TESTED BY: HM

COMMENTS: INITIAL SHEAR. VALUES TO 1.64mm STRAIN.

SHEAR STRAIN (mm)	VERTICAL DISPLACEMENT (mm)	SHEAR STRESS (kPa)	SHEAR STRAIN (mm)	VERTICAL DISPLACEMENT (mm)	SHEAR STRESS (kPa)
0.00	0.000	0.00	0.79	-0.128	57.20
0.02	-0.025	1.88	0.81	-0.130	57.40
0.04	-0.042	4.03	0.83	-0.132	57.32
0.06	-0.051	6.22	0.85	-0.135	56.95
0.08	-0.057	8.33	0.87	-0.140	55.38
0.10	-0.064	10.31	0.90	-0.145	53.07
0.12	-0.069	12.21	0.92	-0.147	51.00
0.14	-0.075	14.19	0.94	-0.151	46.87
0.16	-0.081	16.18	0.96	-0.154	45.30
0.18	-0.084	18.16	0.99	-0.157	44.39
0.20	-0.088	20.02	1.01	-0.160	43.52
0.22	-0.091	21.84	1.04	-0.162	42.99
0.24	-0.094	23.57	1.06	-0.164	42.45
0.26	-0.097	25.39	1.08	-0.165	41.95
0.28	-0.097	27.21	1.11	-0.167	41.58
0.30	-0.097	28.98	1.13	-0.168	41.13
0.32	-0.098	30.80	1.15	-0.170	40.80
0.34	-0.099	32.37	1.17	-0.171	40.43
0.36	-0.101	34.15	1.20	-0.173	40.05
0.39	-0.103	35.92	1.22	-0.173	39.68
0.41	-0.105	37.57	1.24	-0.174	39.31
0.43	-0.107	39.19	1.26	-0.175	39.10
0.45	-0.109	40.63	1.29	-0.177	38.77
0.47	-0.111	42.04	1.31	-0.178	38.44
0.49	-0.113	43.44	1.33	-0.179	38.24
0.51	-0.115	44.89	1.36	-0.180	37.91
0.54	-0.117	46.29	1.38	-0.180	37.74
0.56	-0.117	47.57	1.40	-0.182	37.53
0.58	-0.118	48.81	1.43	-0.182	37.33
0.60	-0.119	50.01	1.45	-0.183	37.12
0.62	-0.121	51.08	1.47	-0.184	36.87
0.64	-0.121	52.12	1.49	-0.185	36.71
0.66	-0.123	53.15	1.51	-0.185	36.54
0.68	-0.124	54.02	1.54	-0.186	36.38
0.70	-0.124	54.80	1.56	-0.187	36.09
0.73	-0.125	55.59	1.58	-0.187	36.01
0.75	-0.126	56.12	1.60	-0.188	35.84
0.77	-0.128	56.82	1.63	-0.188	35.63

DATAFILE - 120kPaS





DIRECT SHEAR TEST
PEAK SHEAR @ 120 kPa
03 07 24 By - HM
DIR - SHEARS FILE - 120kPaSS DATA - 120kPaS

NATIONAL TESTING AO23A01

Sample No	*Hole No*	*Depth*
9	AH 03 - 06	7.60 - 8.15m

Manitoba Hydro
Power Supply
Civil Engineering Department
Concrete & Materials Testing Section

Manitoba Hydro

POWER PLANNING & OPERATIONS
GEOTECHNICAL ENGINEERING
MATERIALS TESTING LAB

NAT. TEST. LAB AO23A01

Sample No	Hole No	Depth
6	AH03 - 02	3.80 - 4.35 m

CONSOLIDATION

	INITIAL	FINAL
MOISTURE (%)	56.9	51.8
SATURATION (%)	101.0	100.5
VOID RATIO	1.555	1.424
WET DENSITY (kg/m3)	1695	1729
DRY DENSITY (kg/m3)	1080	1139

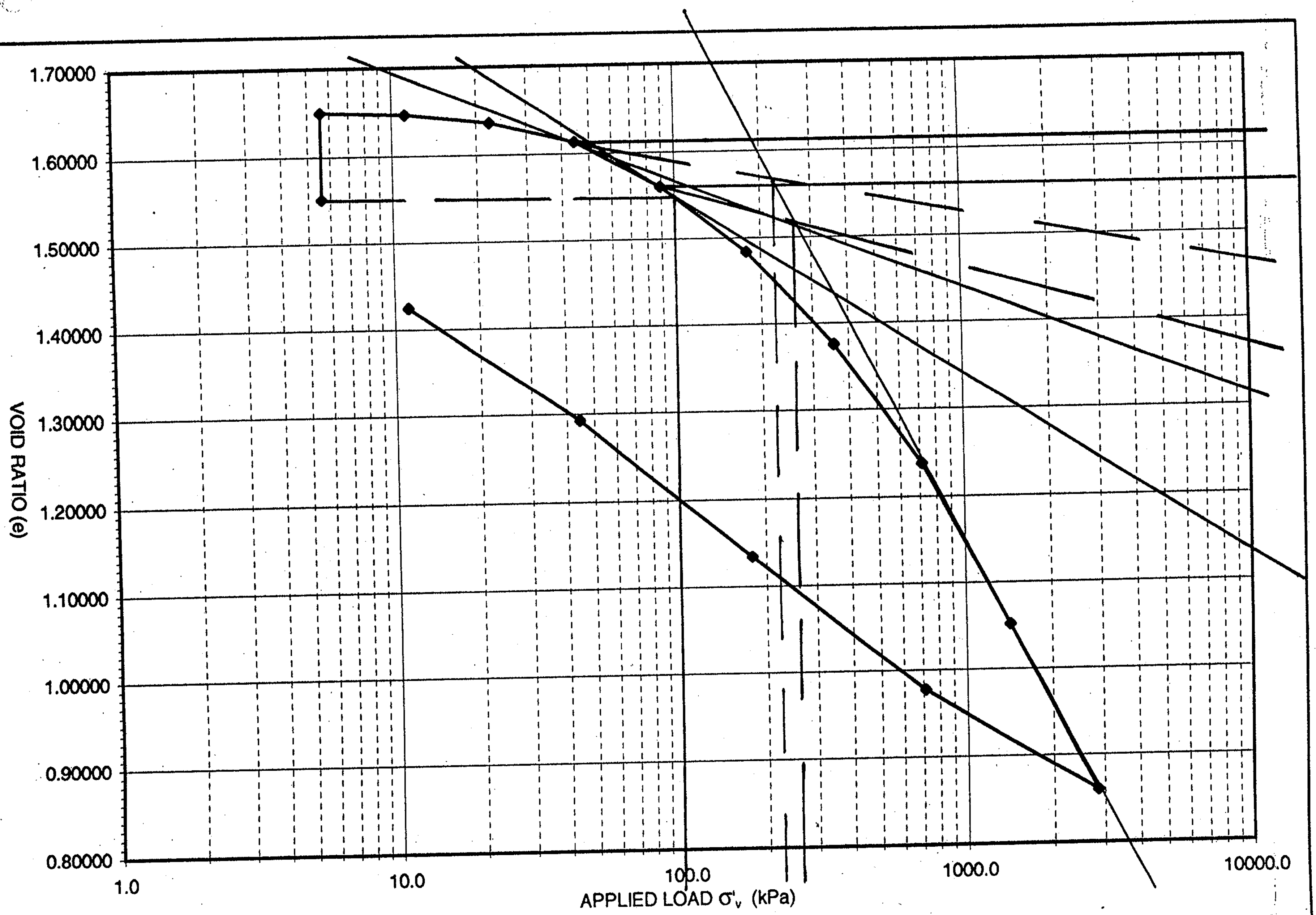
DATE: 03 07 04
BY: HM / JL
FILE: CONS6C
DIR: NAT.TEST.03

APPLIED PRESSURE σ'_v (kPa)	VOID RATIO e	C_v (cm^2/sec)	A_v (cm^2/g)	M_v (cm^2/g)	K (cm/s)
5.6	1.5516	Seating load			
5.6	1.6491	Inundation			
11.1	1.6459	1.74E-04	5.68E-05	2.15E-05	3.74E-09
22.3	1.6357	1.22E-04	9.00E-05	3.41E-05	4.15E-09
44.6	1.6131	7.99E-05	9.95E-05	3.81E-05	3.04E-09
89.1	1.5612	9.16E-05	1.14E-04	4.46E-05	4.08E-09
178.3	1.4842	9.94E-05	8.46E-05	3.41E-05	3.38E-09
356.8	1.3765	8.06E-05	5.91E-05	2.49E-05	2.00E-09
714.3	1.2390	7.15E-05	3.77E-05	1.69E-05	1.20E-09
1429.3	1.0529	4.55E-05	2.55E-05	1.24E-05	5.65E-10
2853.2	0.8594	3.11E-05	1.33E-05	7.17E-06	2.22E-10
714.3	0.9772	Rebound			
178.3	1.1350	Rebound			
44.6	1.2930	Rebound			
11.1	1.4241	Rebound			

Preconsolidation Pressure Range, P'c 220 - 250 kPa
Swelling Pressure 100.0 kPa
Compression Index, Cc 0.6300

C_v - Coefficient of Consolidation
A_v - Coefficient of Compressibility
M_v - Coefficient of Volume Compressibility
K - Coefficient of Permeability

DIR: NAT.TEST.03 FILE: CONS6C



Preconsolidation Pressure Range, P'c = 220 - 250 kPa   Swelling Pressure = 100 kPa   Compression Index Cc = 0.63

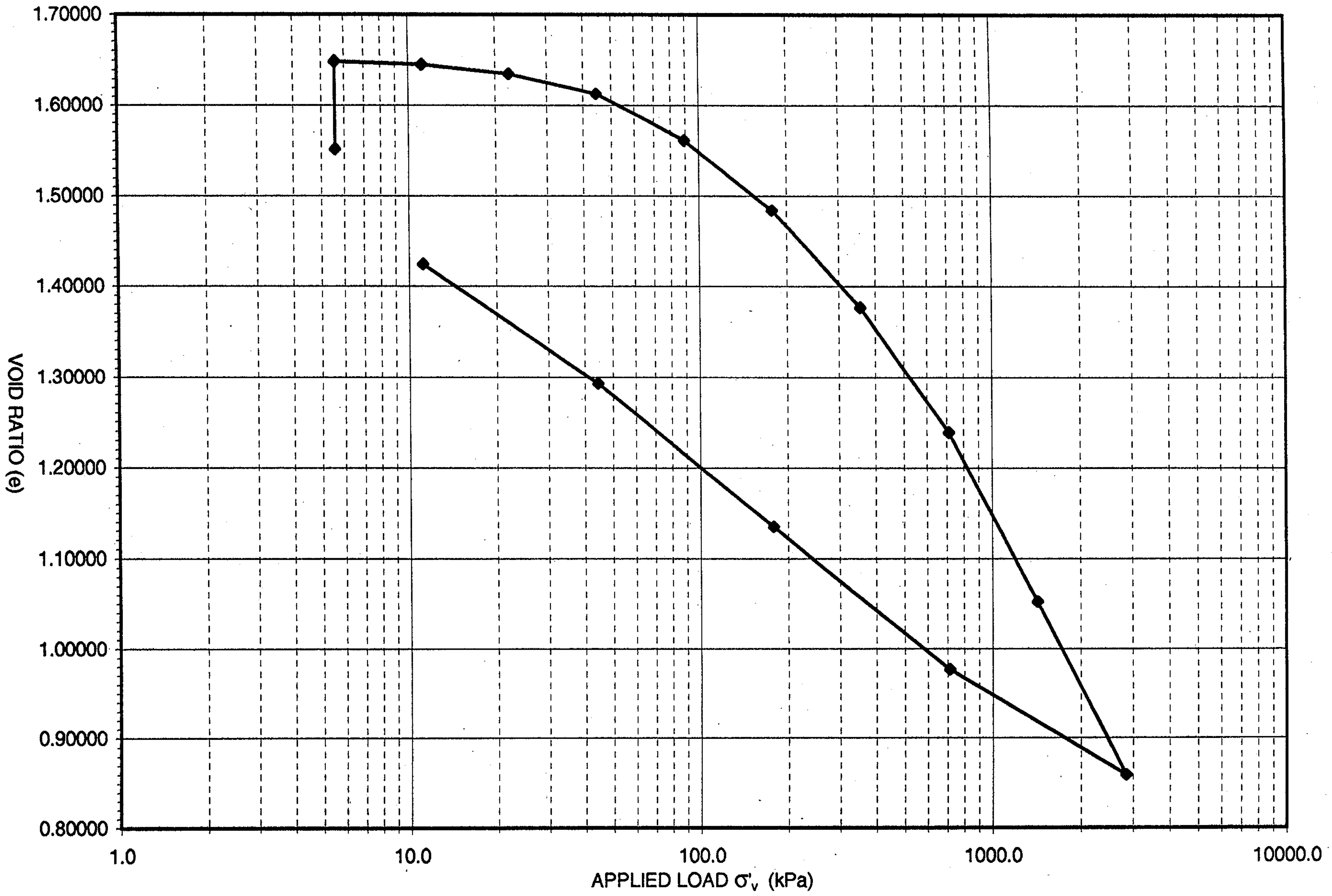
Manitoba Hydro

POWER PLANNING & OPERATIONS
GEOTECHNICAL ENGINEERING
MATERIALS TESTING LAB

NAT. TEST. LAB AO23A01

Sample No	Hole No	Depth
6	AH03 - 02	3.80 - 4.35 m

CONSOLIDATION
03 07 04 BY: HM / JL
FILE: CONS6C DIR:NAT.TEST.03



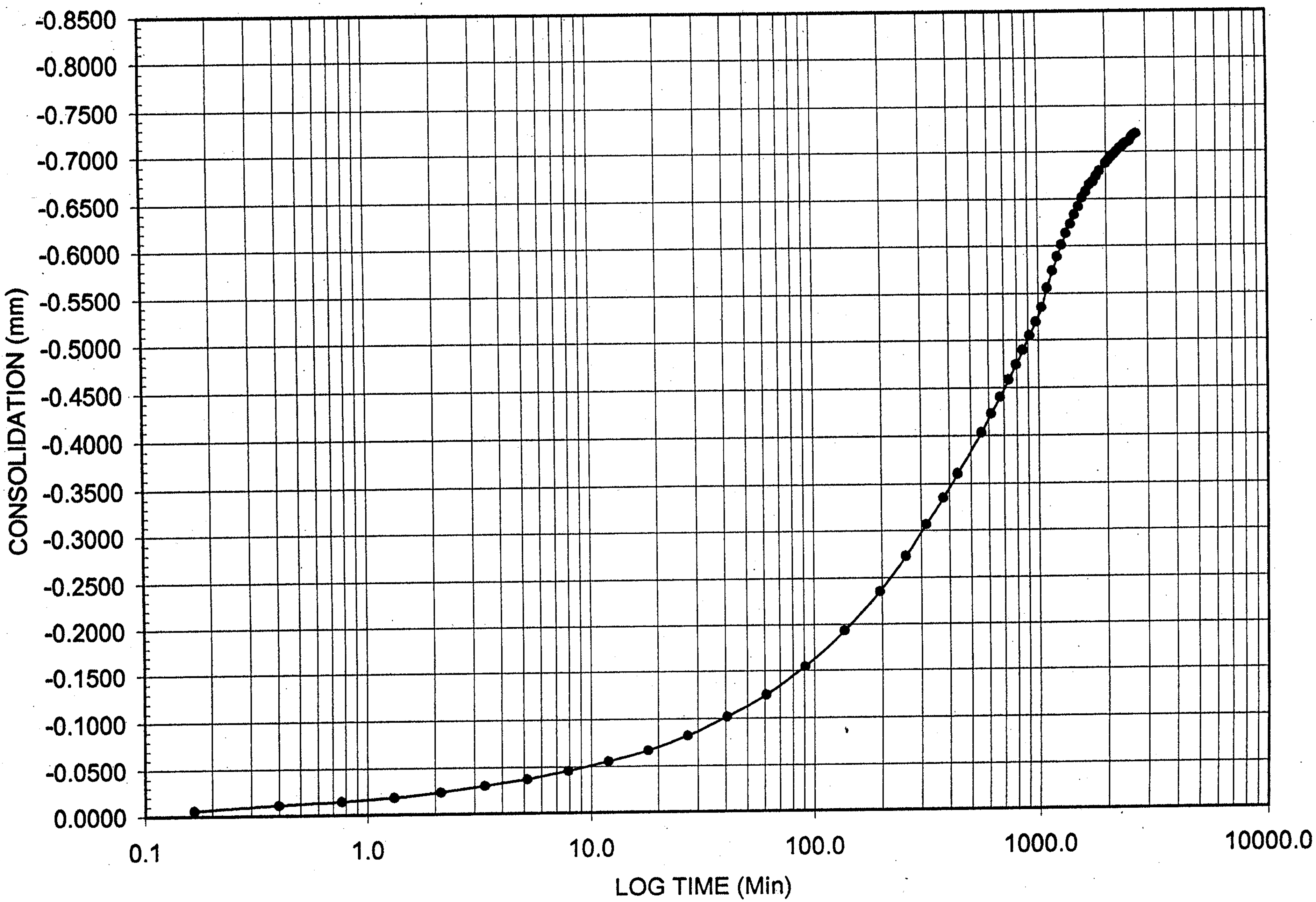
Preconsolidation Pressure Range, P'c = 220 - 250 kPa Swelling Pressure = 100 kPa Compression Index Cc = 0.63

Manitoba Hydro	*POWER PLANNING & OPERATIONS* *GEOTECHNICAL ENGINEERING* *MATERIALS TESTING LAB*	NAT. TEST. LAB AO23A01			CONSOLIDATION
		Sample No 6	Hole No AH03 - 02	Depth 3.80 - 4.35 m	03 07 04 BY: HM / JL FILE: CONS6C DIR:NAT.TEST.03

03 07 06

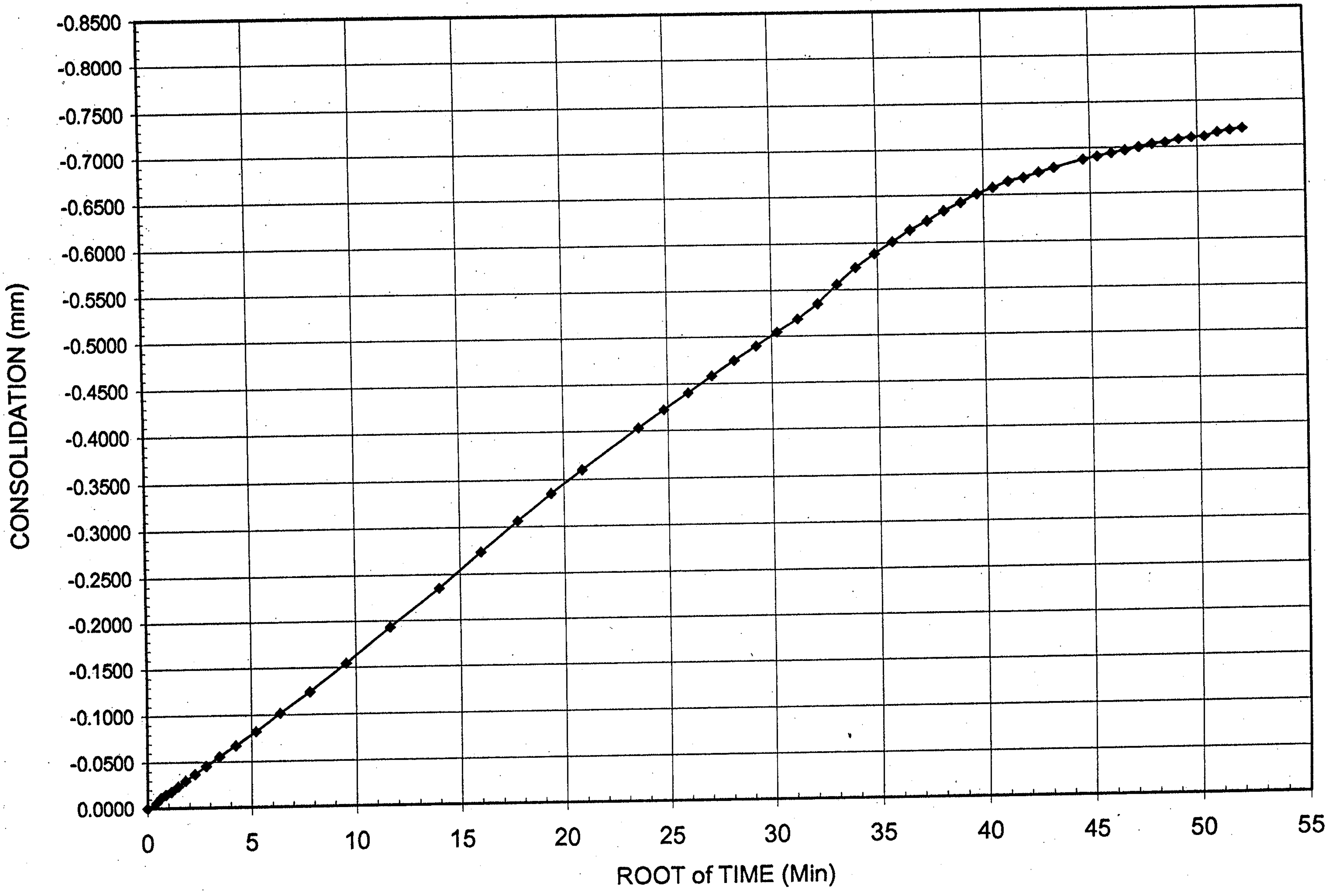
NAT. TEST. LAB AO023A01

S - 6 AH03 - 02 3.80 - 4.35 m



CONSOLIDATION PRESSURE = 5.6 kPa

FILE # - SWELLING #1

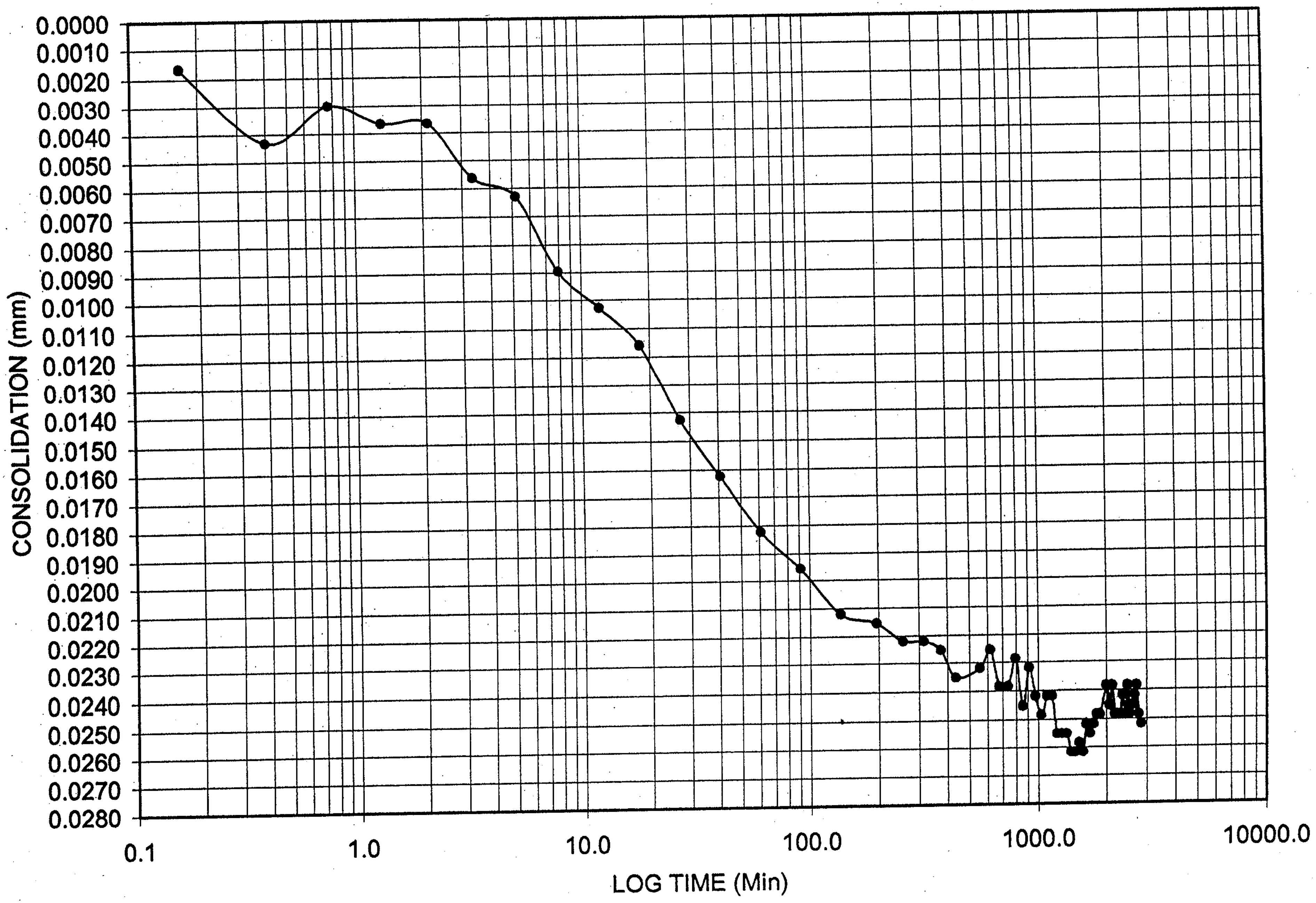


CONSOLIDATION PRESSURE = 5.6 kPa

03 07 08

NAT. TEST. LAB AO023A01

S - 6 AH03 - 02 3.80 - 4.35 m



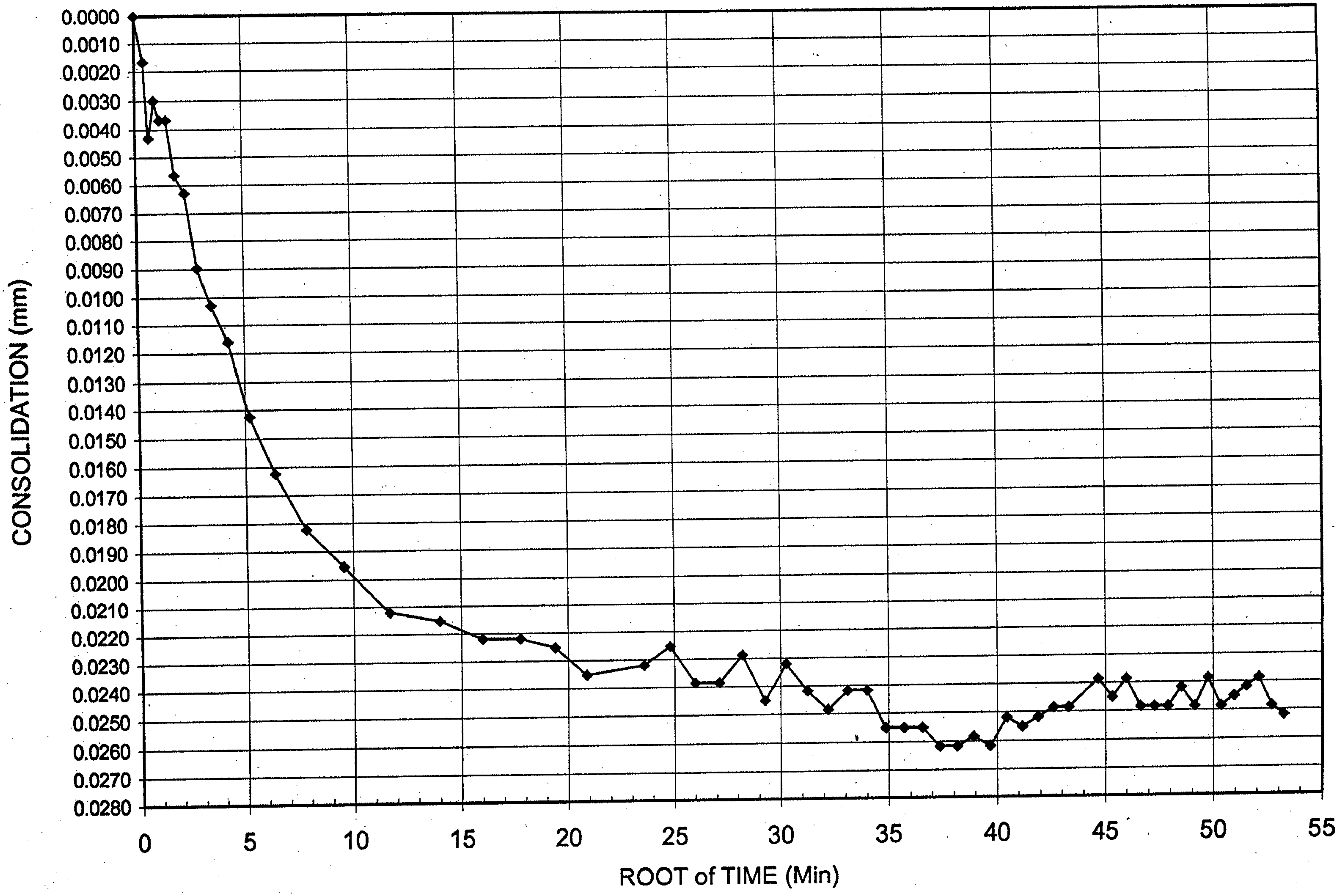
CONSOLIDATION PRESSURE = 11.1 kPa

FILE # CONSOLIDATION #1

03 07 08

NAT. TEST. LAB AO23A01

S - 6 AH03 - 02 3.80 - 4.35 m



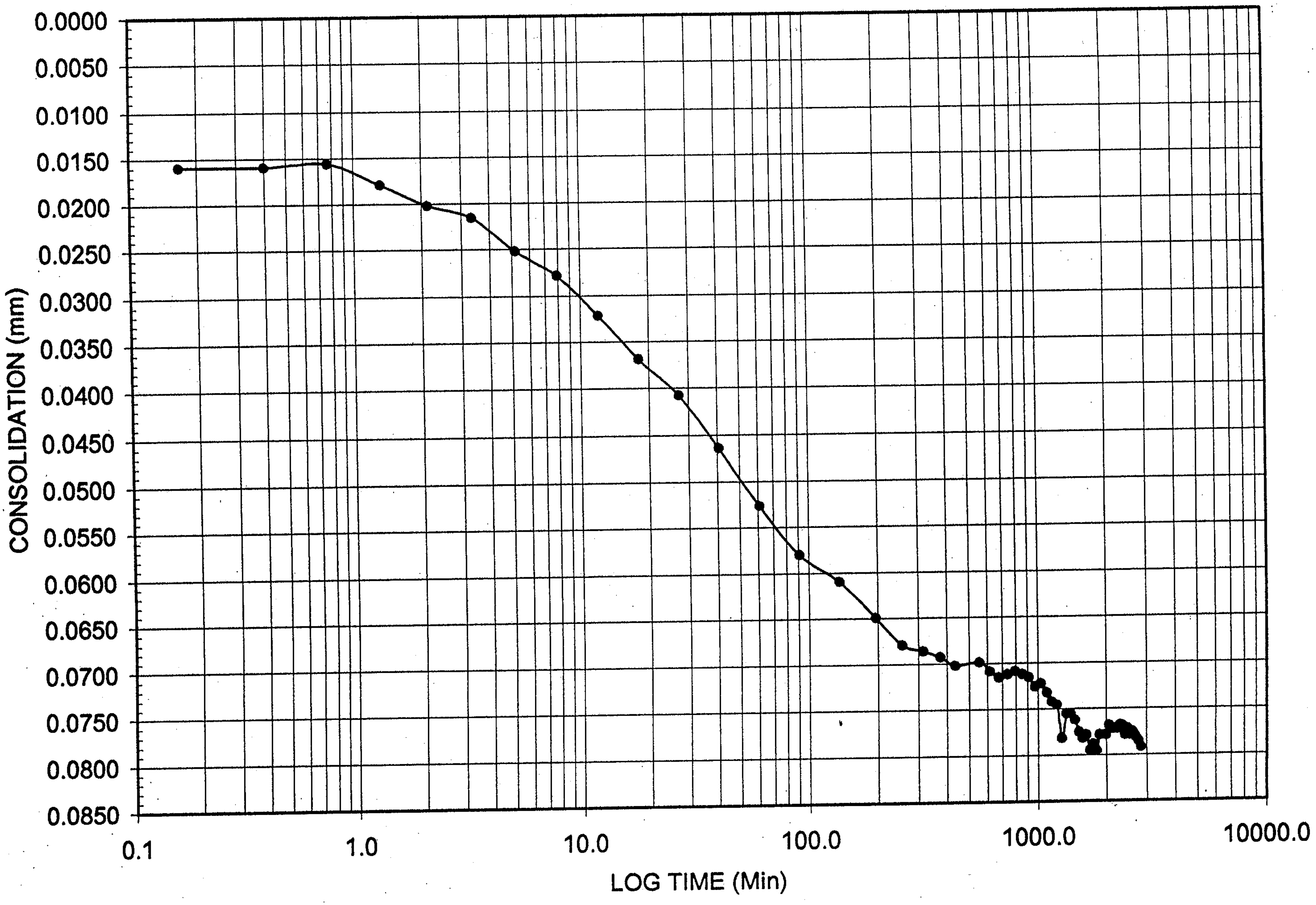
CONSOLIDATION PRESSURE = 11.1 kPa

FILE #: CONSOLIDATION #1

03 07 10

NAT. TEST. LAB AO023A01

S - 6 AH03 - 02 3.80 - 4.35 m



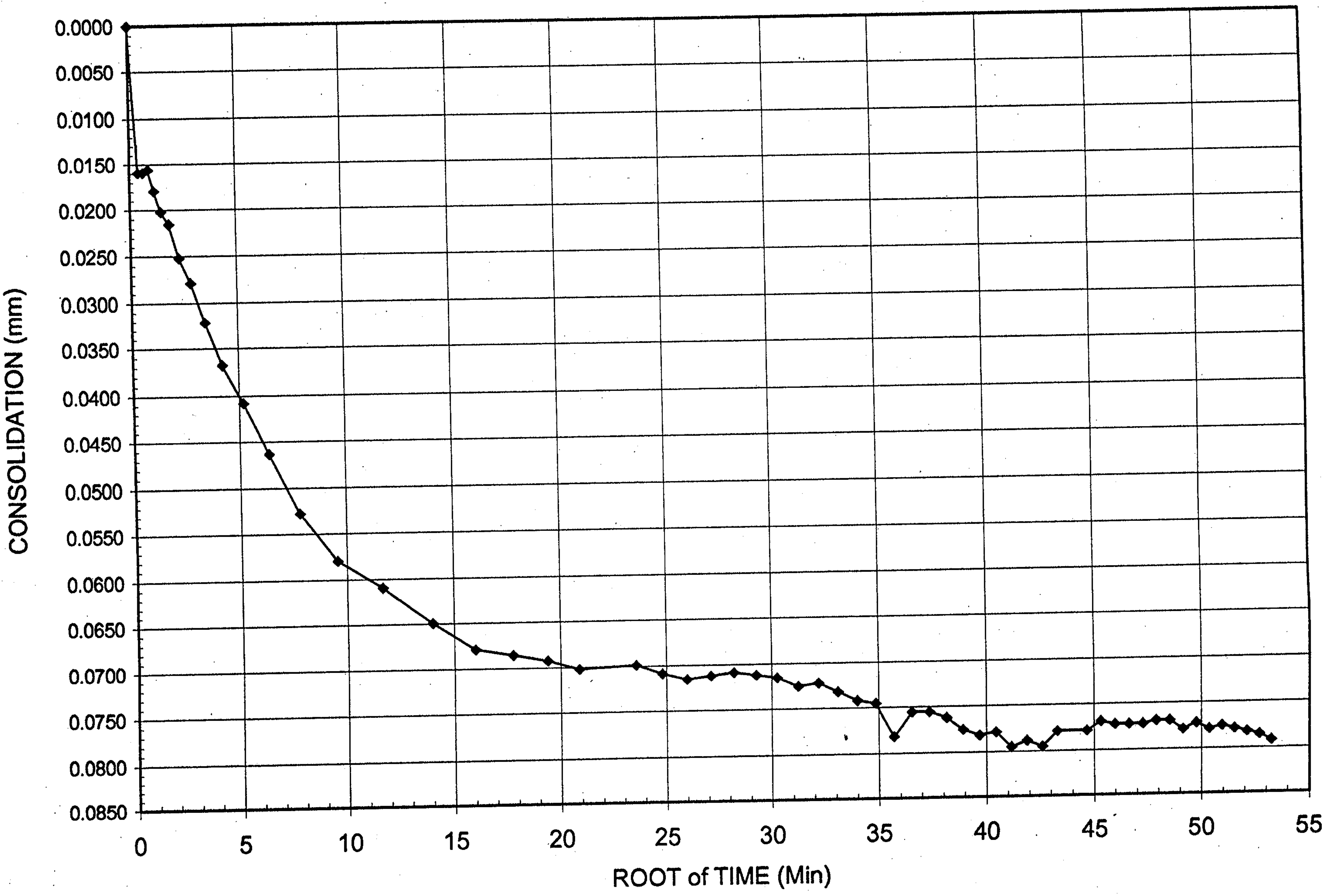
CONSOLIDATION PRESSURE = 22.3 kPa

FILE # - CONSOLIDATION #2

03 07 10

NAT. TEST. LAB AO23A01

S - 6 AH03 - 02 3.80 - 4.35 m



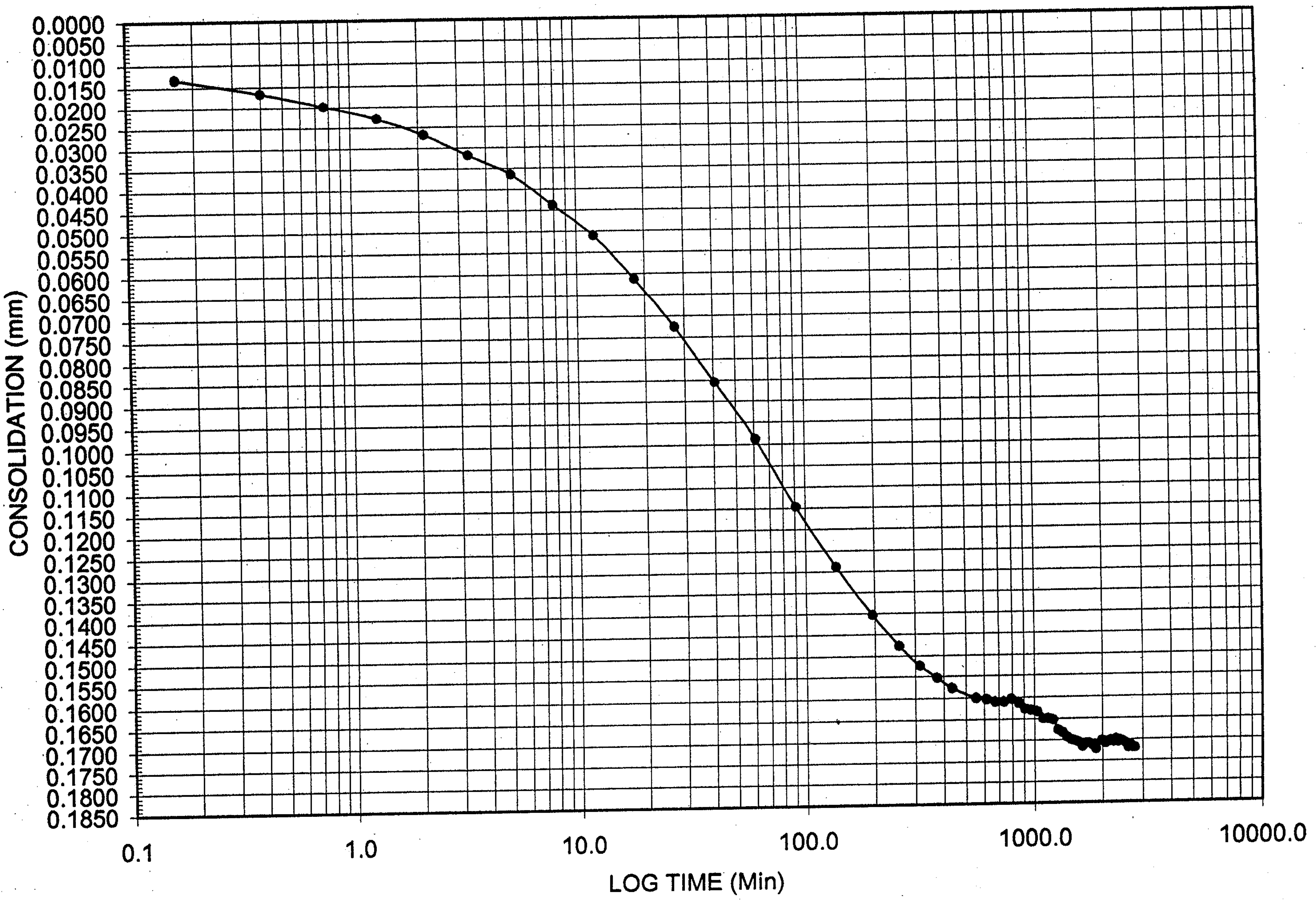
CONSOLIDATION PRESSURE = 22.3 kPa

FILE # CONSOLIDATION #2

03 07 12

NAT. TEST. LAB AO023A01

S - 6 AH03 - 02 3.80 - 4.35 m



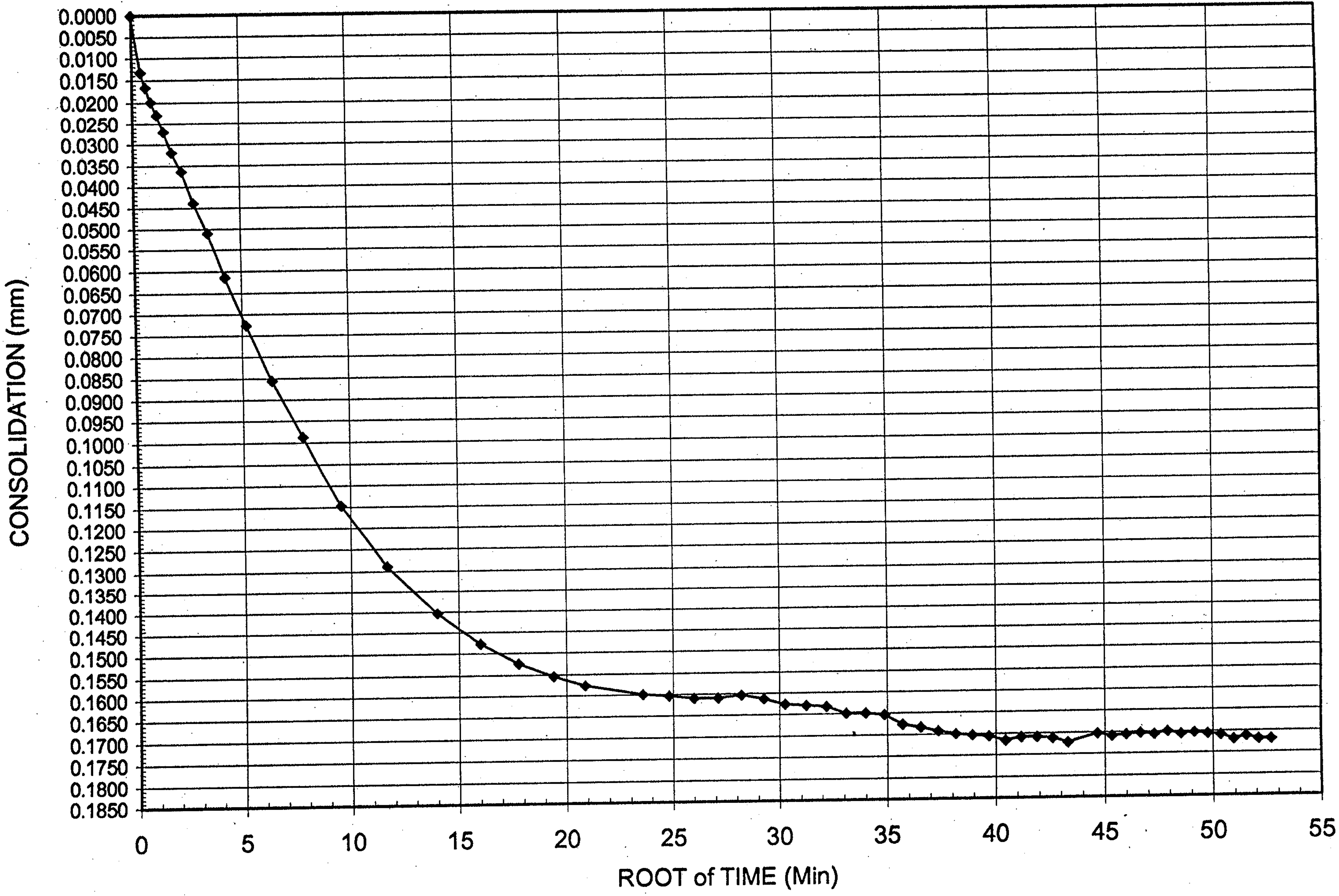
CONSOLIDATION PRESSURE = 44.6 kPa

FILE # CONSOLIDATION #3

03 07 12

NAT. TEST. LAB AO23A01

S - 6 AH03 - 02 3.80 - 4.35 m

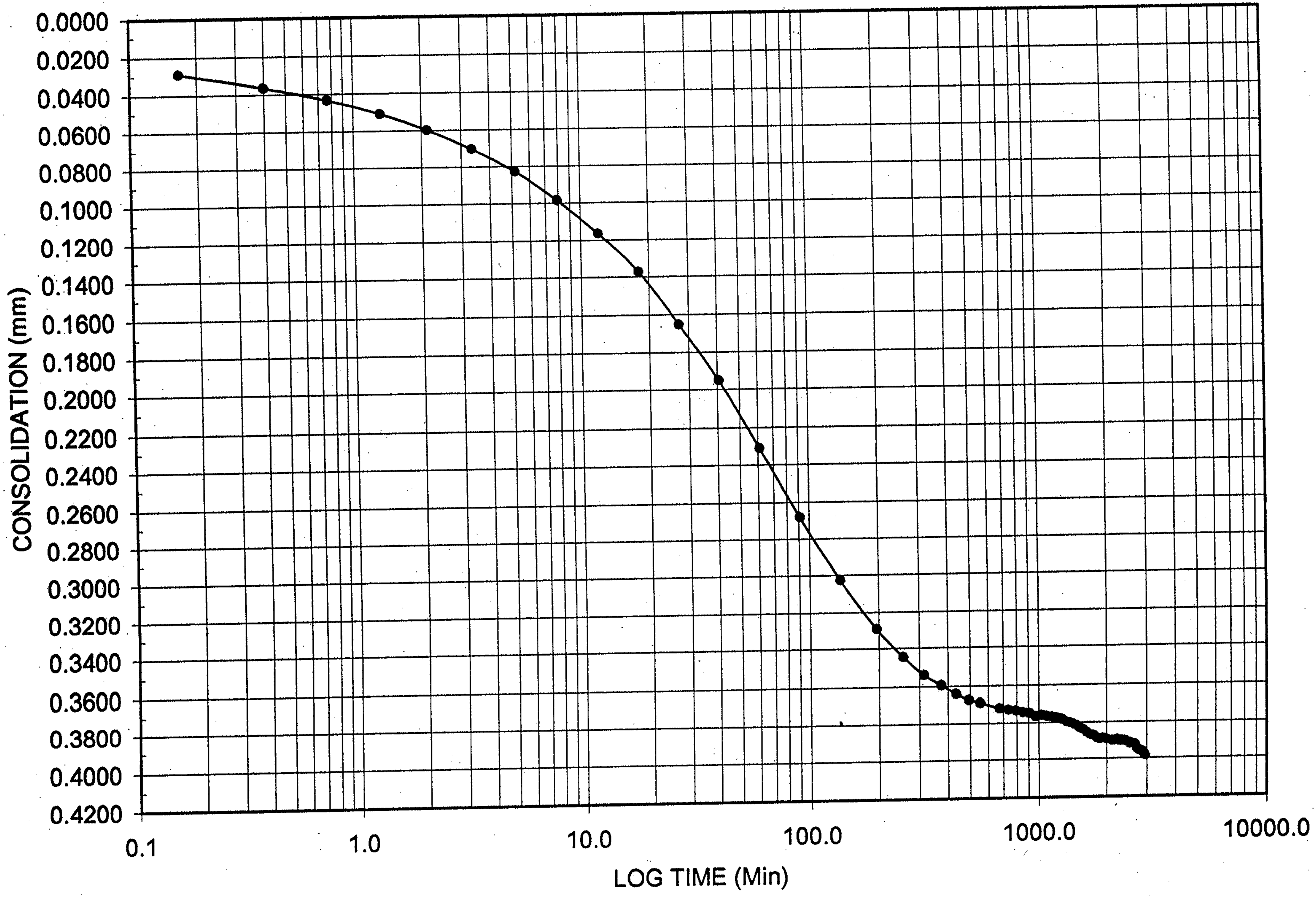


CONSOLIDATION PRESSURE = 44.6 kPa

03 07 14

NAT. TEST. LAB AO023A01

S - 6 AH03 - 02 3.__ - 4.35 m



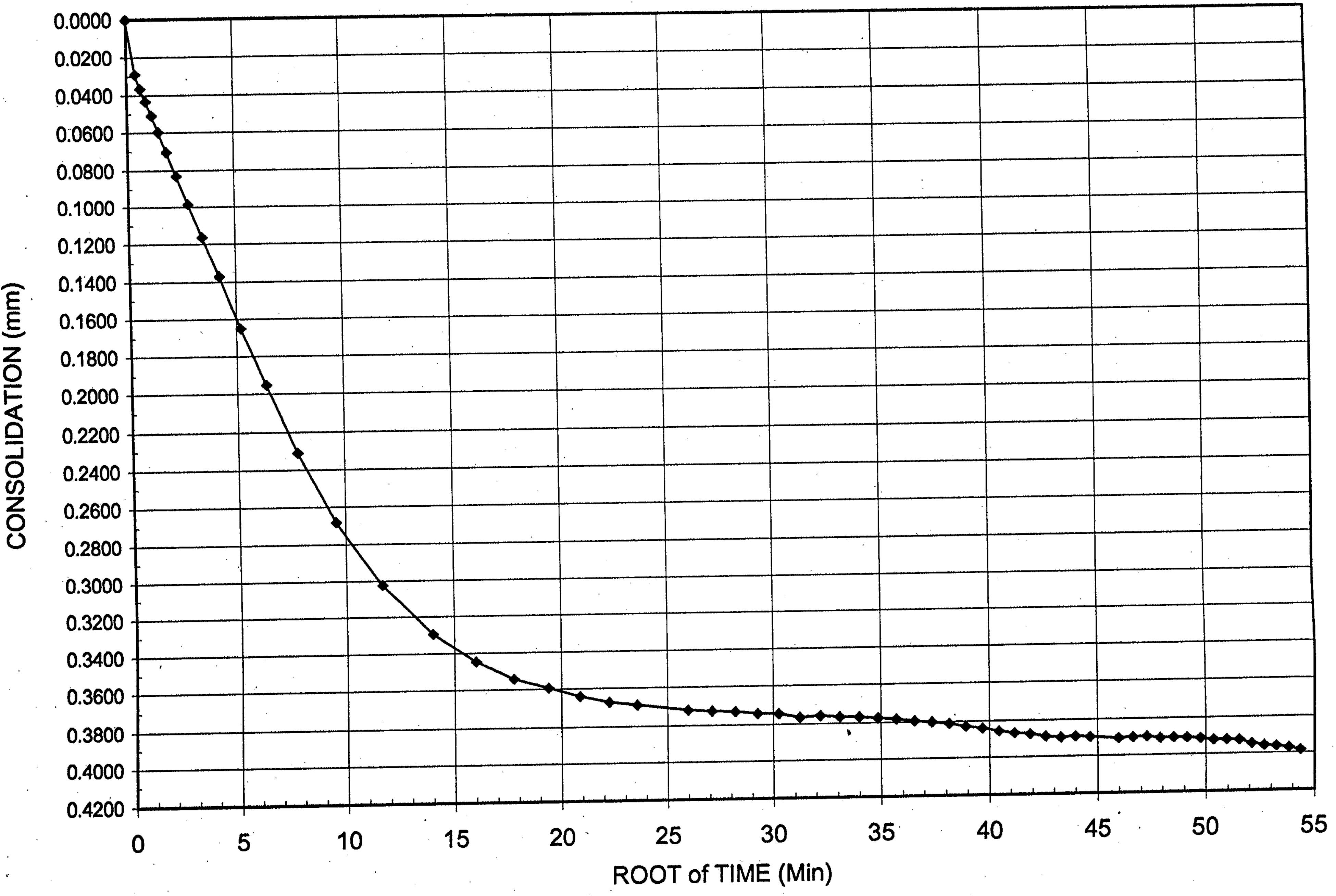
CONSOLIDATION PRESSURE = 89.1 kPa

FILE # - CONSOLIDATION #4

03 07 14

NAT. TEST. LAB AO23A01

S - 6 AH03 - 02 3.80 - 4.35 m



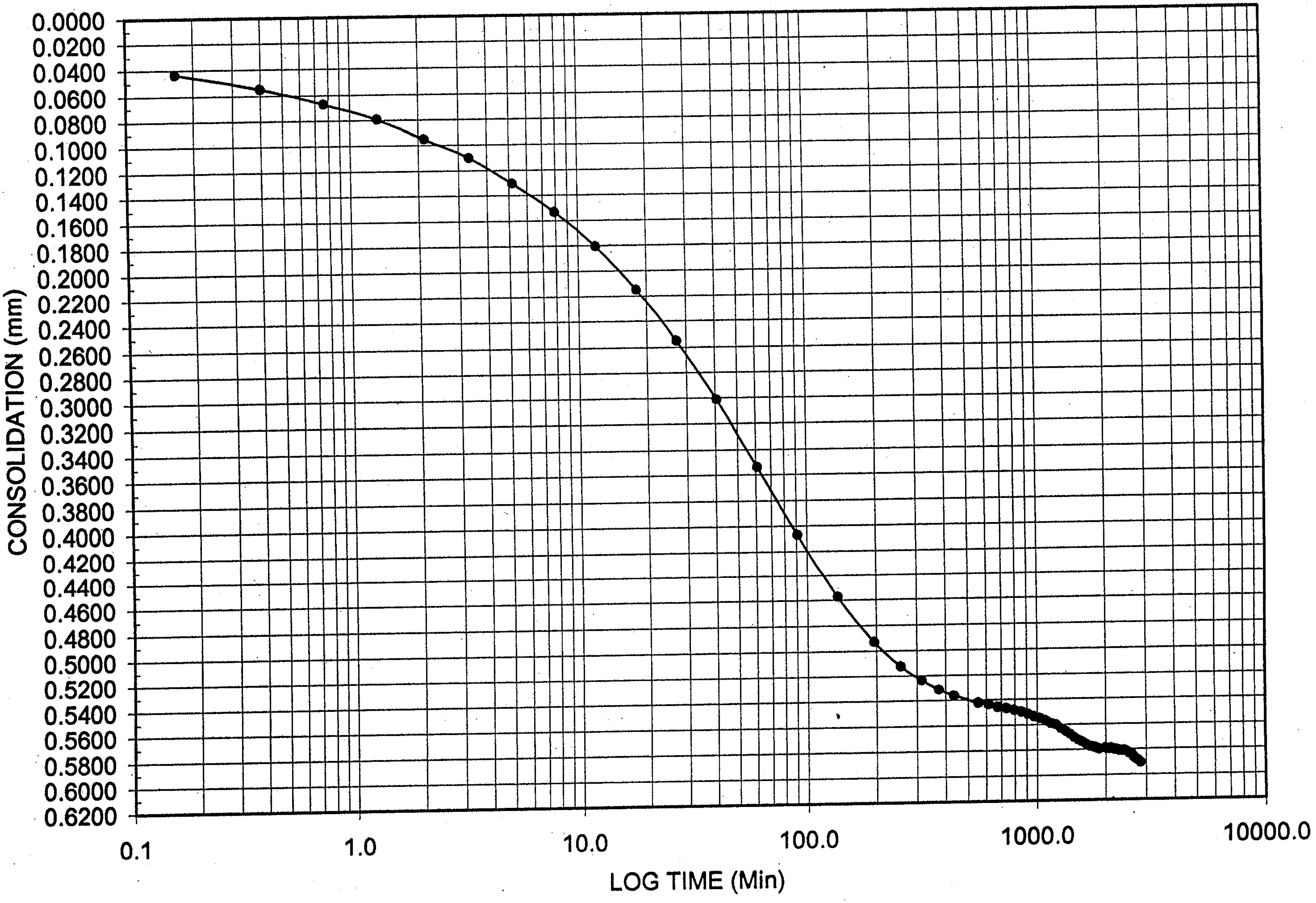
CONSOLIDATION PRESSURE = 89.1 kPa

FILE # CONSOLIDATION #4

03 07 16

NAT. TEST. LAB AO023A01

S - 6 AH03 - 02 3.80 - 4.35 m

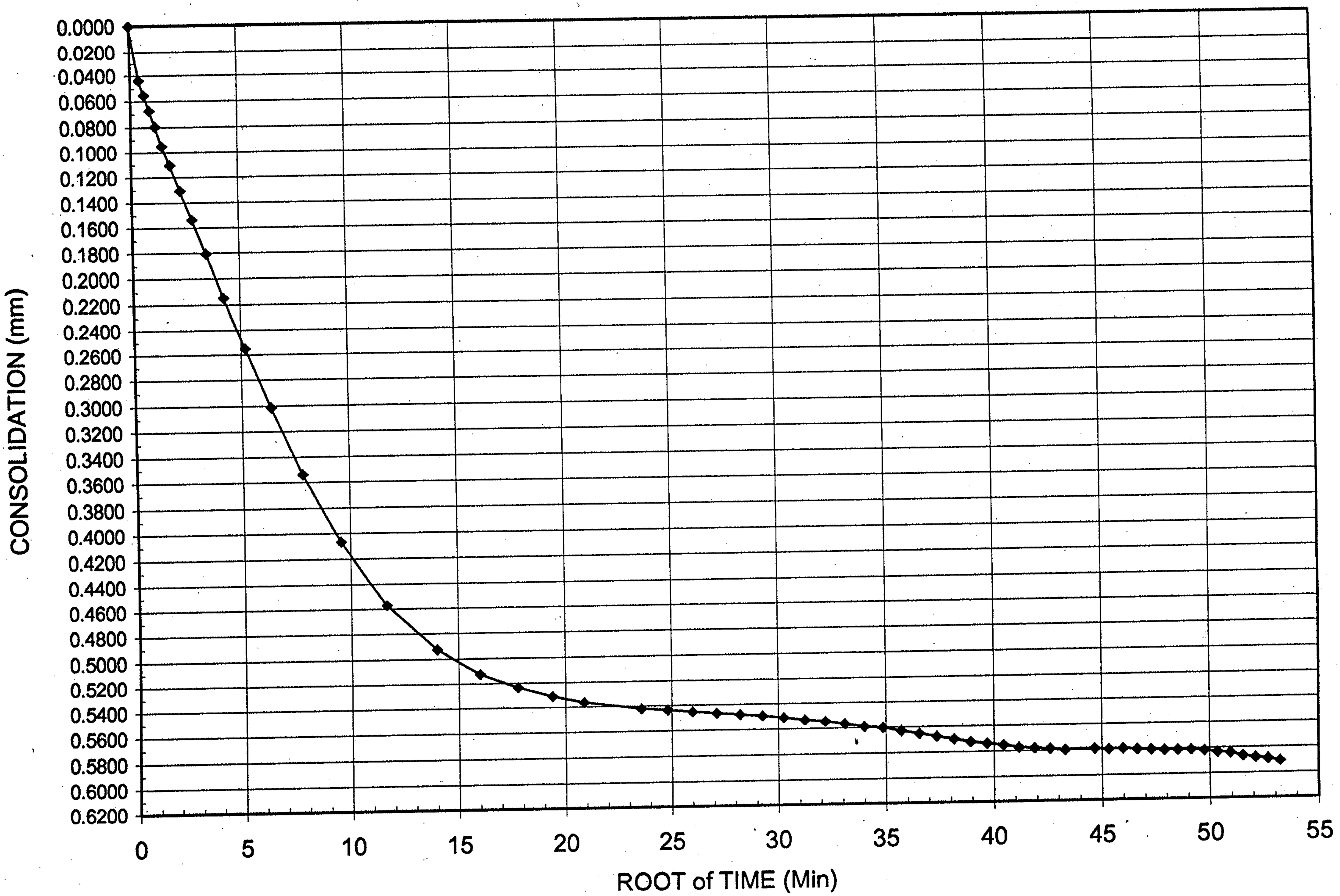


CONSOLIDATION PRESSURE = 178.3 kPa

03 07 16

NAT. TEST. LAB AO23A01

S - 6 AH03 - 02 3.80 - 4.35 m



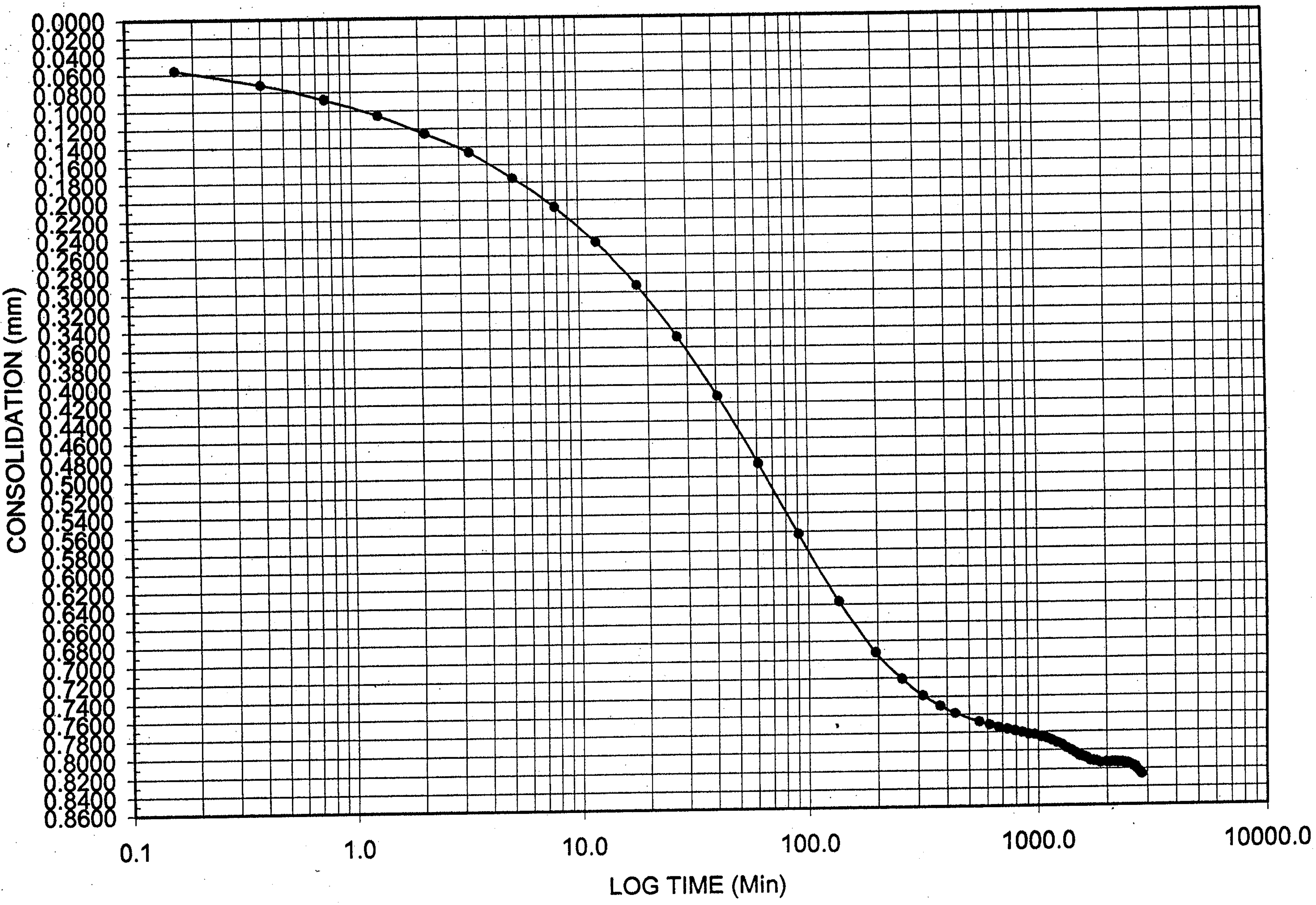
CONSOLIDATION PRESSURE = 178.3 kPa

FILE # CONSOLIDATION #5

03 07 18

NAT. TEST. LAB AO023A01

S - 6 AH03 - 02 3.[illegible] - 4.35 m



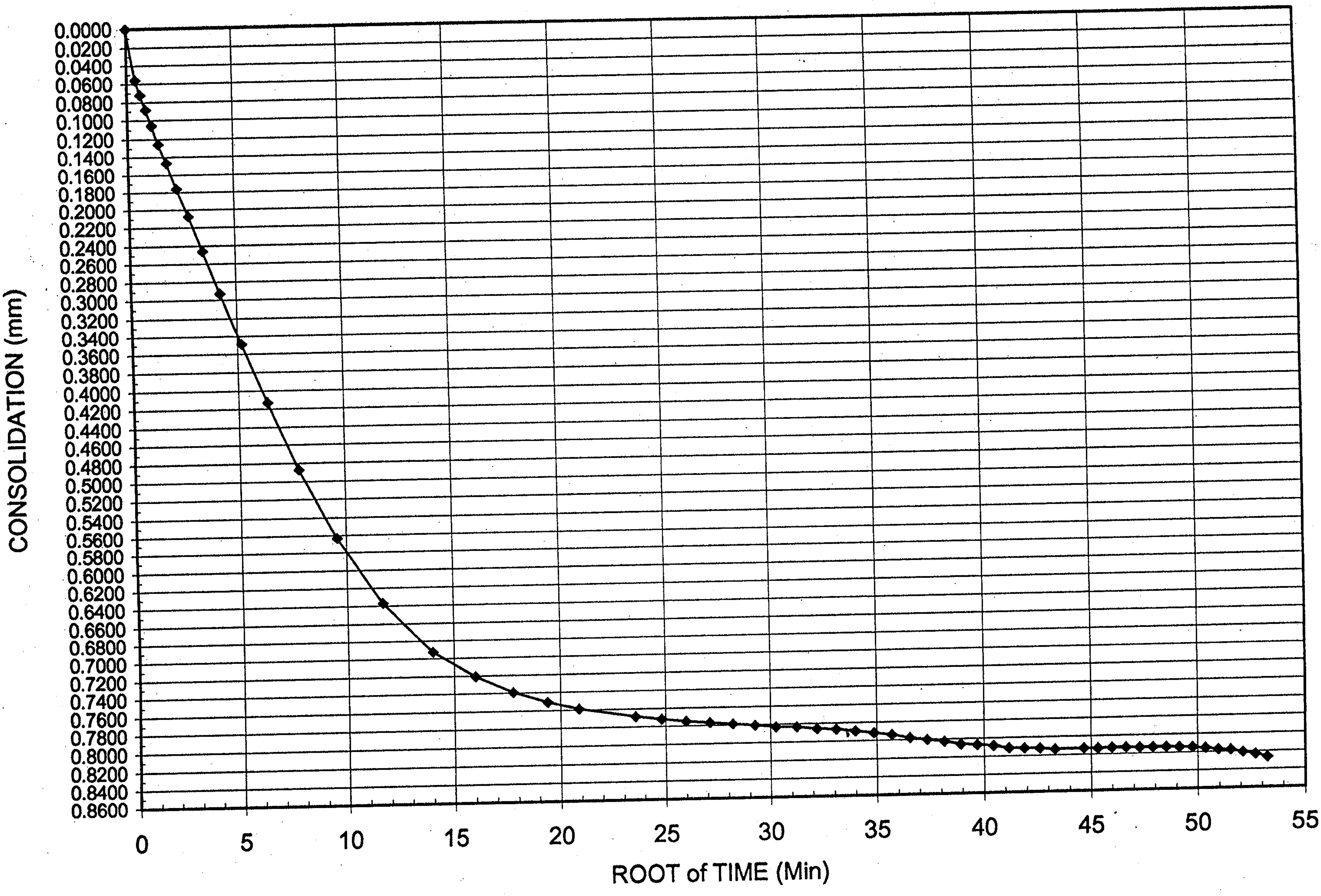
CONSOLIDATION PRESSURE = 356.8 kPa

FILE # - CONSOLIDATION #6

03 07 18

NAT. TEST. LAB AO23A01

S - 6 AH03 - 02 3.80 - 4.35 m



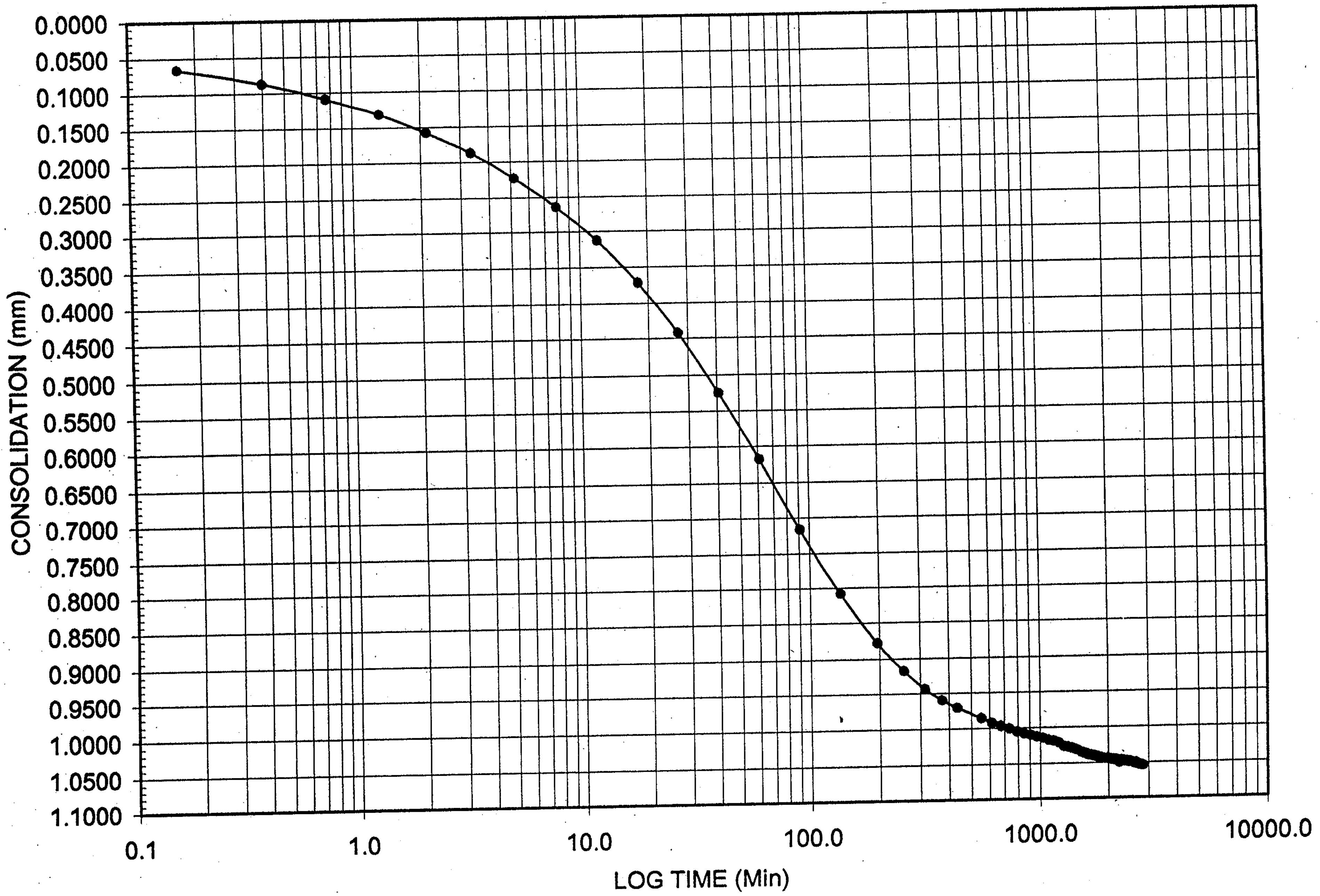
CONSOLIDATION PRESSURE = 356.8 kPa

FILE # - CONSOLIDATION #6

03 07 20

NAT. TEST. LAB AO023A01

S - 6 AH03 - 02 3.80 - 4.35 m



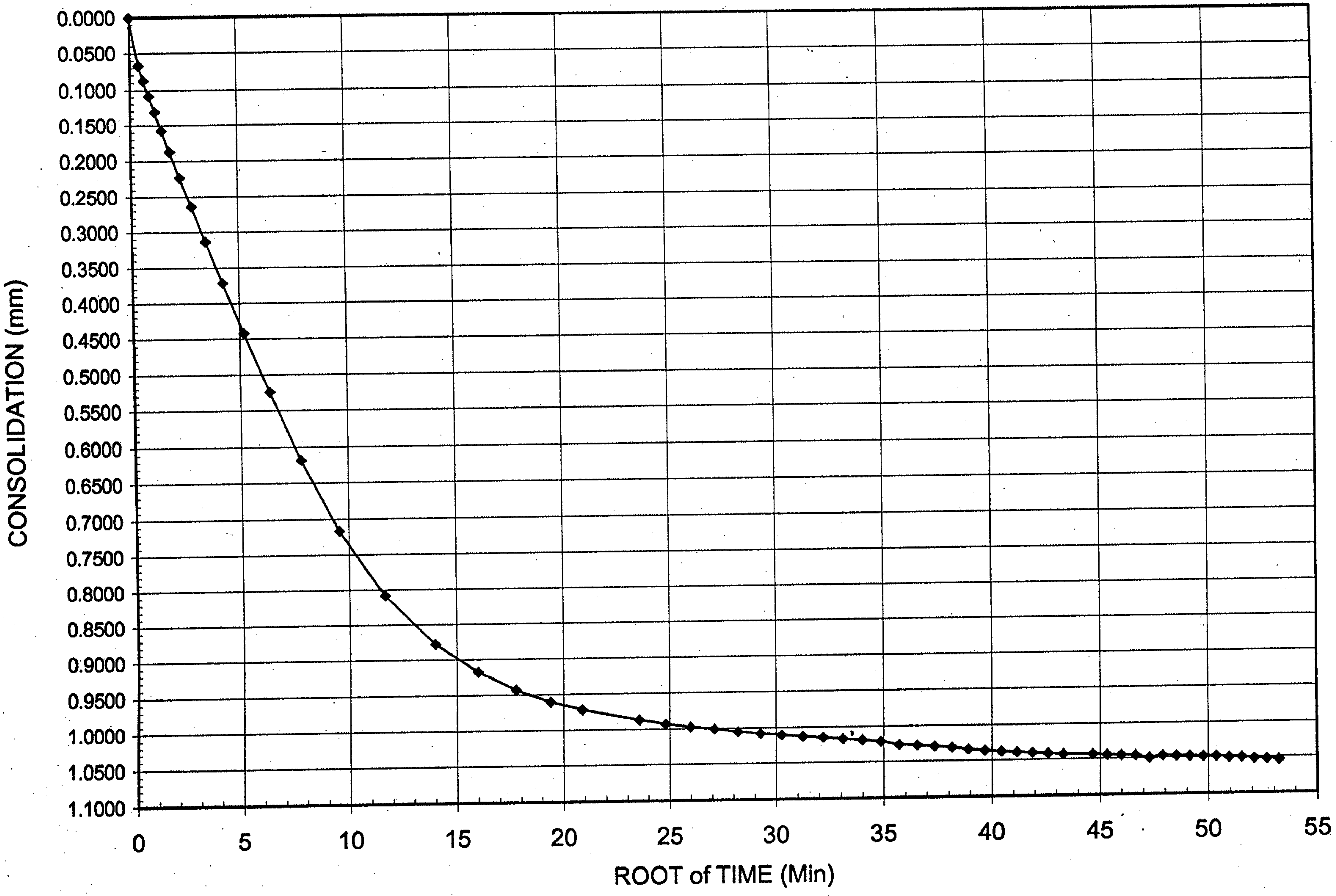
CONSOLIDATION PRESSURE = 714.3 kPa

FILE # - CONSOLIDATION #7

03 07 20

NAT. TEST. LAB AO23A01

S - 6 AH03 - 02 3.80 - 4.35 m



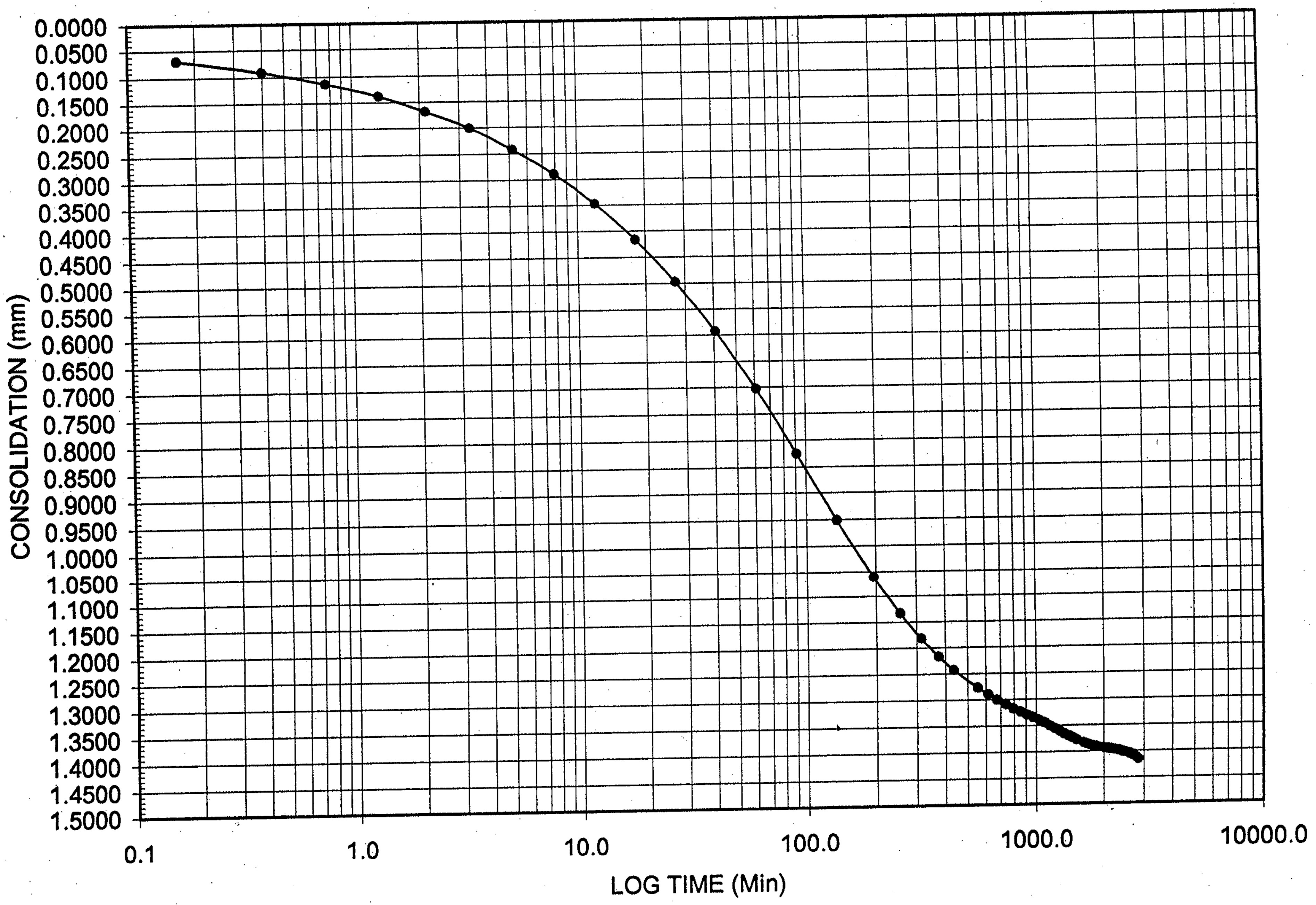
CONSOLIDATION PRESSURE = 714.3 kPa

FILE # CONSOLIDATION #7

03 07 22

NAT. TEST. LAB AO023A01

S - 6 AH03 - 02 3.80 - 4.35 m



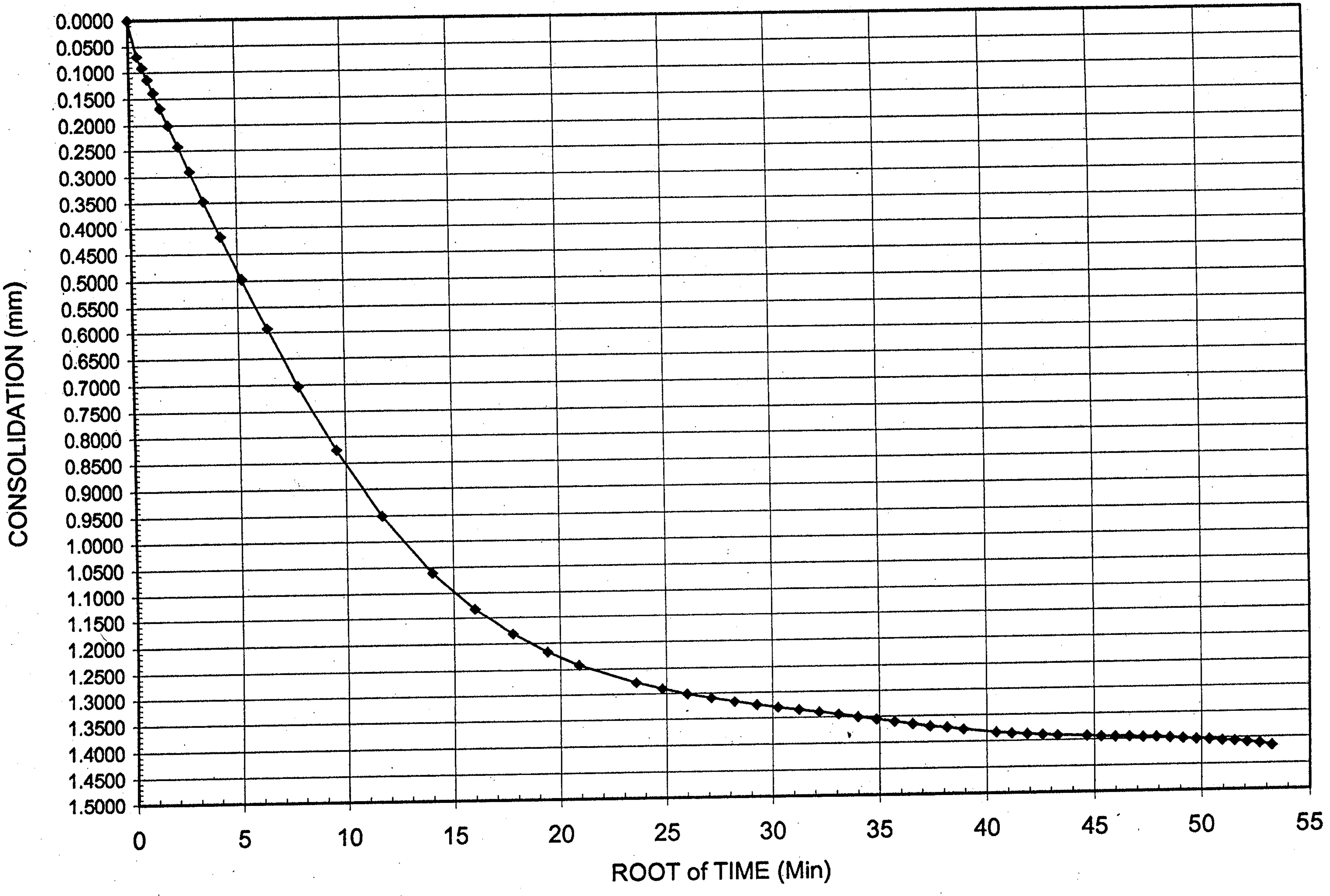
CONSOLIDATION PRESSURE = 1429.3 kPa

FILE # - CONSOLIDATION #8

03 07 22

NAT. TEST. LAB AO23A01

S - 6 AH03 - 02 3.80 - 4.35 m



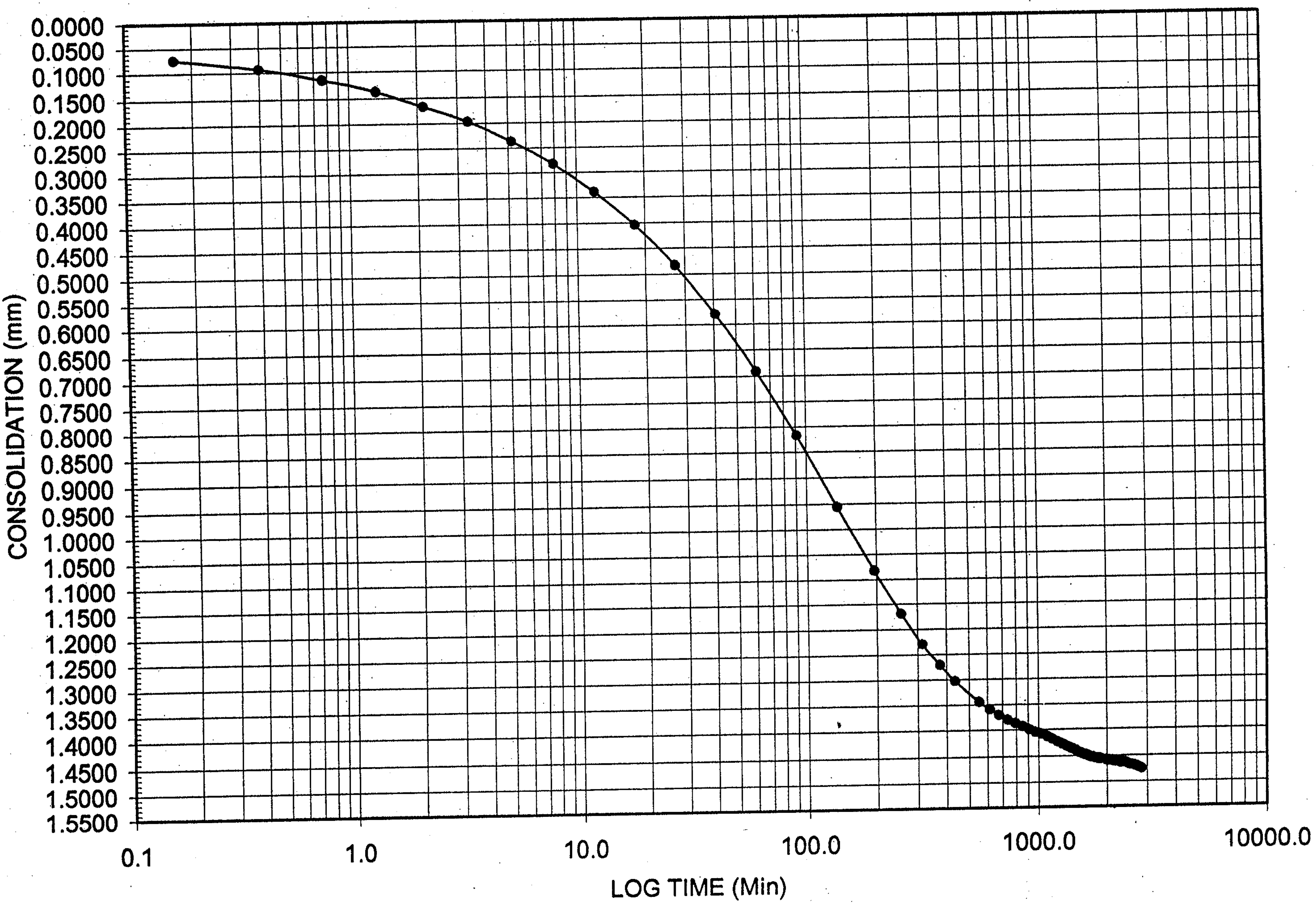
CONSOLIDATION PRESSURE = 1429.3 kPa

FILE # - CONSOLIDATION #8

03 07 24

NAT. TEST. LAB AO023A01

S - 6 AH03 - 02 3.[illegible] - 4.35 m



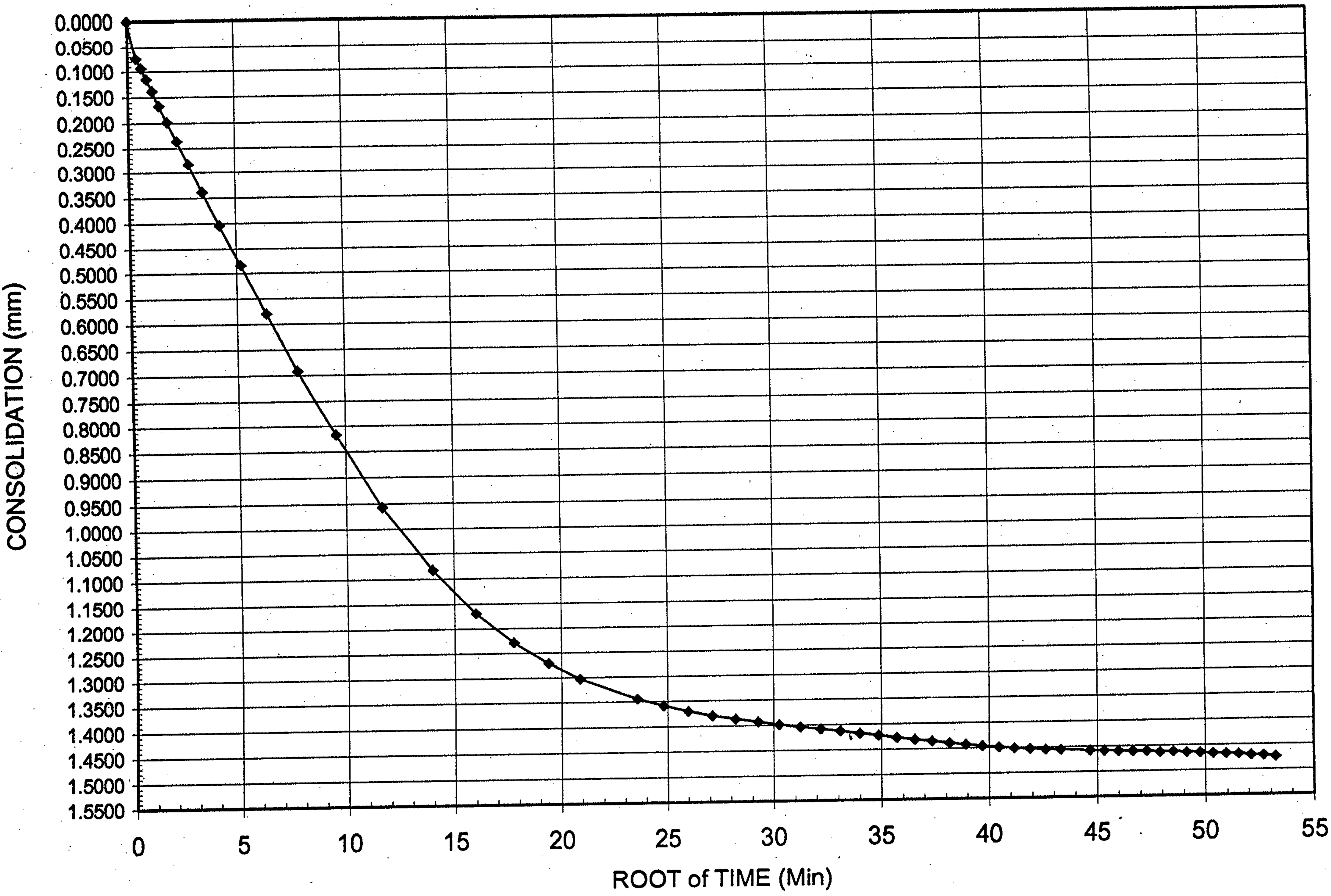
CONSOLIDATION PRESSURE = 2853.2 kPa

FILE # - CONSOLIDATION #9

03 07 24

NAT. TEST. LAB AO23A01

S - 6 AH03 - 02 3.80 - 4.35 m

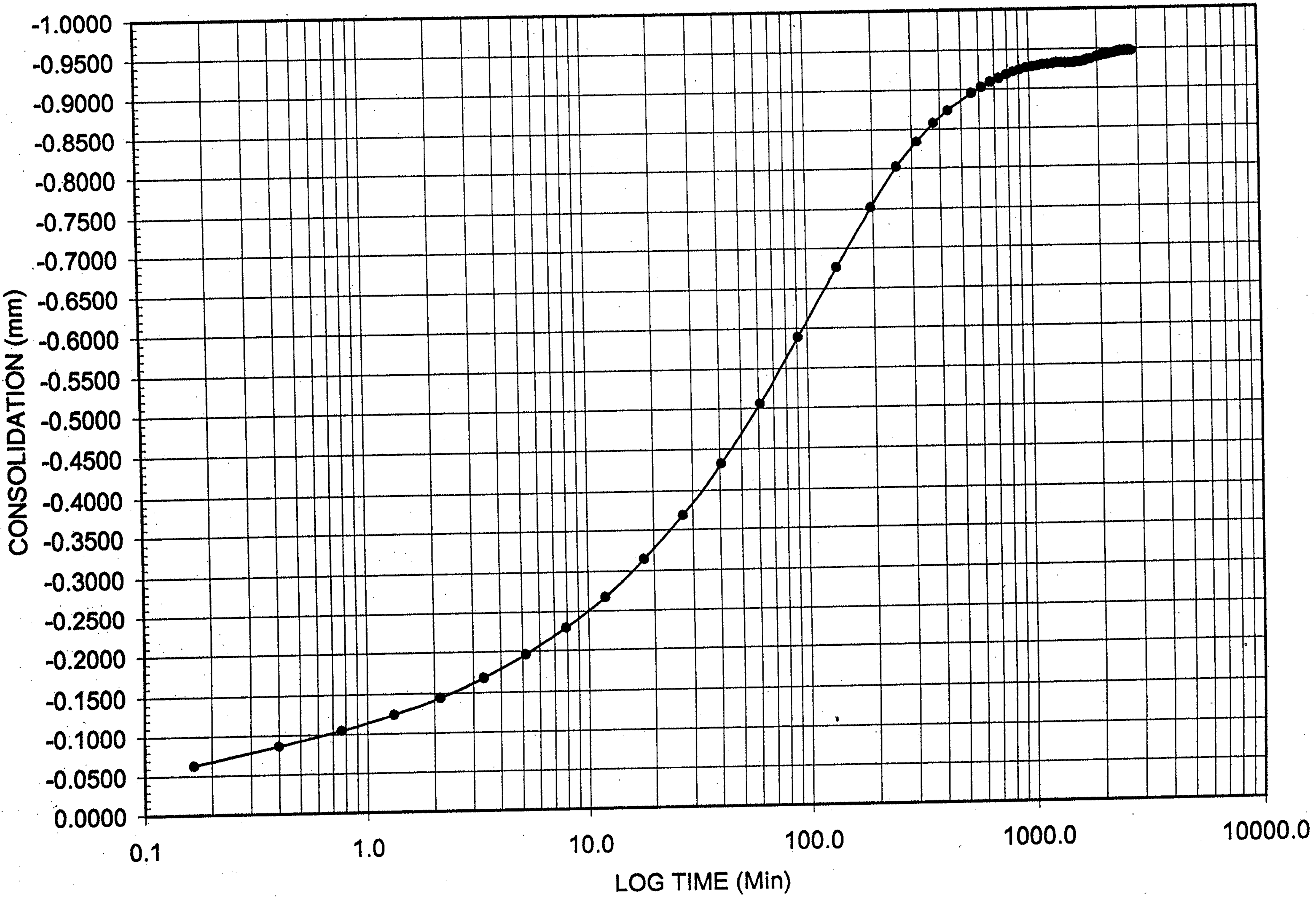


CONSOLIDATION PRESSURE = 2853.2 kPa

03 07 26

NAT. TEST. LAB AO023A01

S - 6 AH03 - 02 3.80 - 4.35 m



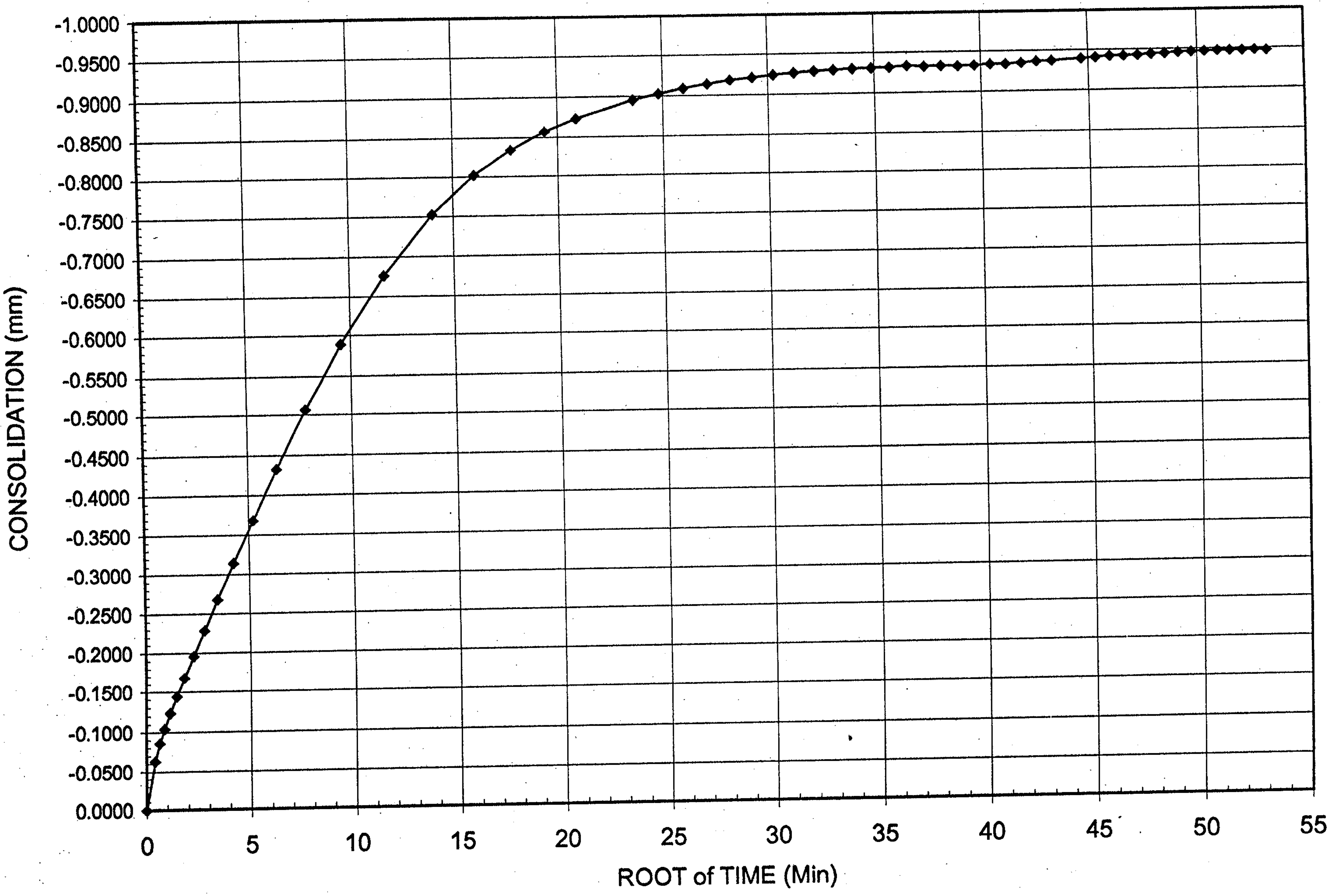
CONSOLIDATION PRESSURE = 714.3 kPa

FILE # CONSOLIDATION #10

03 07 26

NAT. TEST. LAB AO23A01

S - 6 AH03 - 02 3.80 - 4.35 m



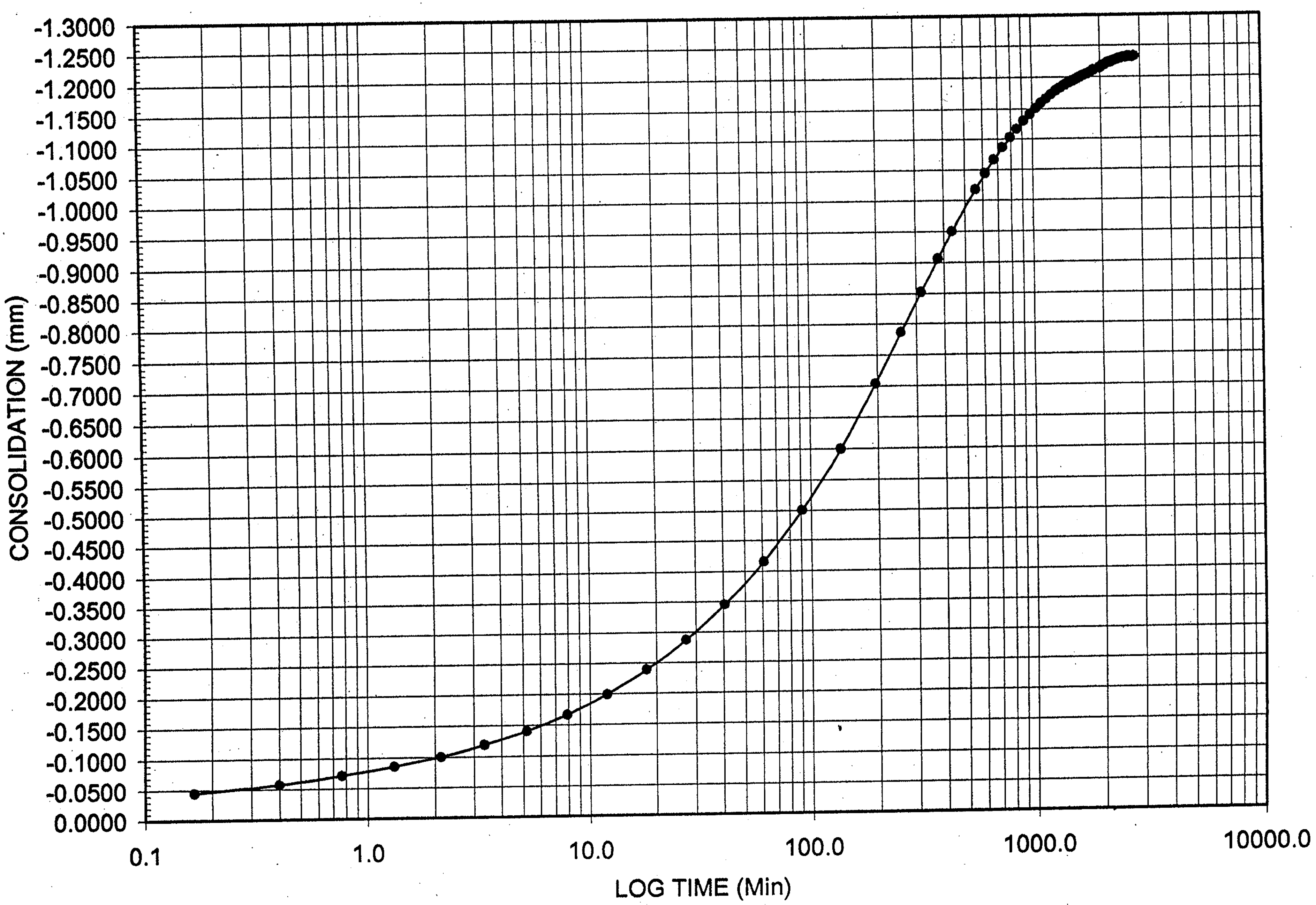
CONSOLIDATION PRESSURE = 714.3 kPa

FILE # - CONSOLIDATION #10

03 07 28

NAT. TEST. LAB AO023A01

S - 6 AH03 - 02 3.[illegible] - 4.35 m



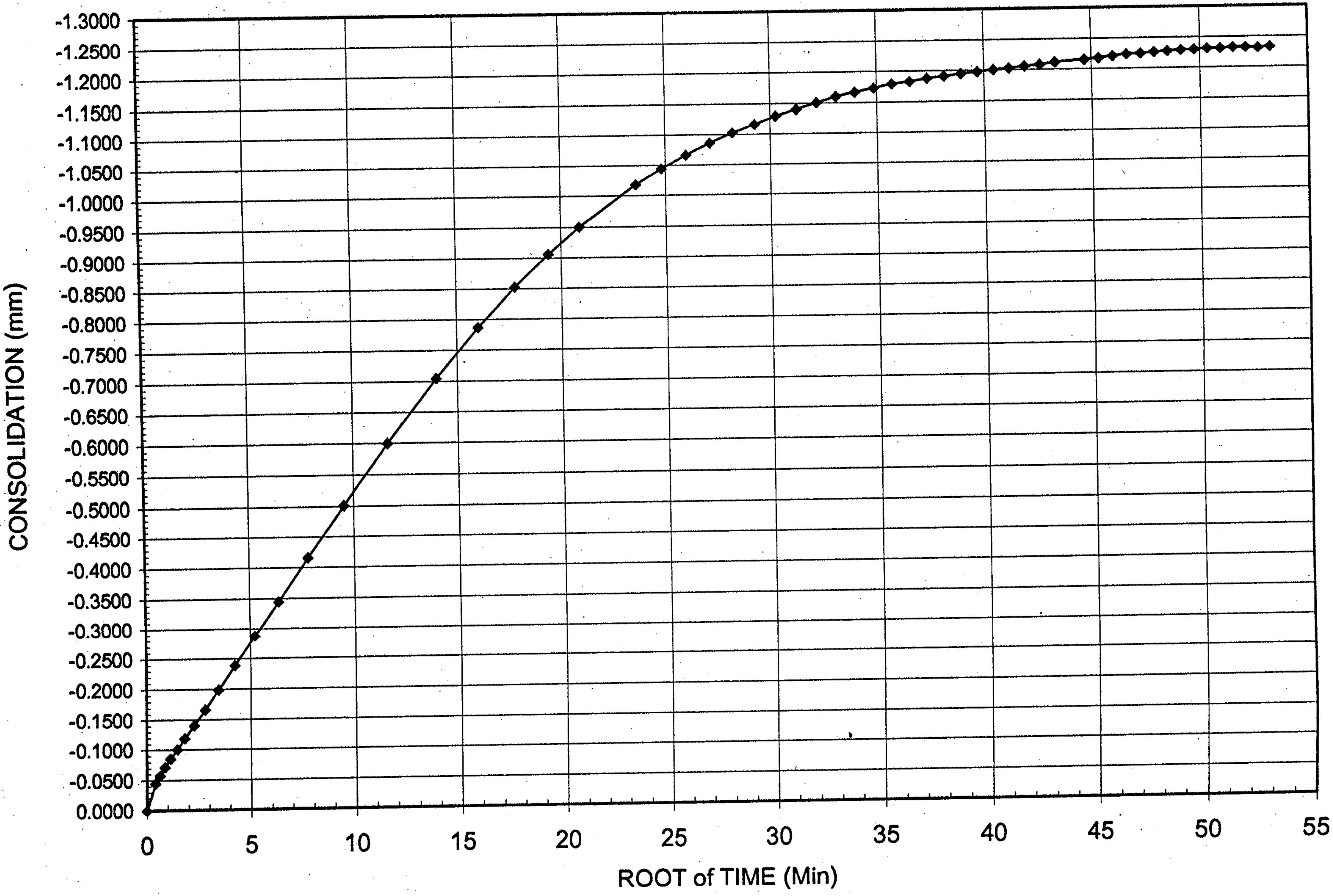
CONSOLIDATION PRESSURE = 178.3 kPa

FILE # - CONSOLIDATION #11

03 07 28

NAT. TEST. LAB AO23A01

S - 6 AH03 - 02 3.80 - 4.35 m

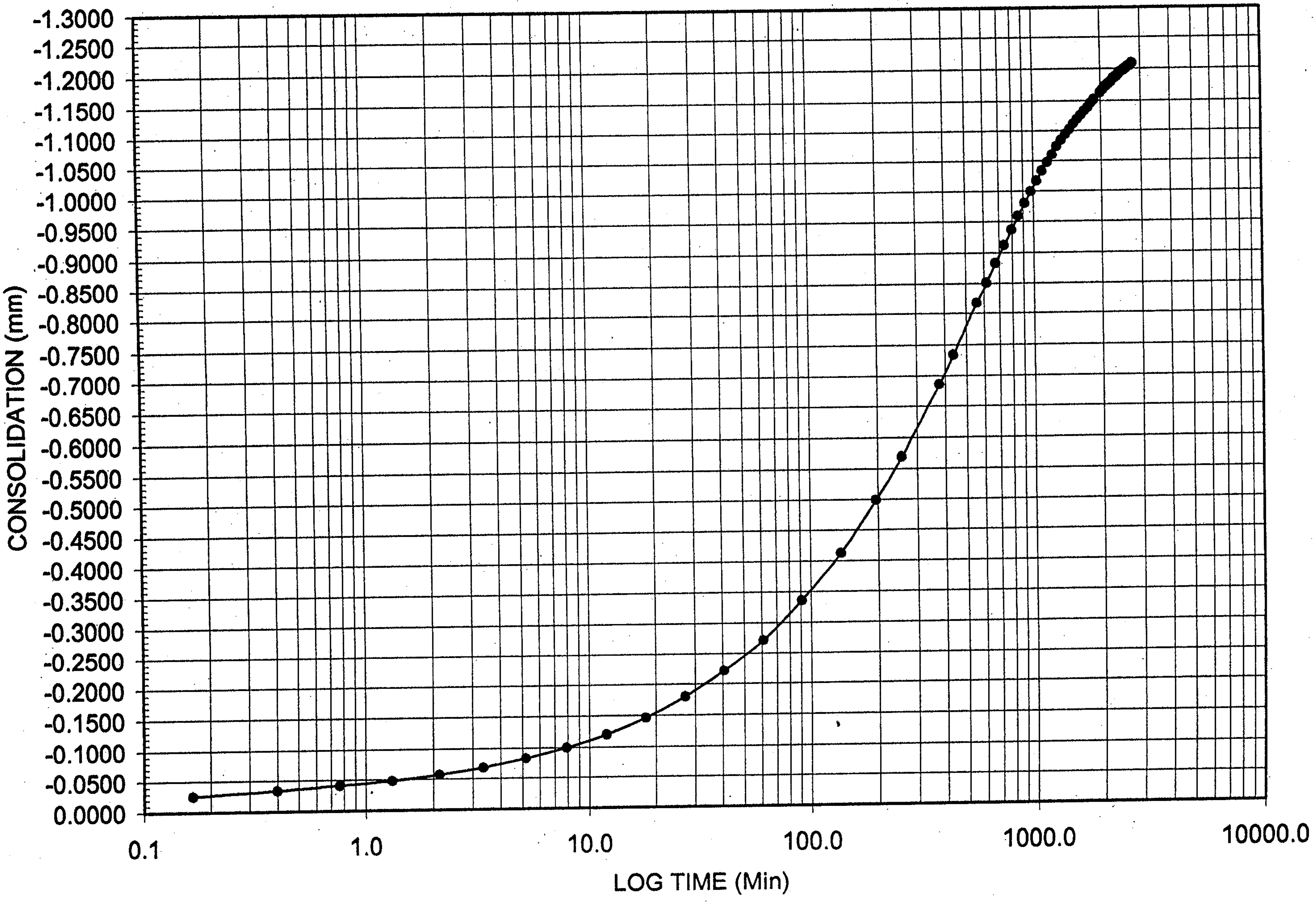


CONSOLIDATION PRESSURE = 178.3 kPa

03 07 30

NAT. TEST. LAB AO023A01

S-6 AH03-02 -4.35 m



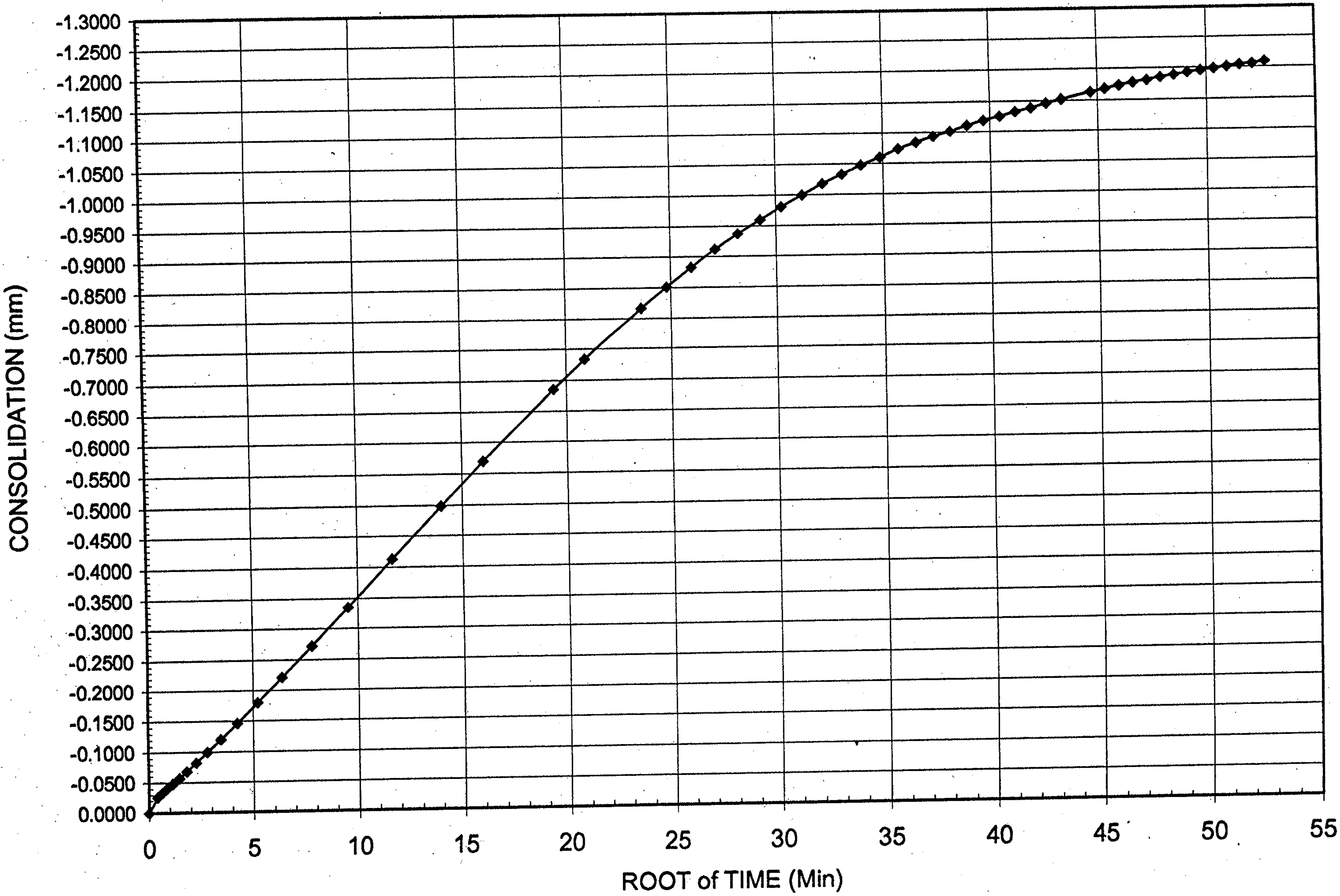
CONSOLIDATION PRESSURE = 44.6 kPa

FILE # - CONSOLIDATION #12

03 07 30

NAT. TEST. LAB AO23A01

S - 6 AH03 - 02 3.80 - 4.35 m



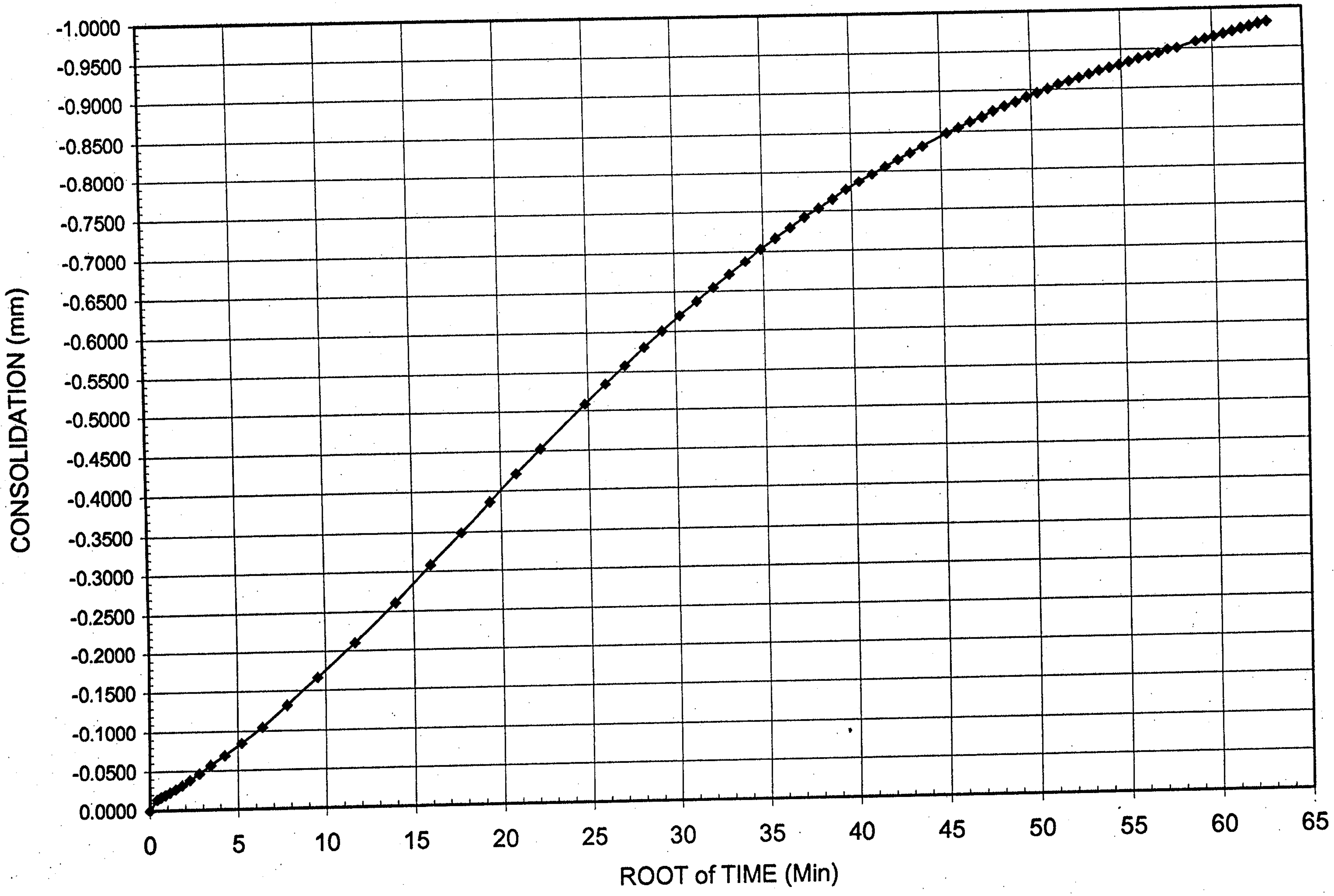
CONSOLIDATION PRESSURE = 44.6 kPa

FILE # - CONSOLIDATION #12

03 08 02

NAT. TEST. LAB AO23A01

S - 6 AH03 - 02 3.80 - 4.35 m

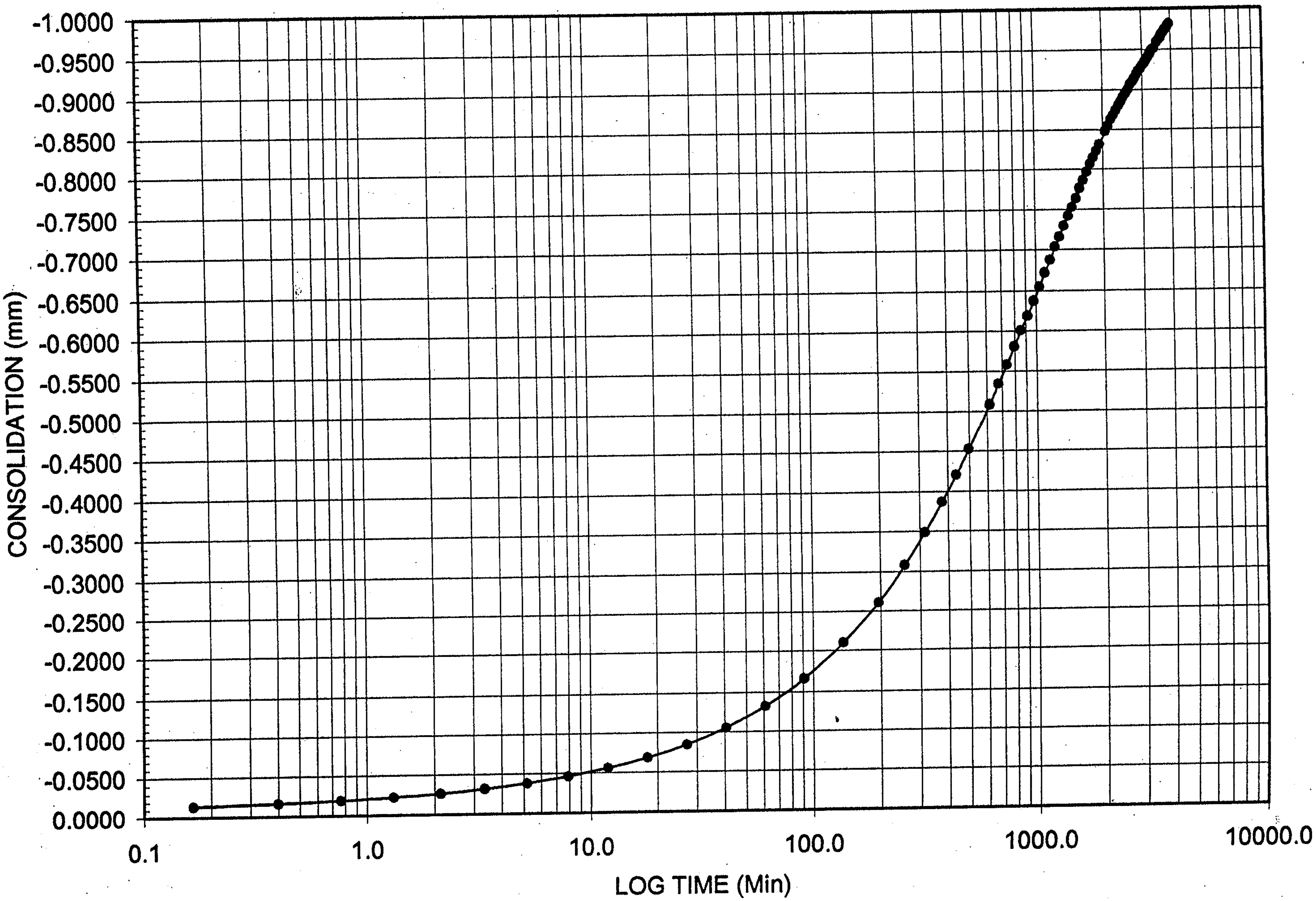


CONSOLIDATION PRESSURE = 11.1 kPa

03 08 02

NAT. TEST. LAB AO023A01

S - 6 AH03 - 02 3.80 - 4.35 m



CONSOLIDATION PRESSURE = 11.1 kPa

Manitoba Hydro

POWER PLANNING & OPERATIONS
GEOTECHNICAL ENGINEERING
MATERIALS TESTING LAB

NAT. TEST. LAB AO23A01

Sample No	Hole No	Depth
9	AH03 - 06	7.60 - 8.15 m

CONSOLIDATION

	INITIAL	FINAL
MOISTURE (%)	40.9	32.6
SATURATION (%)	97.3	98.5
VOID RATIO	1.161	0.914
WET DENSITY (kg/m3)	1800	1913
DRY DENSITY (kg/m3)	1277	1442

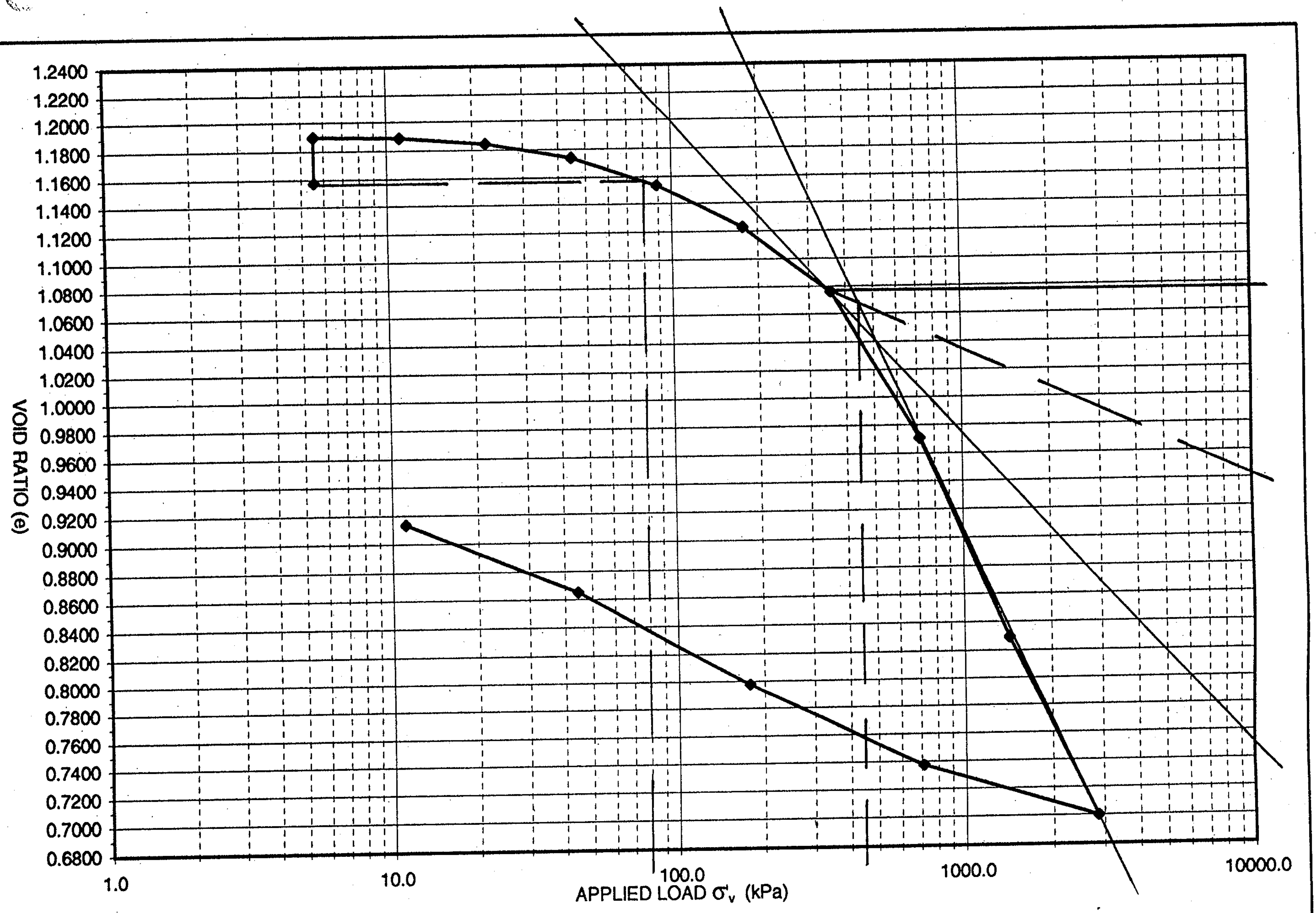
DATE: 03 07 04
BY: HM / JL
FILE: CONS9C
DIR: NAT.TEST.03

APPLIED PRESSURE σ'_v (kPa)	VOID RATIO e	C_v (cm^2/sec)	A_v (cm^2/g)	M_v (cm^2/g)	K (cm/s)
5.5	1.1578	Seating load			
5.5	1.1902	Inundation			
11.1	1.1892	1.18E-03	1.71E-05	7.80E-06	9.21E-09
22.3	1.1846	1.58E-03	4.09E-05	1.87E-05	2.94E-08
44.5	1.1741	1.48E-03	4.62E-05	2.12E-05	3.15E-08
89.1	1.1539	1.40E-03	4.45E-05	2.06E-05	2.89E-08
178.2	1.1231	1.75E-03	3.39E-05	1.60E-05	2.79E-08
356.7	1.0759	1.42E-03	2.59E-05	1.25E-05	1.77E-08
714.3	0.9711	5.22E-04	2.87E-05	1.46E-05	7.60E-09
1429.8	0.8298	3.33E-04	1.94E-05	1.06E-05	3.52E-09
2854.2	0.7001	1.87E-04	8.93E-06	5.25E-06	9.78E-10
714.3	0.7373	Rebound			
178.2	0.7976	Rebound			
44.5	0.8653	Rebound			
11.1	0.9137	Rebound			

Preconsolidation Pressure, P'c	430 kPa
Swelling Pressure	80.0 kPa
Compression Index, Cc	0.4540

C_v - Coefficient of Consolidation
A_v - Coefficient of Compressibility
M_v - Coefficient of Volume Compressibility
K - Coefficient of Permeability

DIR: NAT.TEST.03 FILE: CONS9C



Preconsolidation Pressure, P'c = 430 kPa   Swelling Pressure = 80 kPa   Compression Index Cc = 0.454

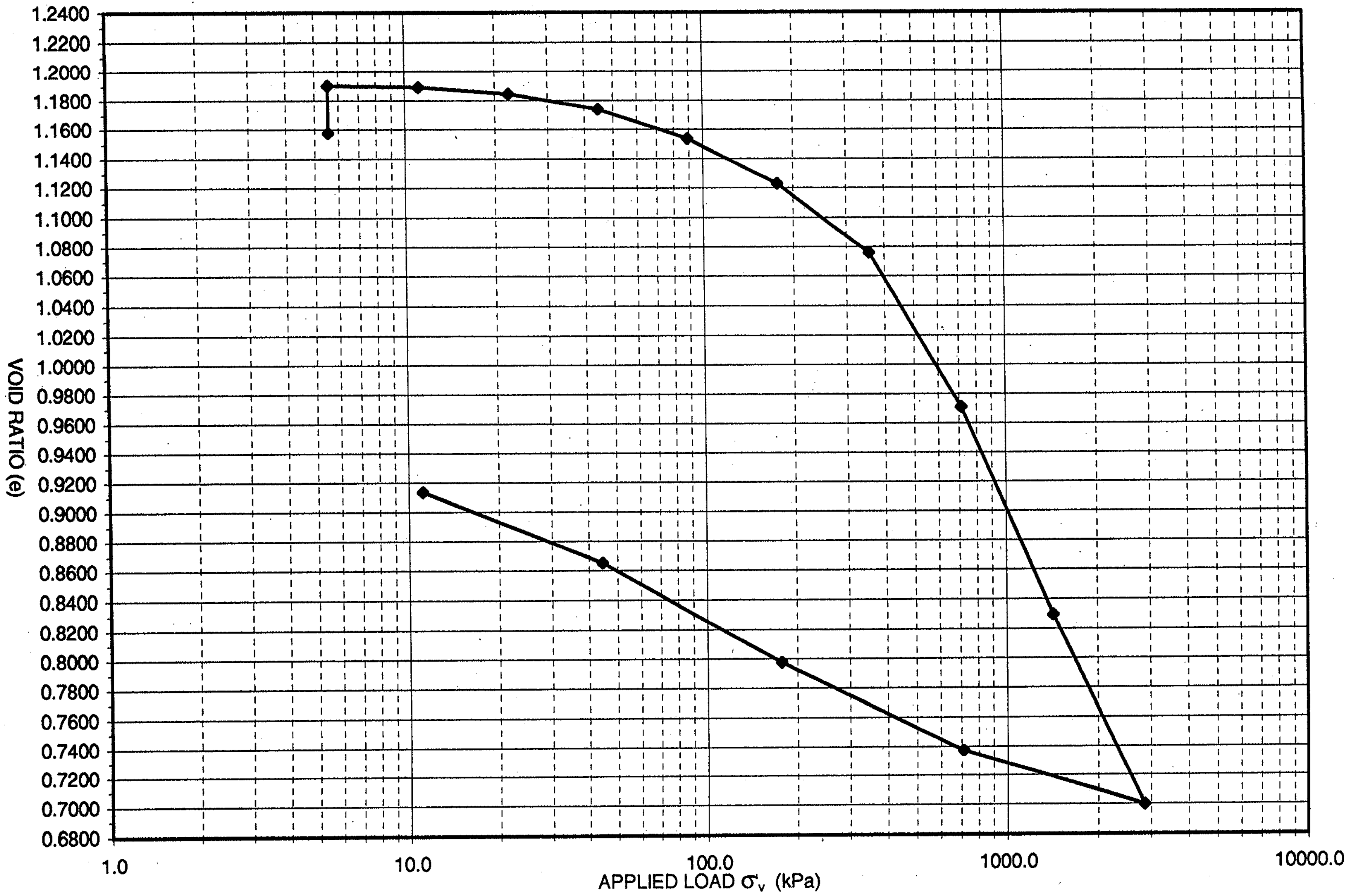
Manitoba Hydro

POWER PLANNING & OPERATIONS
GEOTECHNICAL ENGINEERING
MATERIALS TESTING LAB

NAT. TEST. LAB   AO23A01

Sample No	Hole No	Depth
9	AH03 - 06	7.60 - 8.15 m

CONSOLIDATION
03 07 04 BY: HM / JL
FILE: CONS9C DIR:NAT.TEST.03



Preconsolidation Pressure, P'c = 430 kPa   Swelling Pressure = 80 kPa   Compression Index Cc = 0.454

Manitoba Hydro

POWER PLANNING & OPERATIONS
GEOTECHNICAL ENGINEERING
MATERIALS TESTING LAB

NAT. TEST. LAB AO23A01

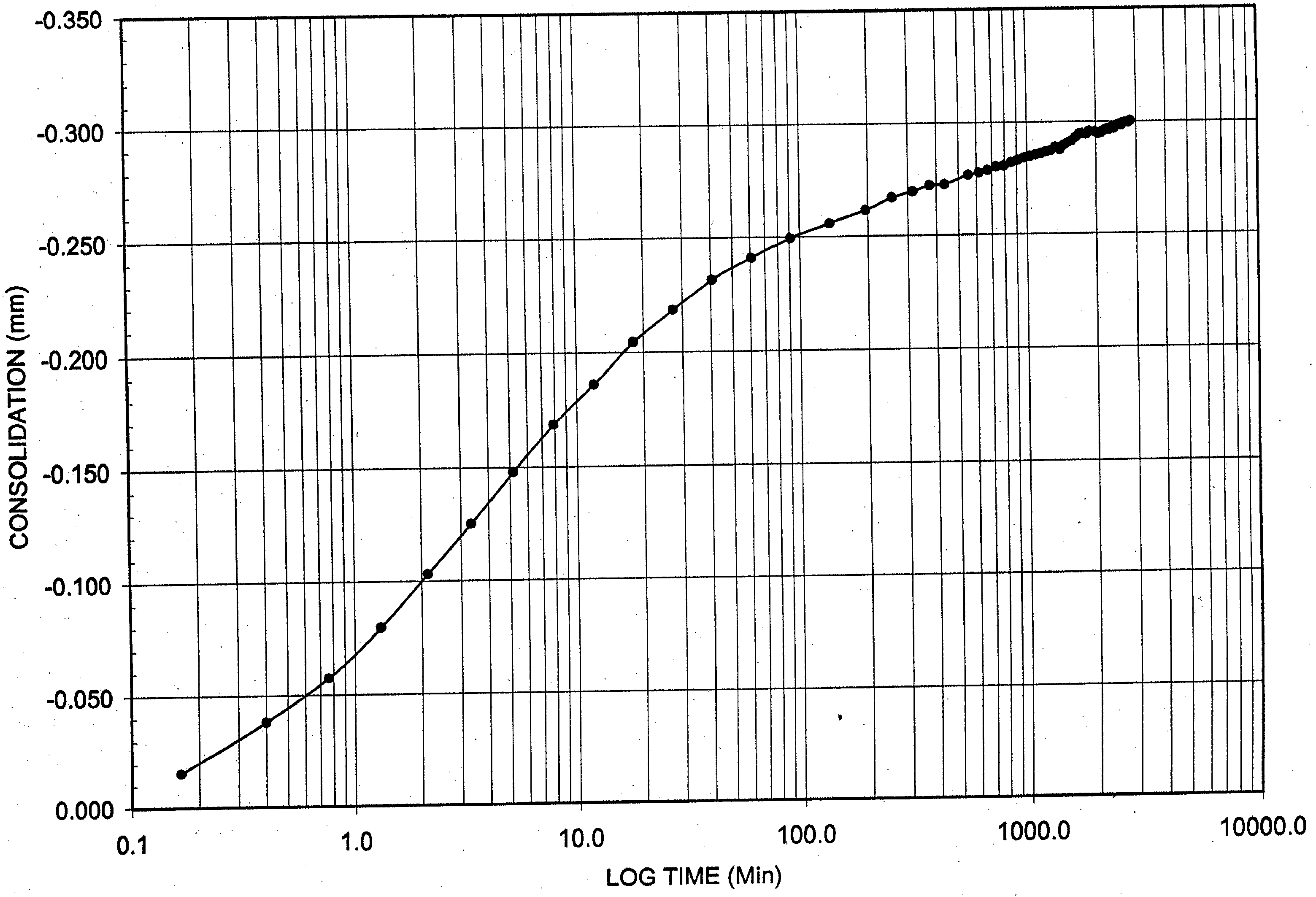
Sample No	Hole No	Depth
9	AH03 - 06	7.60 - 8.15 m

CONSOLIDATION
03 07 04 BY: HM / JL
FILE: CONS9C DIR:NAT.TEST.03

03 07 06

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.60 - 8.15 m

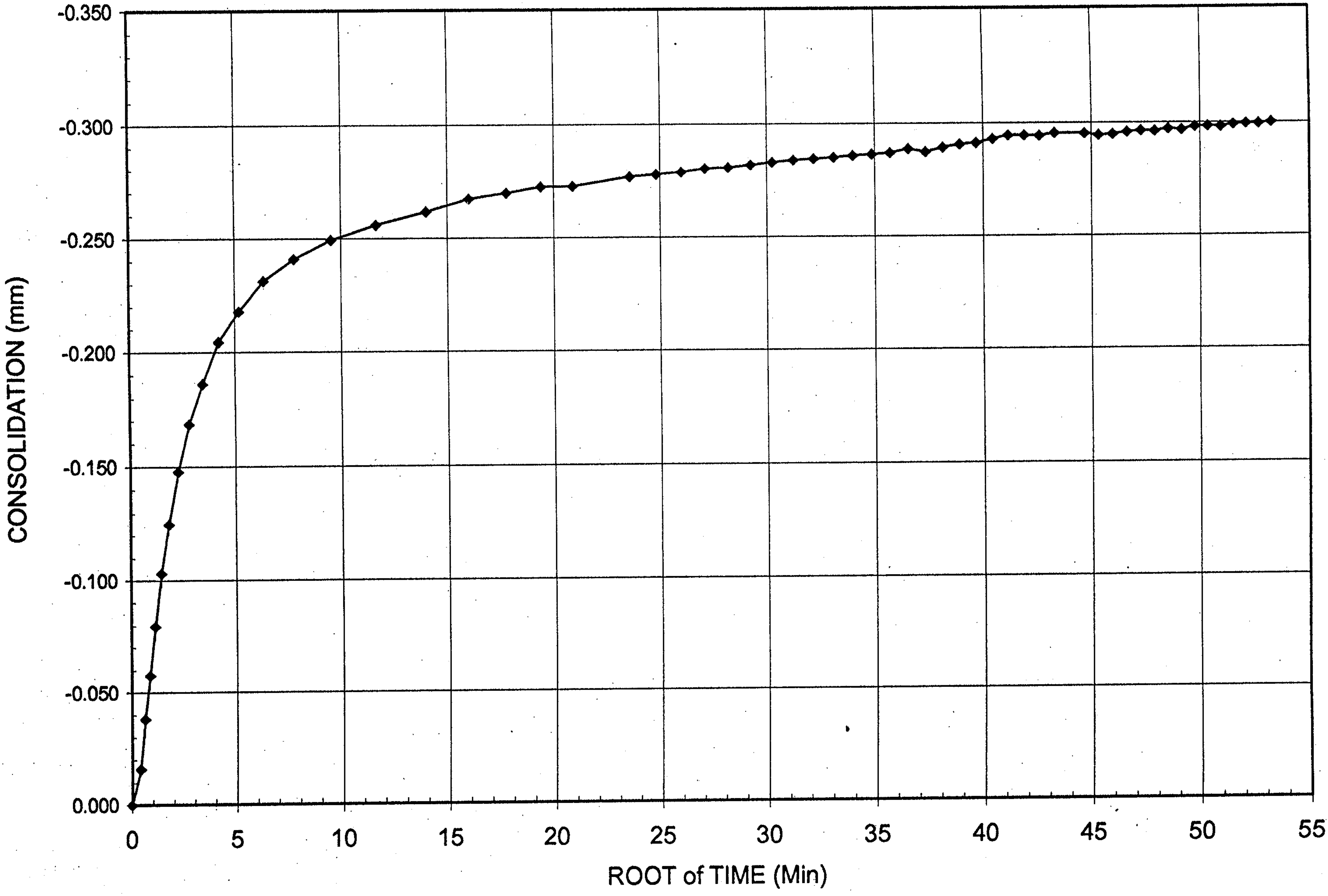


CONSOLIDATION PRESSURE = 5.5 kPa

SWELLING # 1

FILE # SWELLING

03 07 06 NAT. TEST LAB AO023A01 S - 9 AH03 - 06 7.60 - 8.15 m

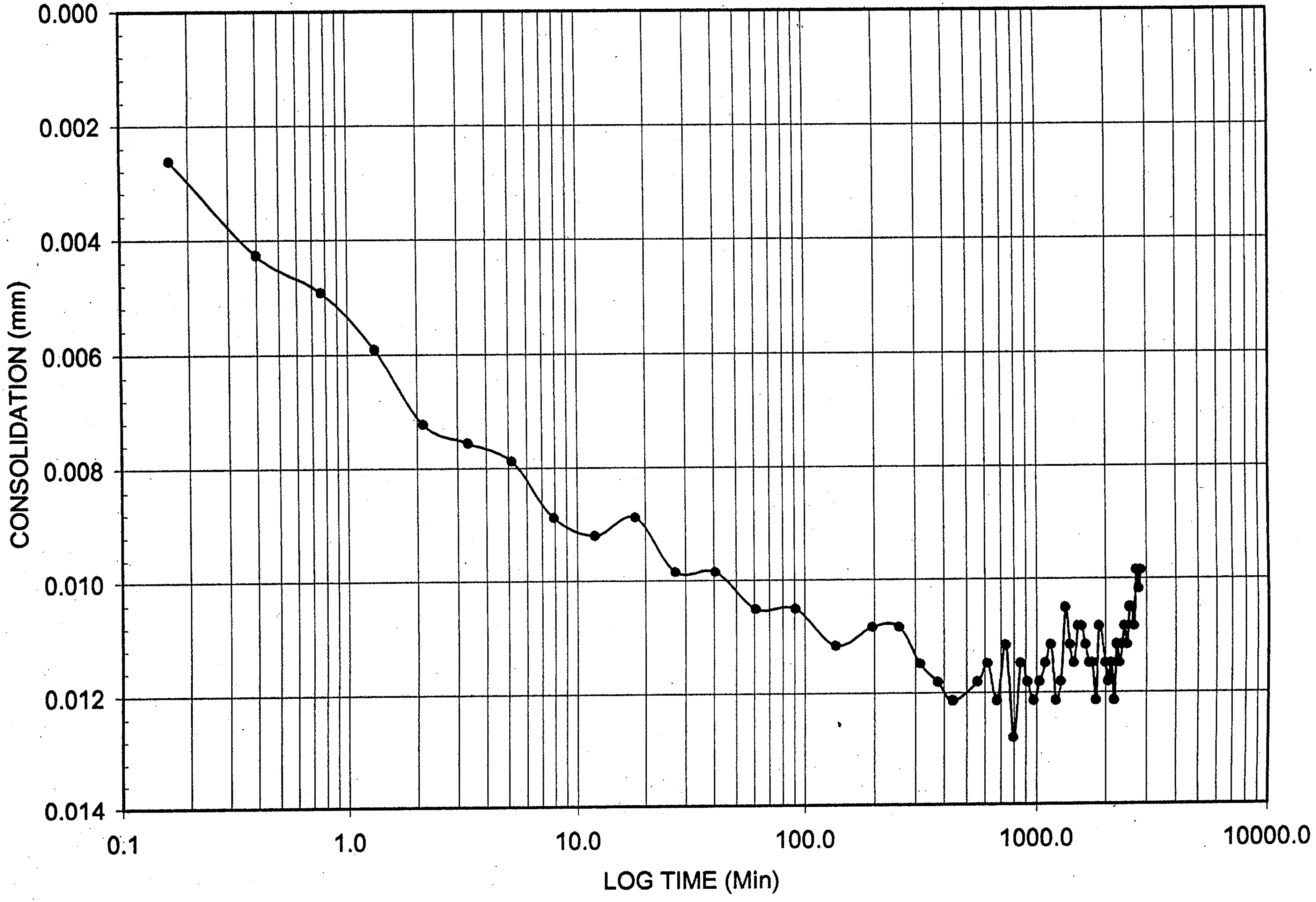


CONSOLIDATION PRESSURE = 5.5 kPa

03 07 08

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.60 - 8.15 m



LOAD # 2

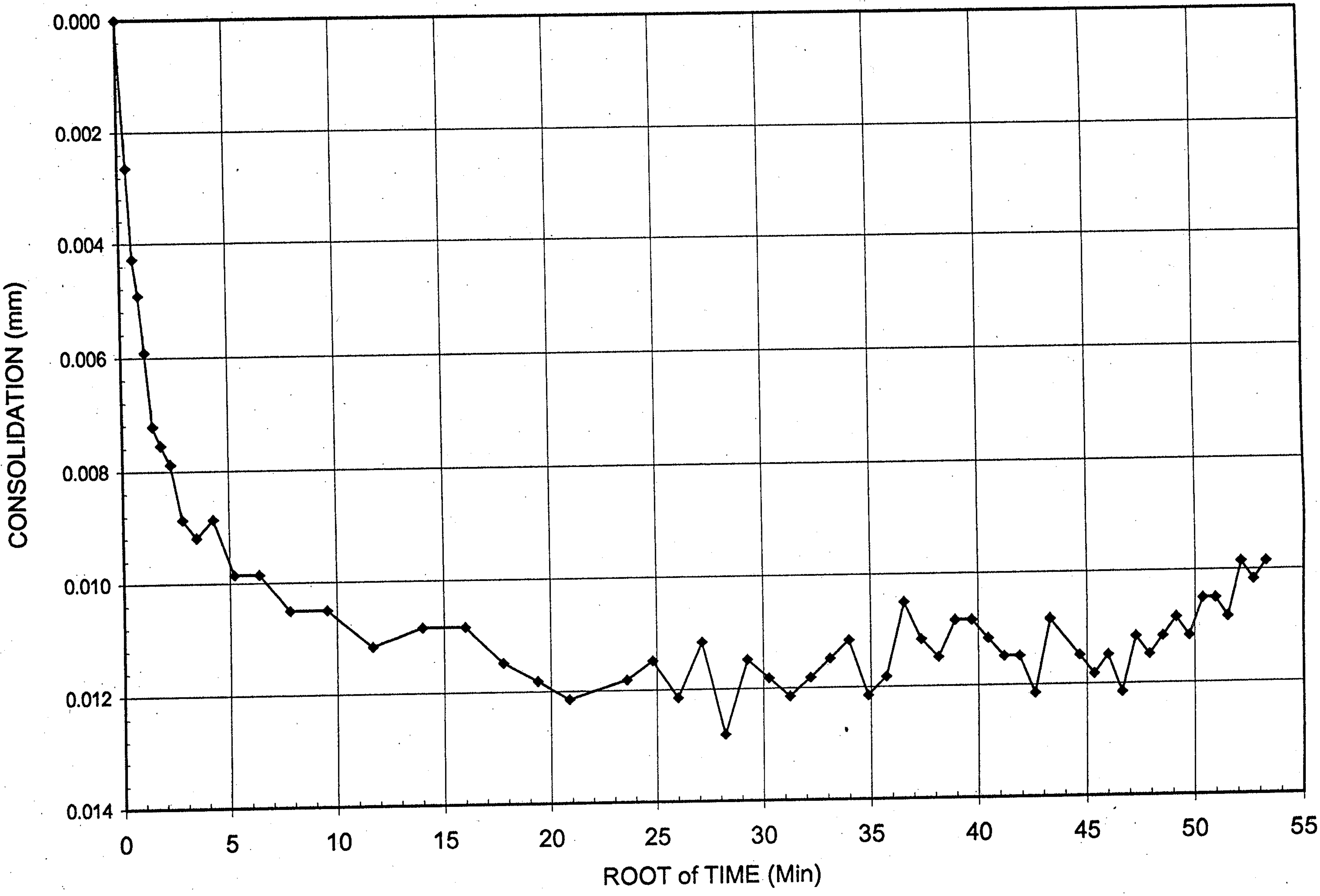
CONSOLIDATION PRESSURE = 11.1 kPa

FILE # - CONSOLIDATION #1

03 07 08

NAT. TEST LAB AO023A01

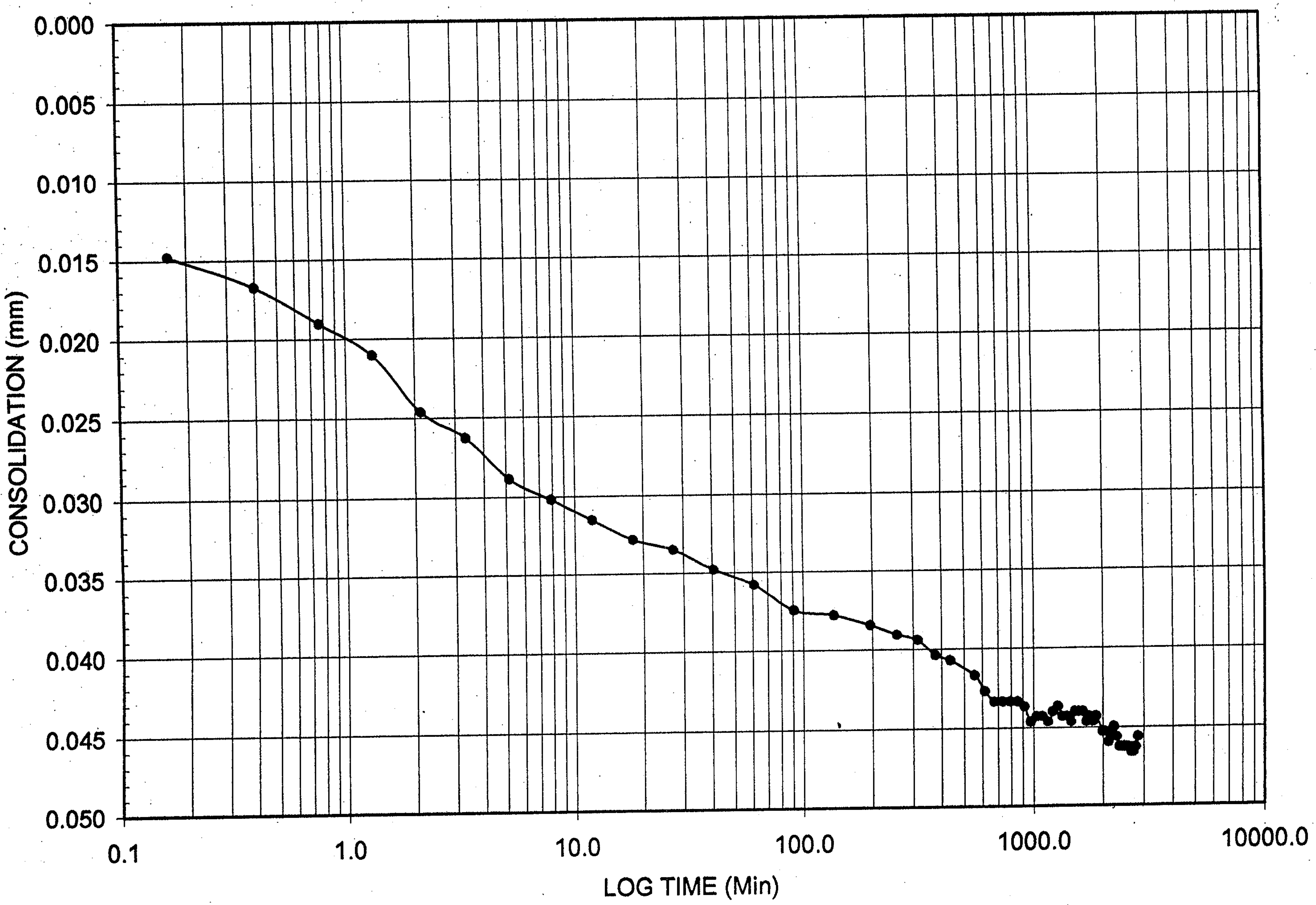
S - 9 AH03 - 06 7.60 - 8.15 m



CONSOLIDATION PRESSURE = 11.1 kPa

FILE # - CONSOLIDATION #1

03 07 10 NAT. TEST LAB AO023A01 S - 9 AH03 - 06 7.[illegible] - 8.15 m

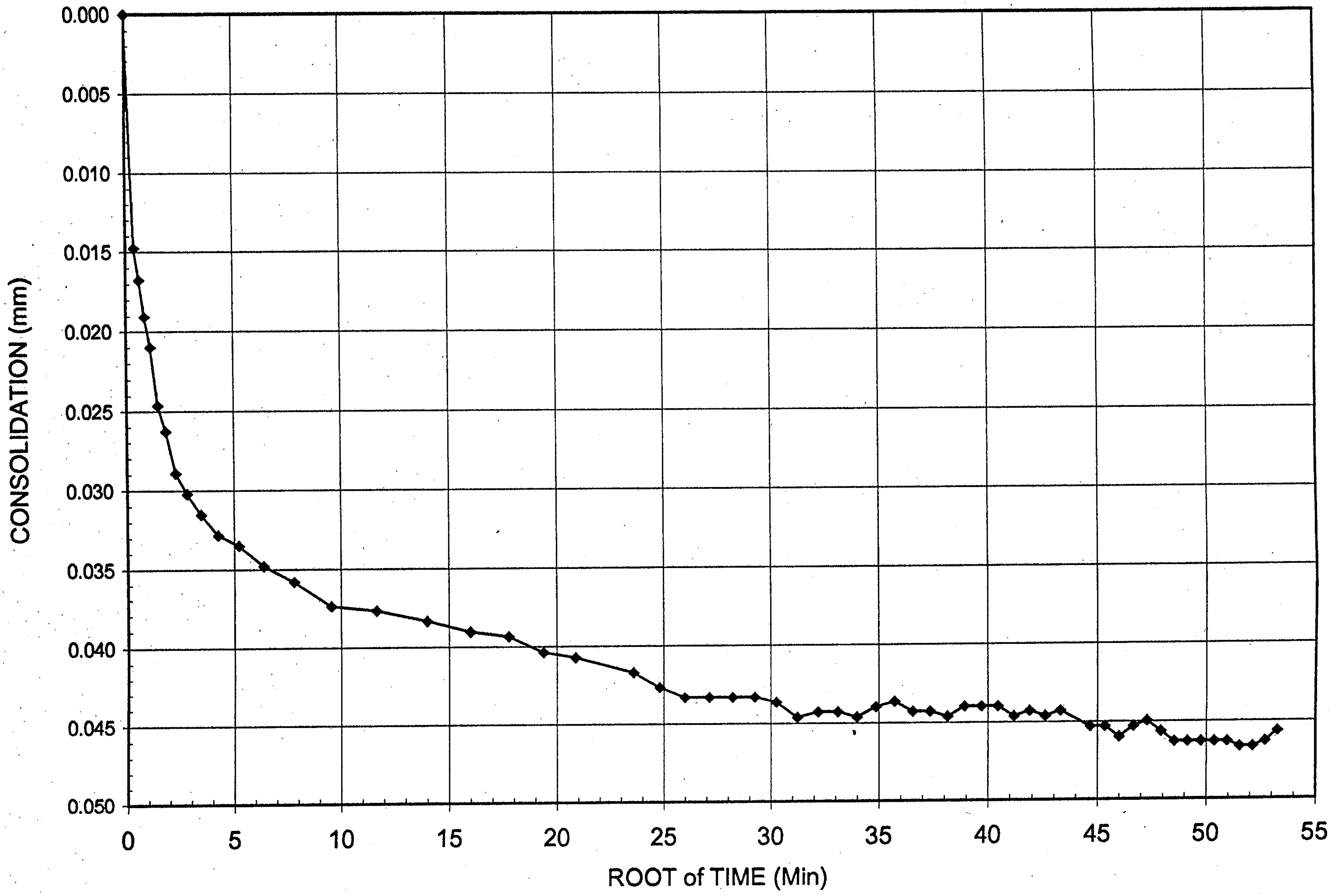


CONSOLIDATION PRESSURE = 22.3 kPa

LOAD # 3

FILE # CONSOLIDATION #

03 07 10 NAT. TEST LAB AO023A01 S - 9 AH03 - 06 7.60 - 8.15 m



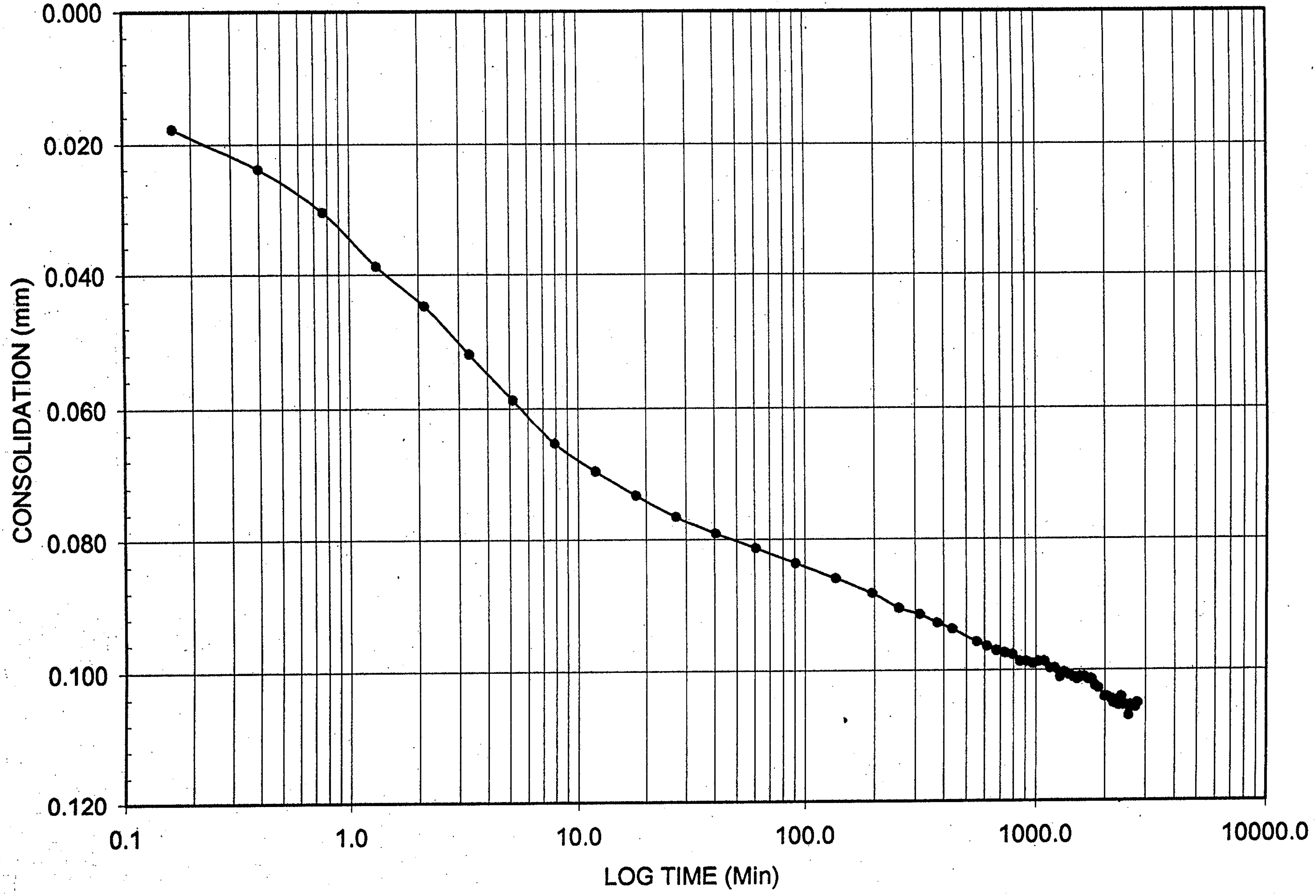
CONSOLIDATION PRESSURE = 22.3 kPa

LOAD #2 FILE # CONSOLIDATION #2

03 07 12

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.60 - 8.15 m

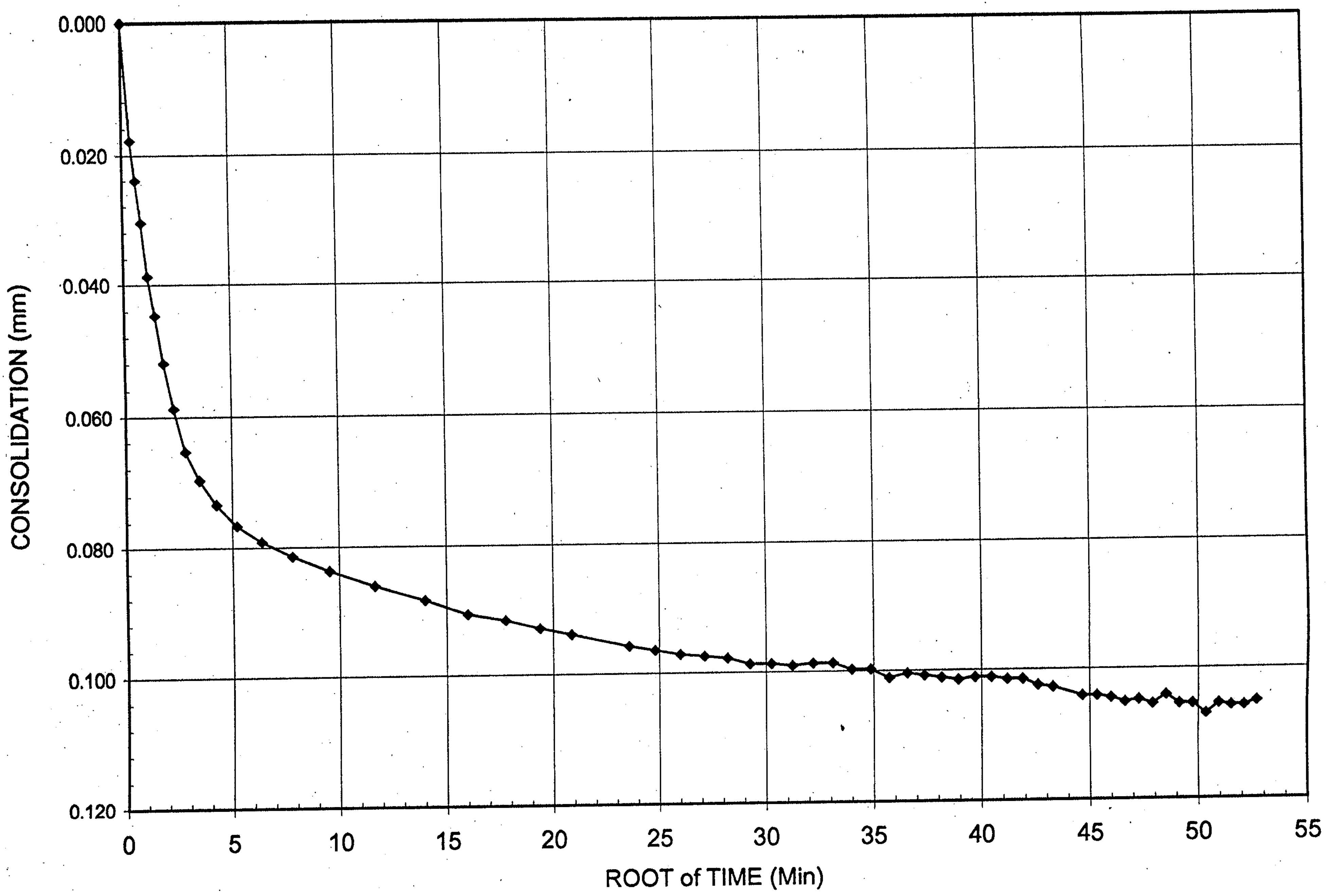


LOAD # 4

CONSOLIDATION PRESSURE = 44.5 kPa

FILE # - CONSOLIDATION #3

03 07 12 NAT. TEST LAB AO023A01 S - 9 AH03 - 06 7.60 - 8.15 m

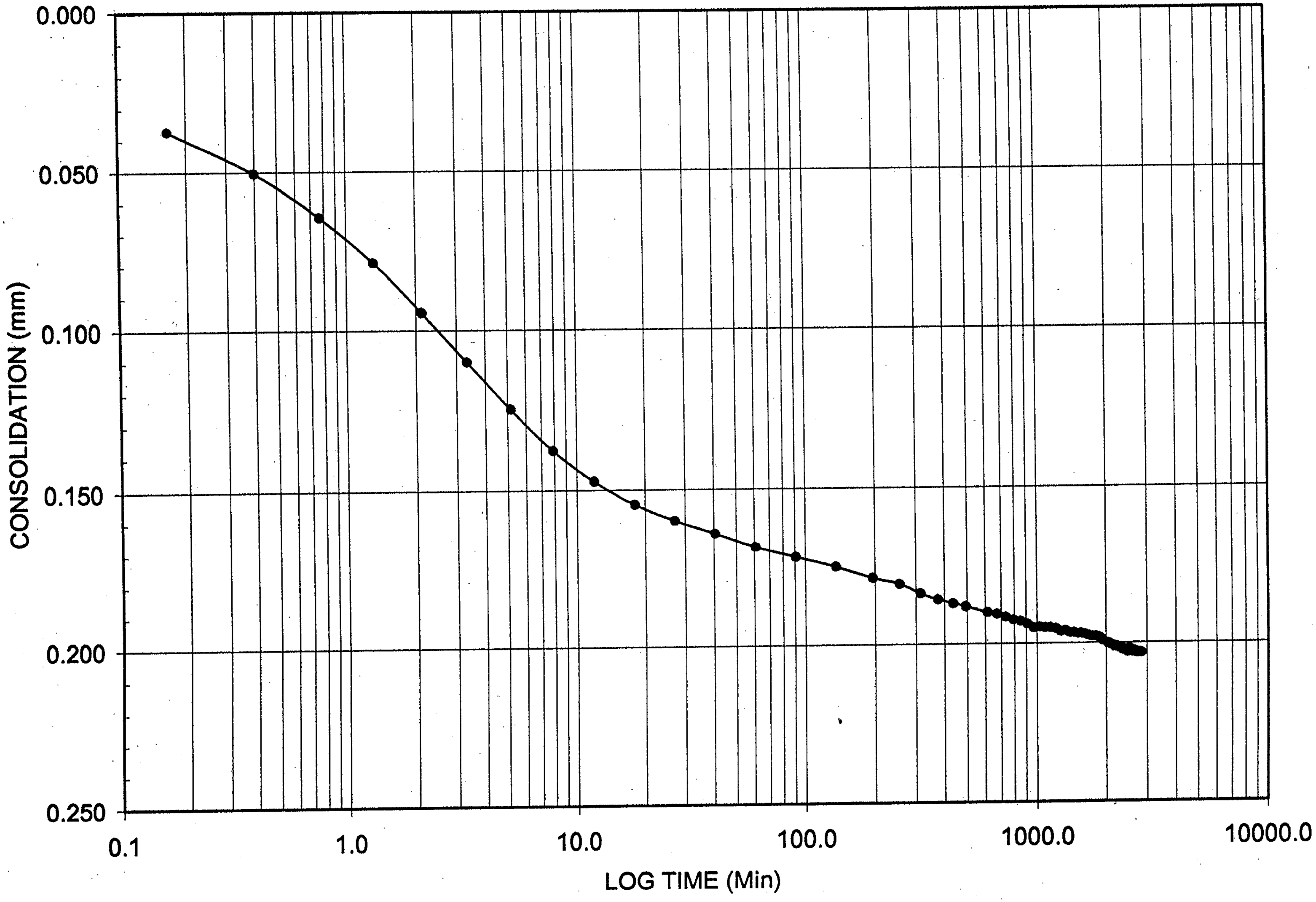


CONSOLIDATION PRESSURE = 44.5 kPa

03 07 14

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.60 - 8.15 m



CONSOLIDATION PRESSURE = 89.1 kPa

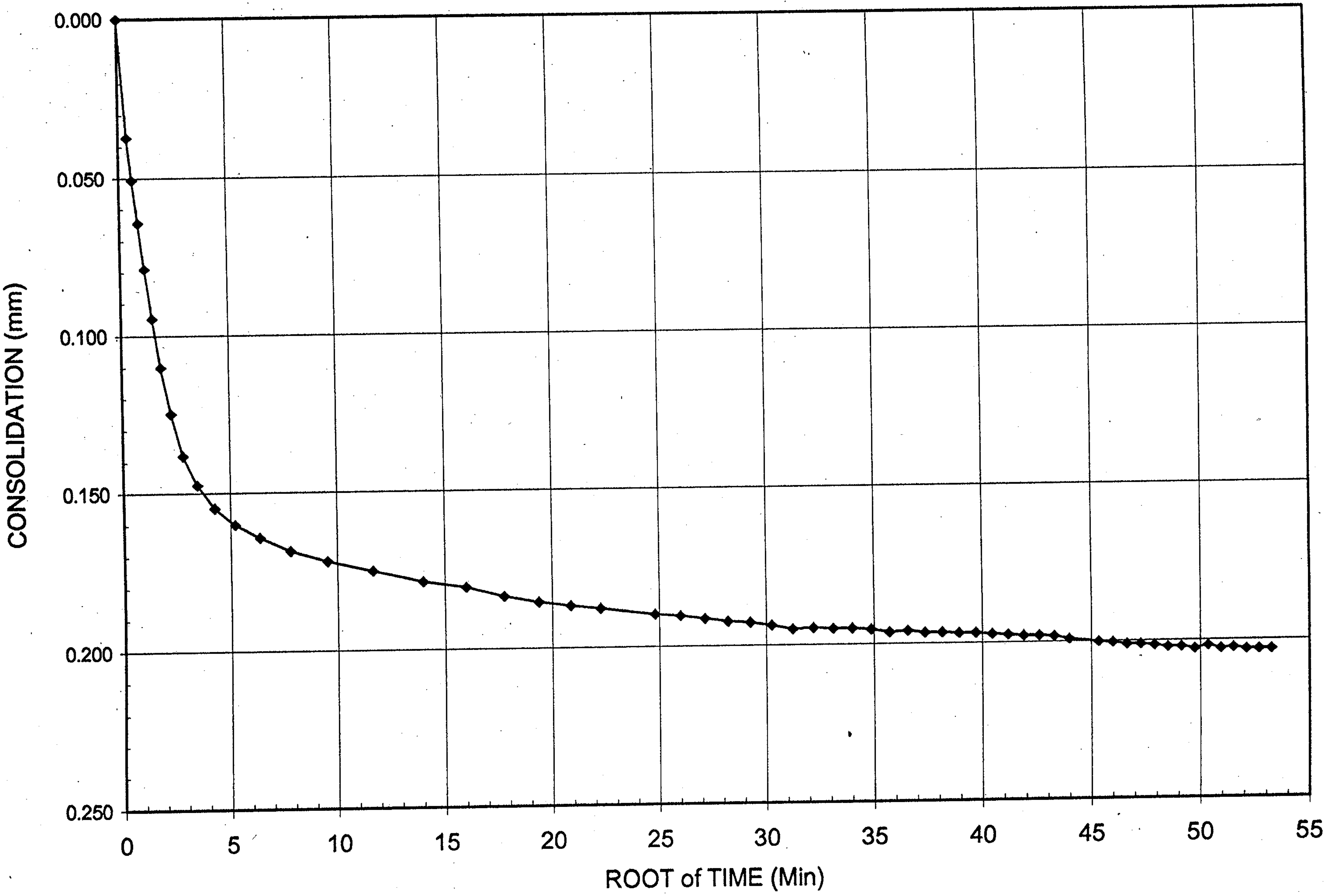
LOAD # 5

FILE # .. CONSOLIDATION #4

03 07 14

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.60 - 8.15 m



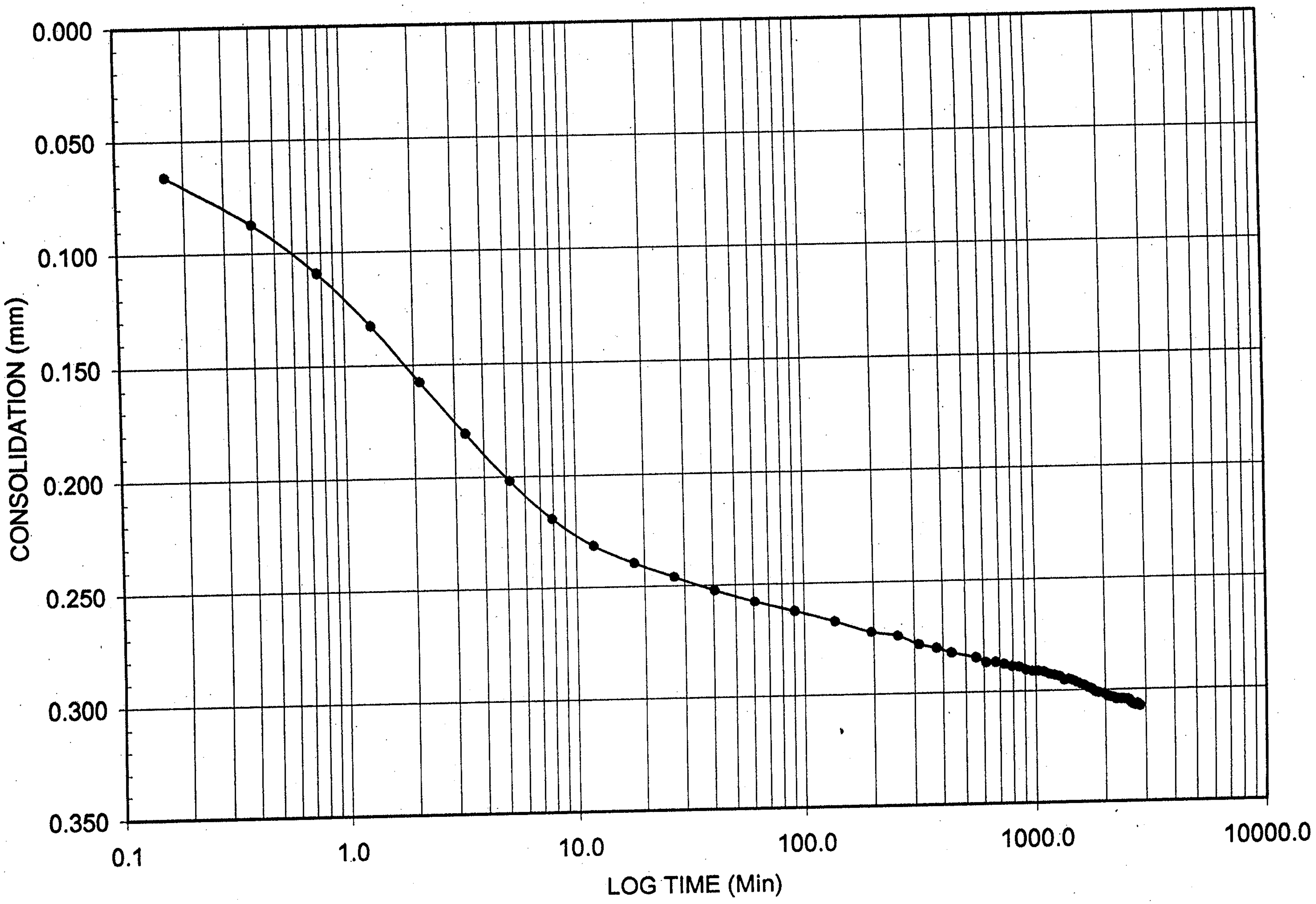
CONSOLIDATION PRESSURE = 89.1 kPa

FILE # - CONSOLIDATION #4

03 07 16

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 [illegible] - 8.15 m



CONSOLIDATION PRESSURE = 178.2 kPa

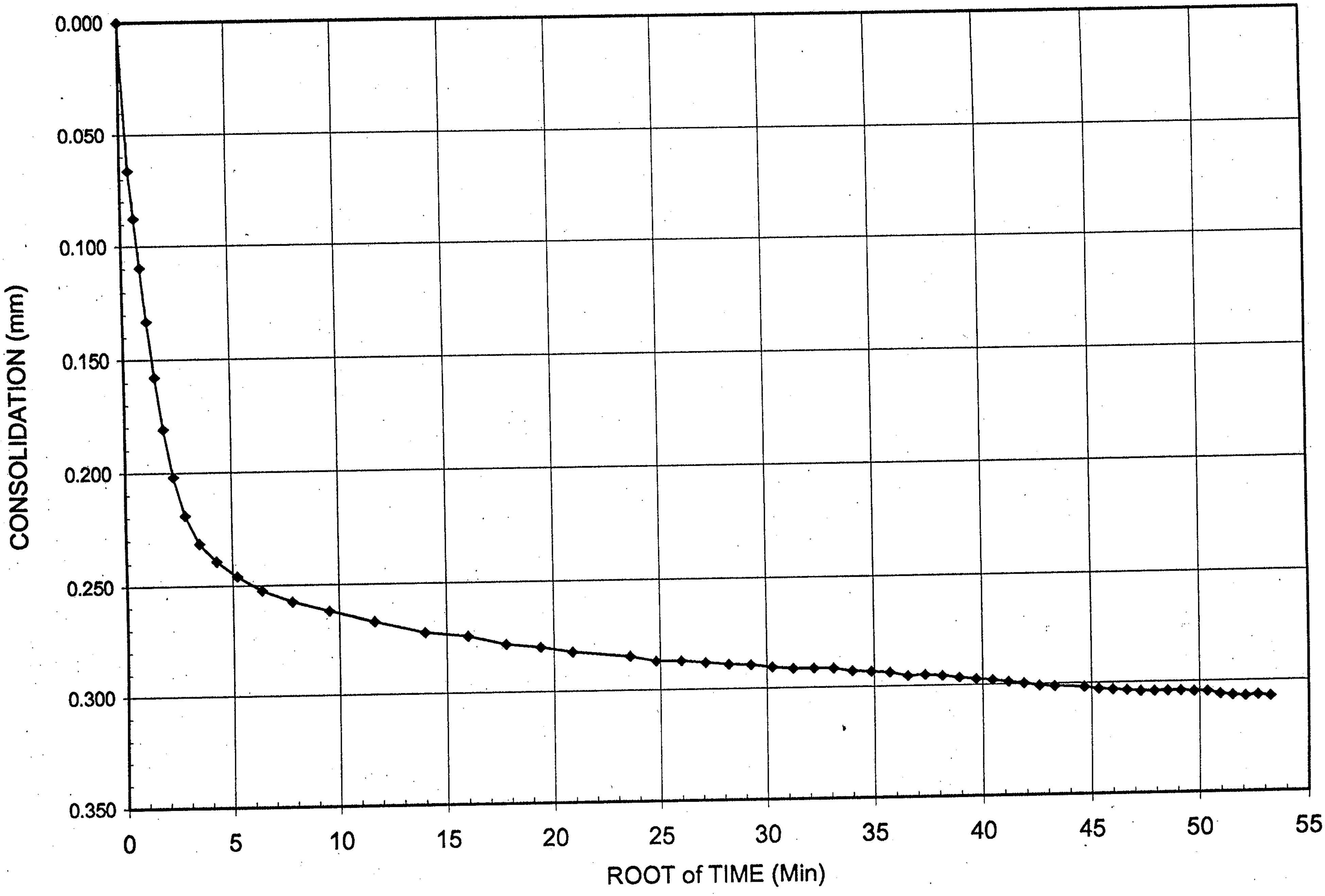
LOAD # 6

FILE # - CONSOLIDATION #5

03 07 16

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.60 - 8.15 m



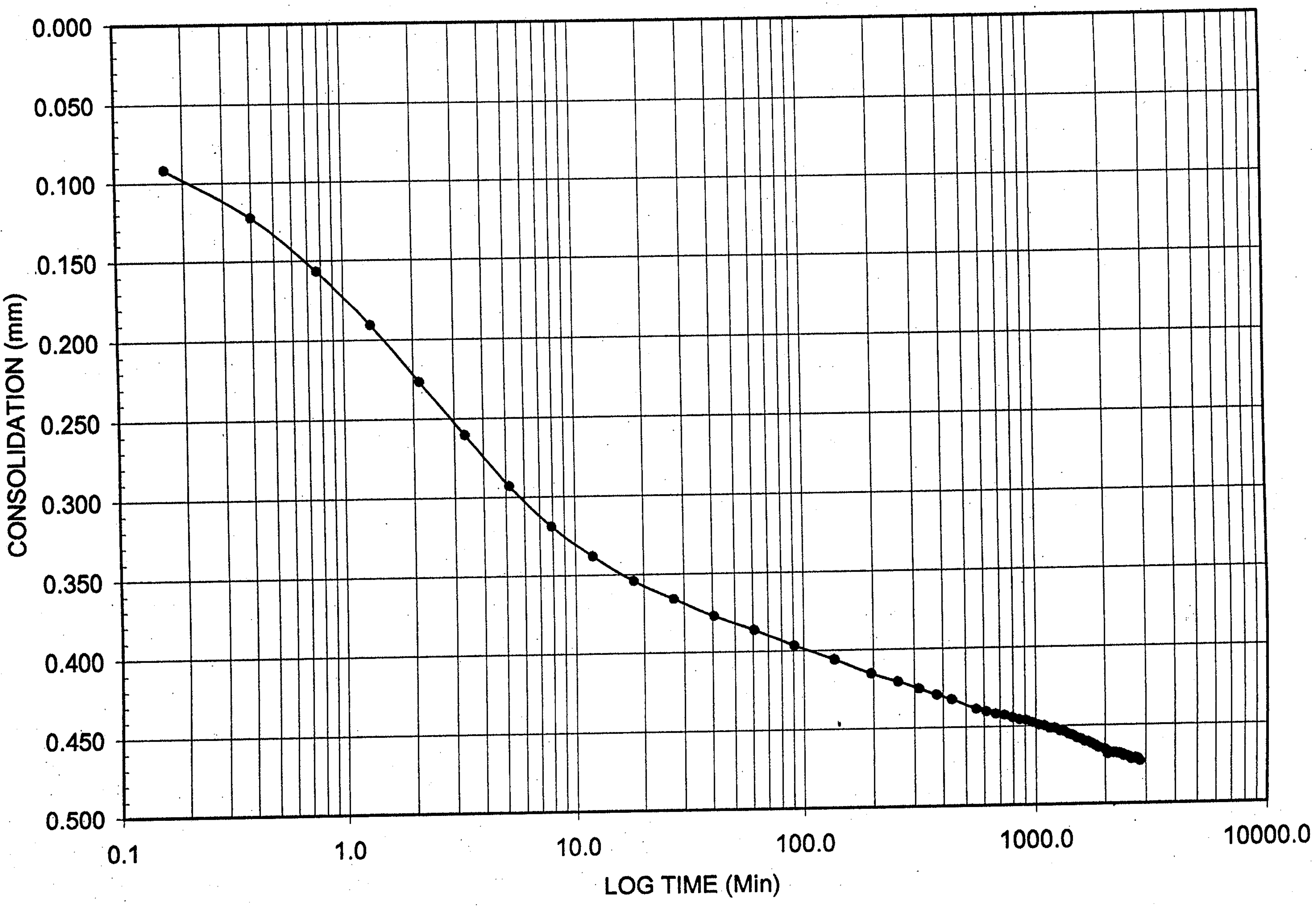
CONSOLIDATION PRESSURE = 178.2 kPa

FILE # - CONSOLIDATION #5

03 07 18

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7. - 8.15 m



CONSOLIDATION PRESSURE = 356.7 kPa

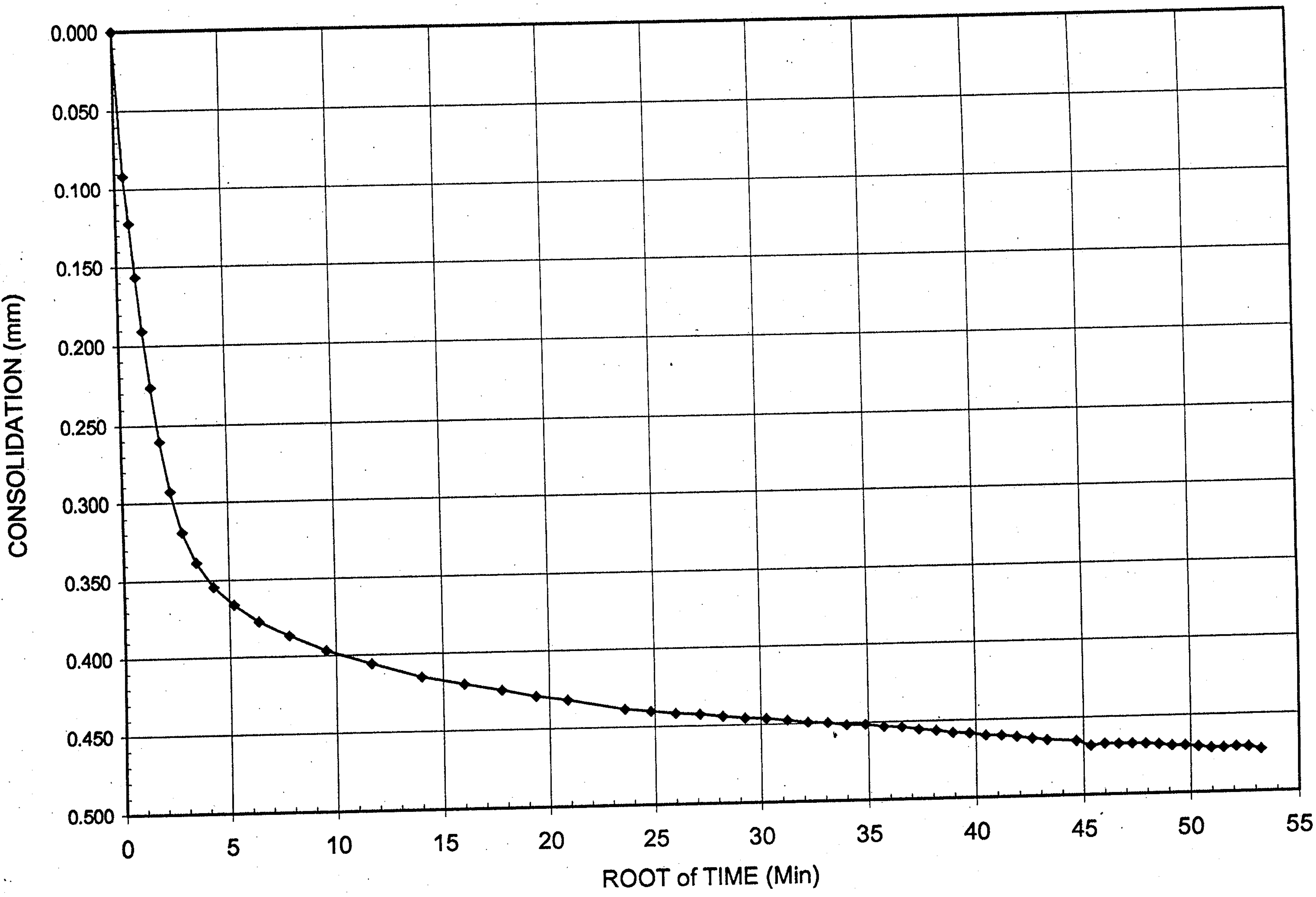
LOAD # 7

FILE # - CONSOLIDATION #6

03 07 18

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.60 - 8.15 m



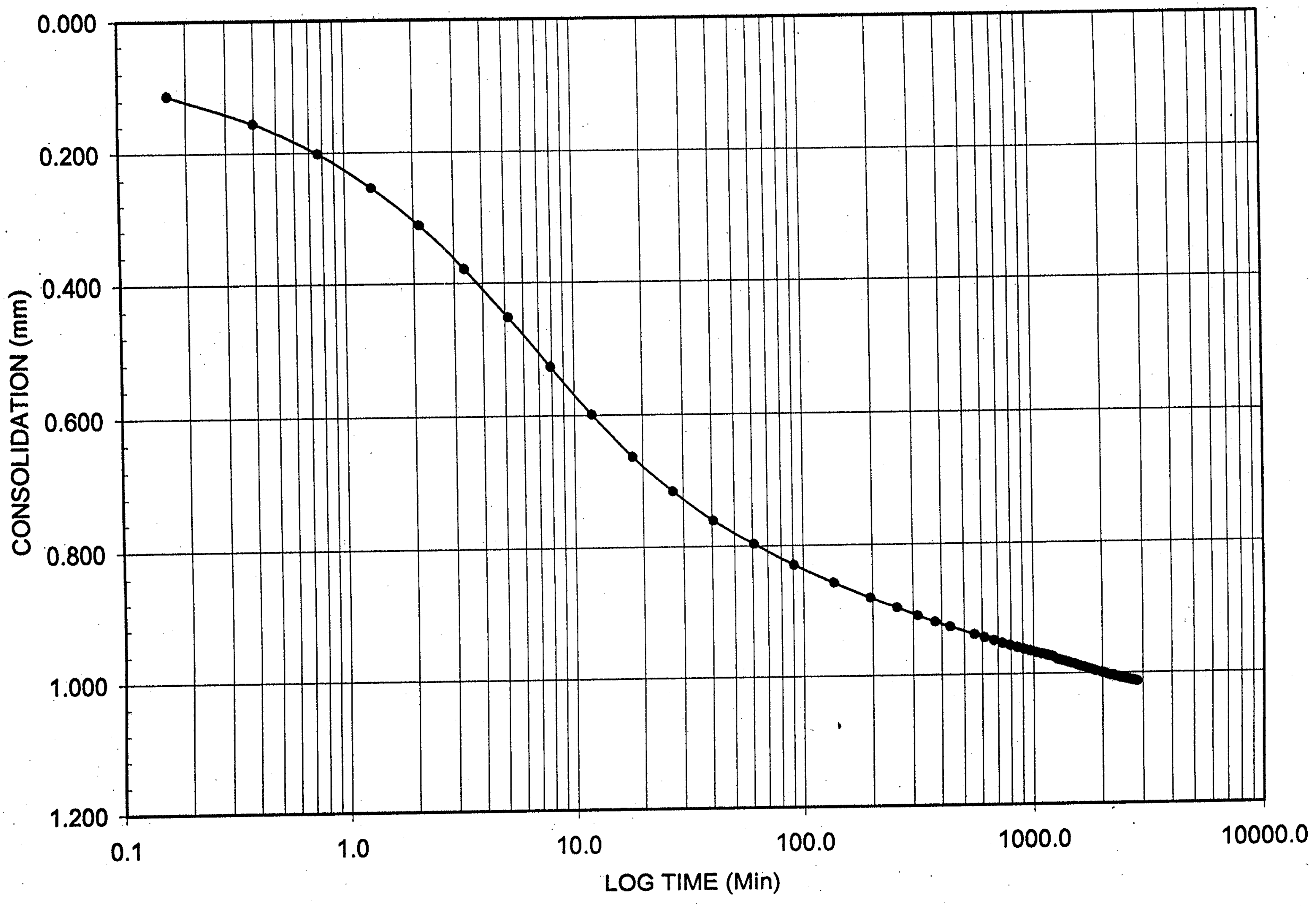
CONSOLIDATION PRESSURE = 356.7 kPa

FILE # - CONSOLIDATION #6

03 07 20

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.00 - 8.15 m



CONSOLIDATION PRESSURE = 714.3 kPa

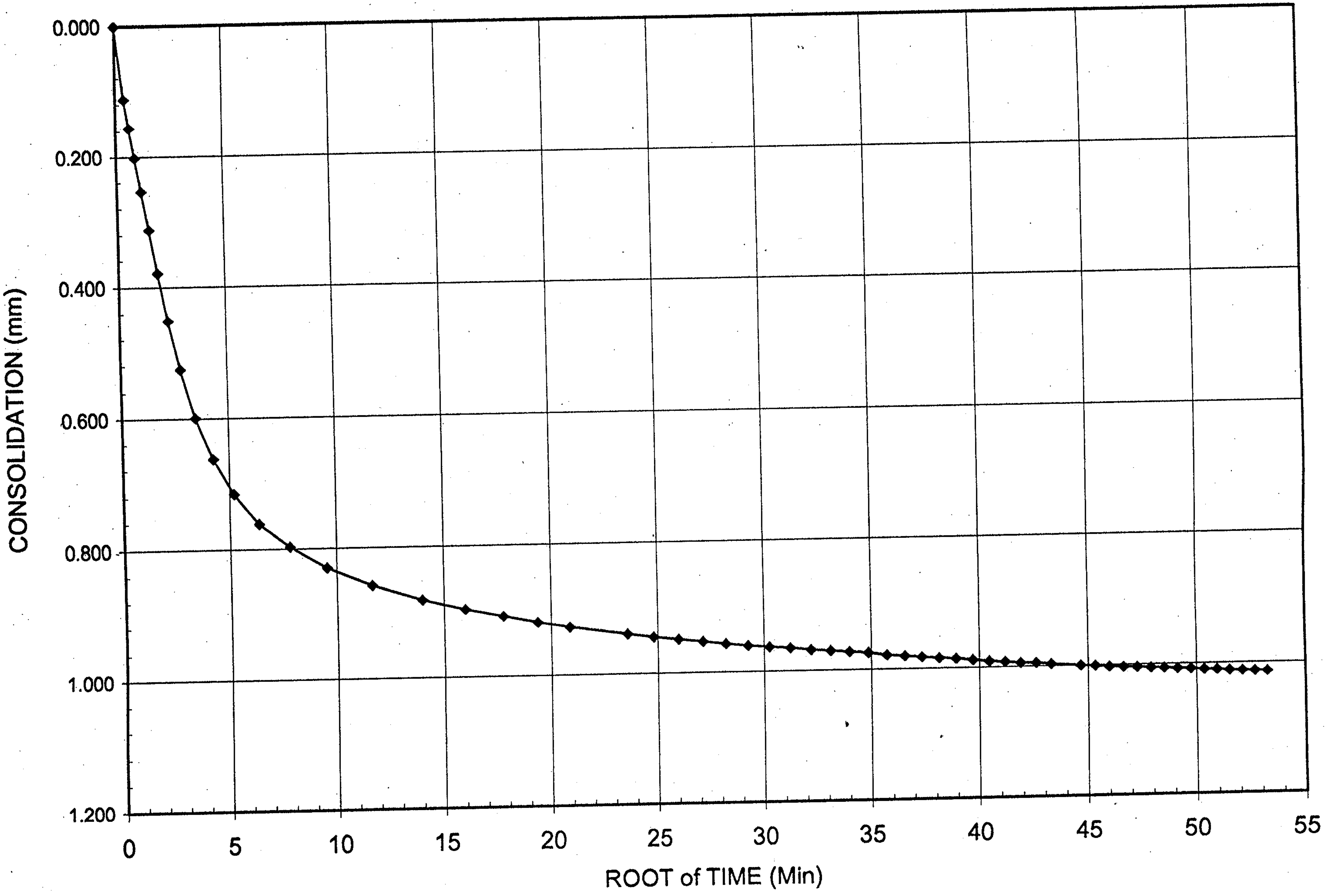
LOAD # 8

FILE # - CONSOLIDATION #7

03 07 20

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.60 - 8.15 m

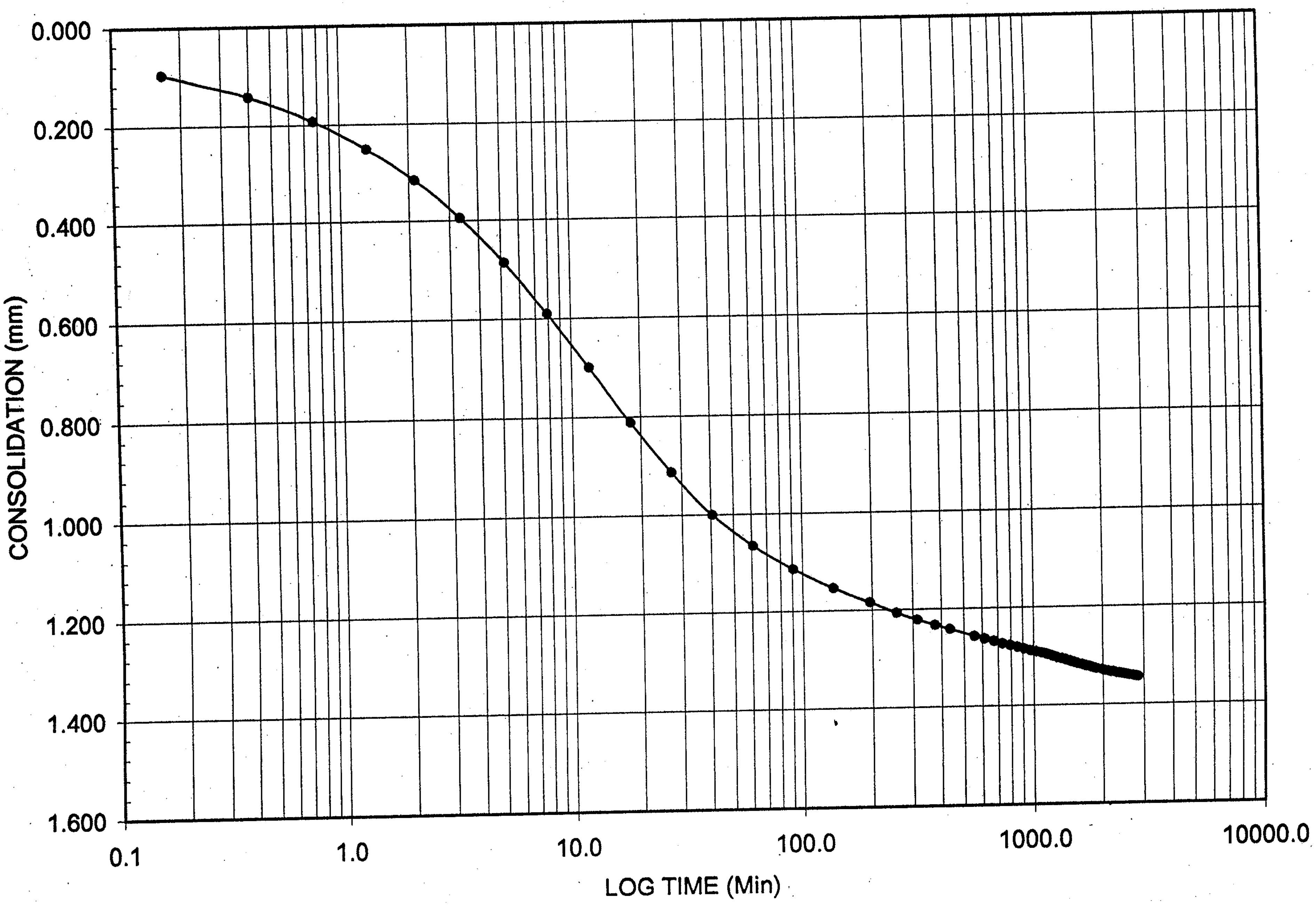


CONSOLIDATION PRESSURE = 714.3 kPa

03 07 22

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.60 - 8.15 m



CONSOLIDATION PRESSURE = 1429.8 kPa

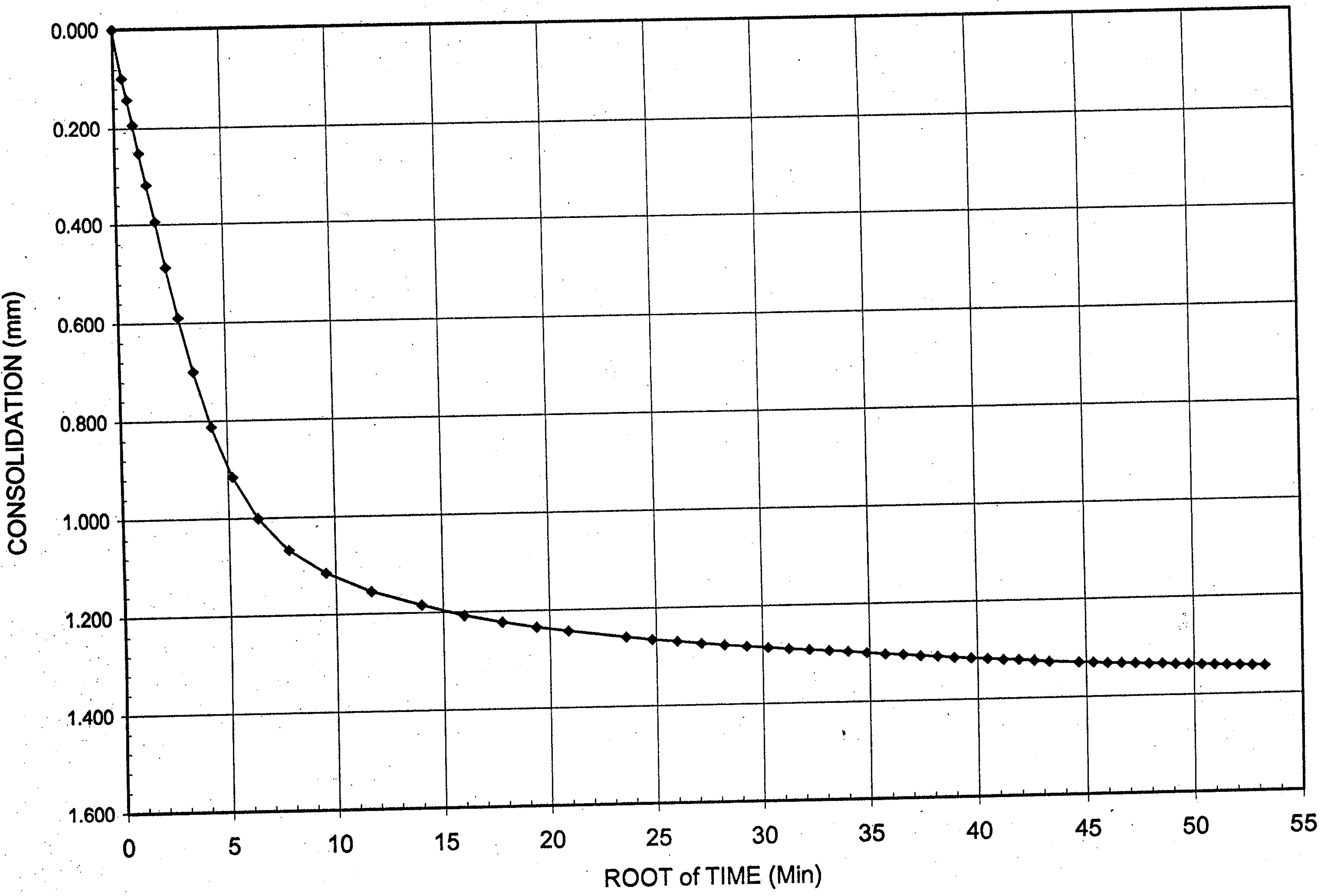
LOAD # 9

FILE # - CONSOLIDATION #8

03 07 22

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.60 - 8.15 m



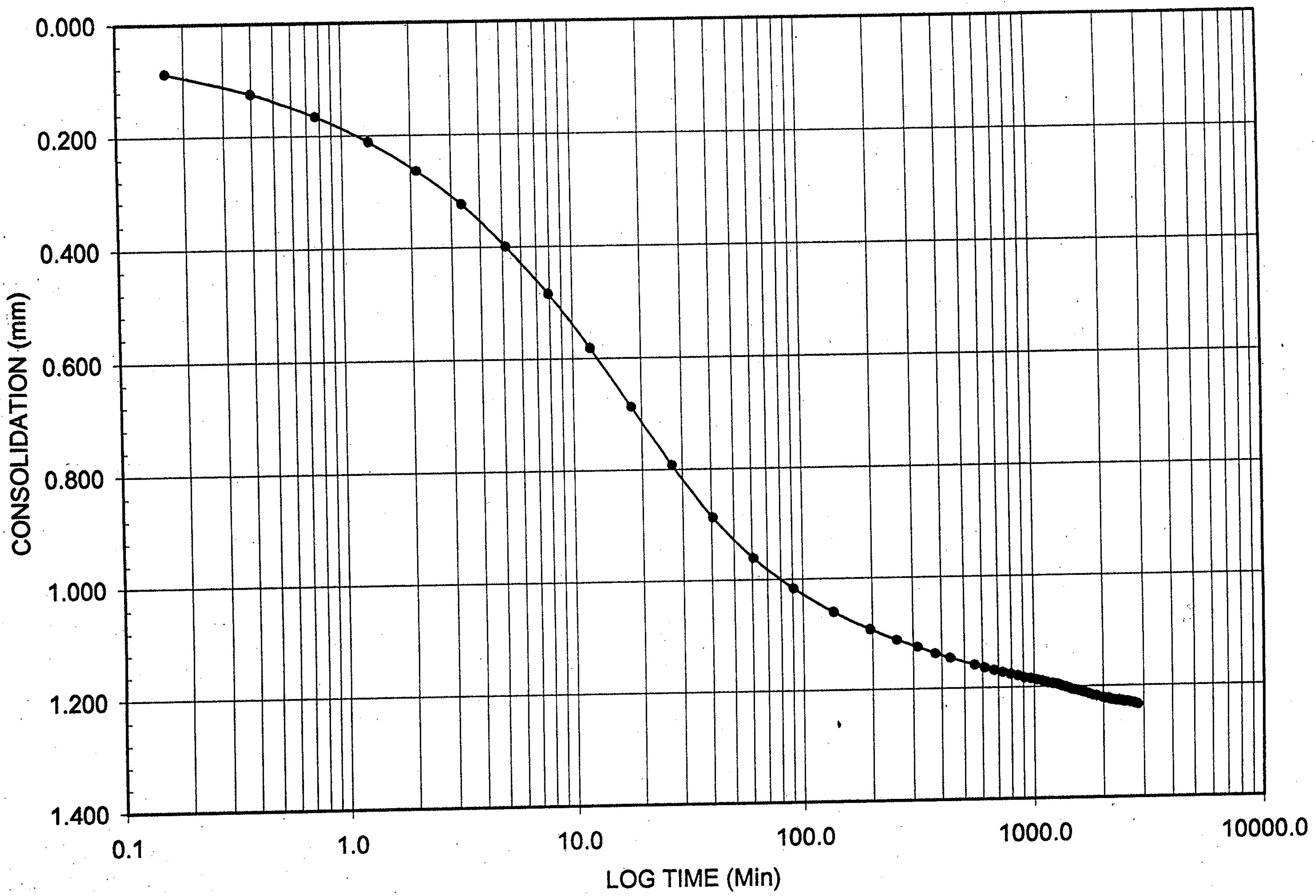
CONSOLIDATION PRESSURE = 1429.8 kPa

FILE # - CONSOLIDATION #8

03 07 24

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.[illegible] - 8.15 m



CONSOLIDATION PRESSURE = 2854.2 kPa

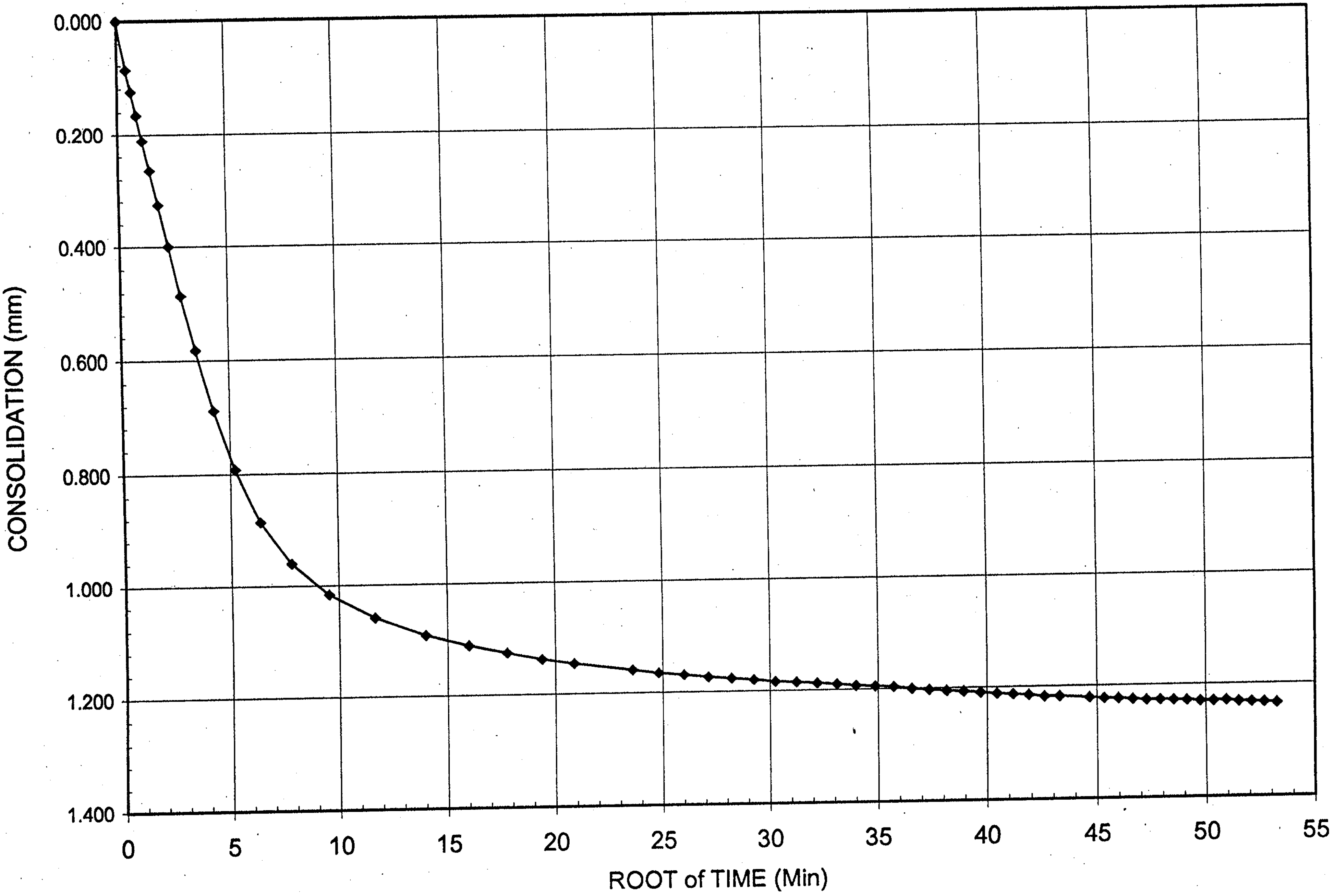
LOAD # 10

FILE # - CONSOLIDATION #9

03 07 24

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.60 - 8.15 m



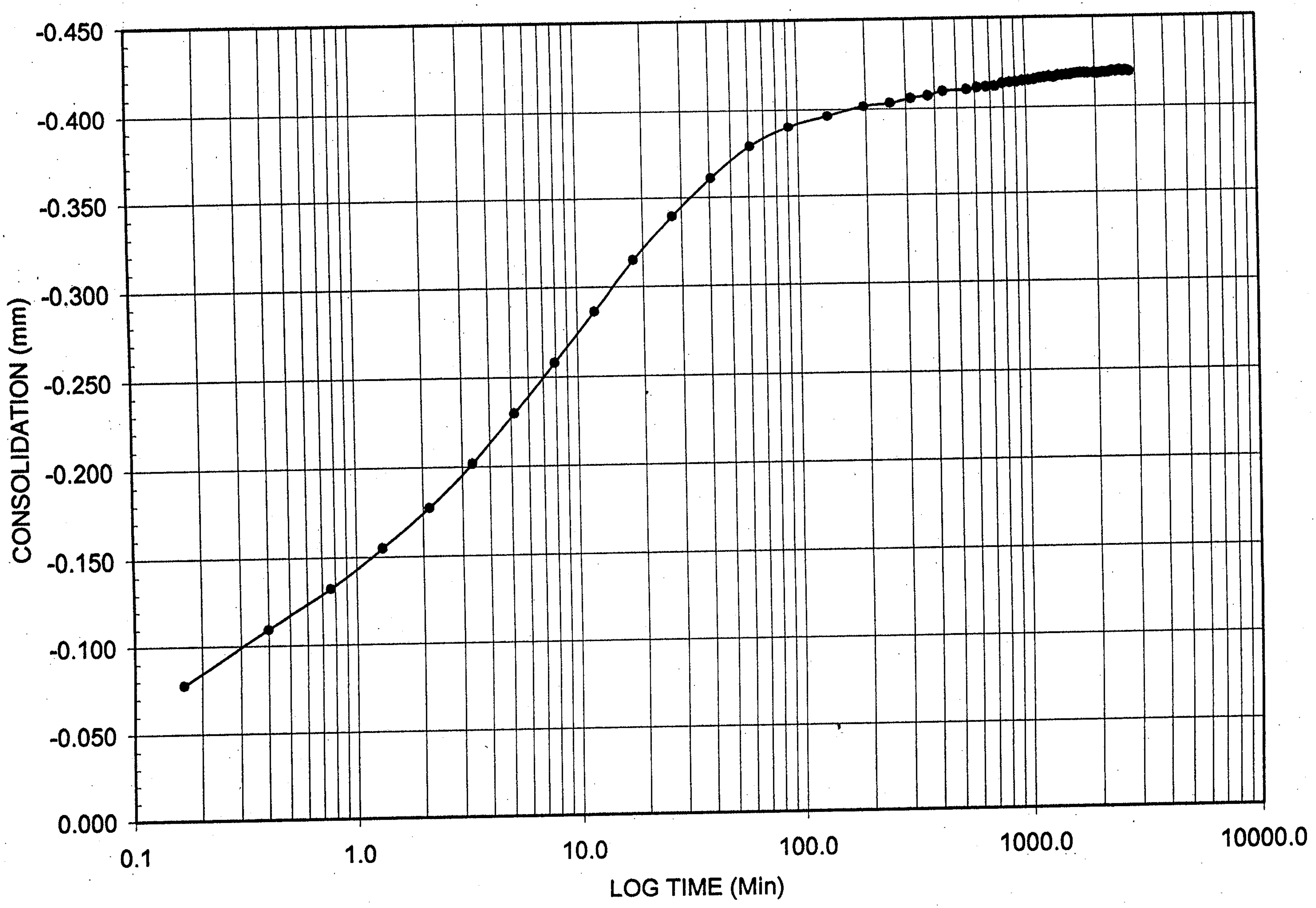
CONSOLIDATION PRESSURE = 2854.2 kPa

FILE # CONSOLIDATION #9

03 07 26

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.00 - 8.15 m



CONSOLIDATION PRESSURE = 714.3 kPa

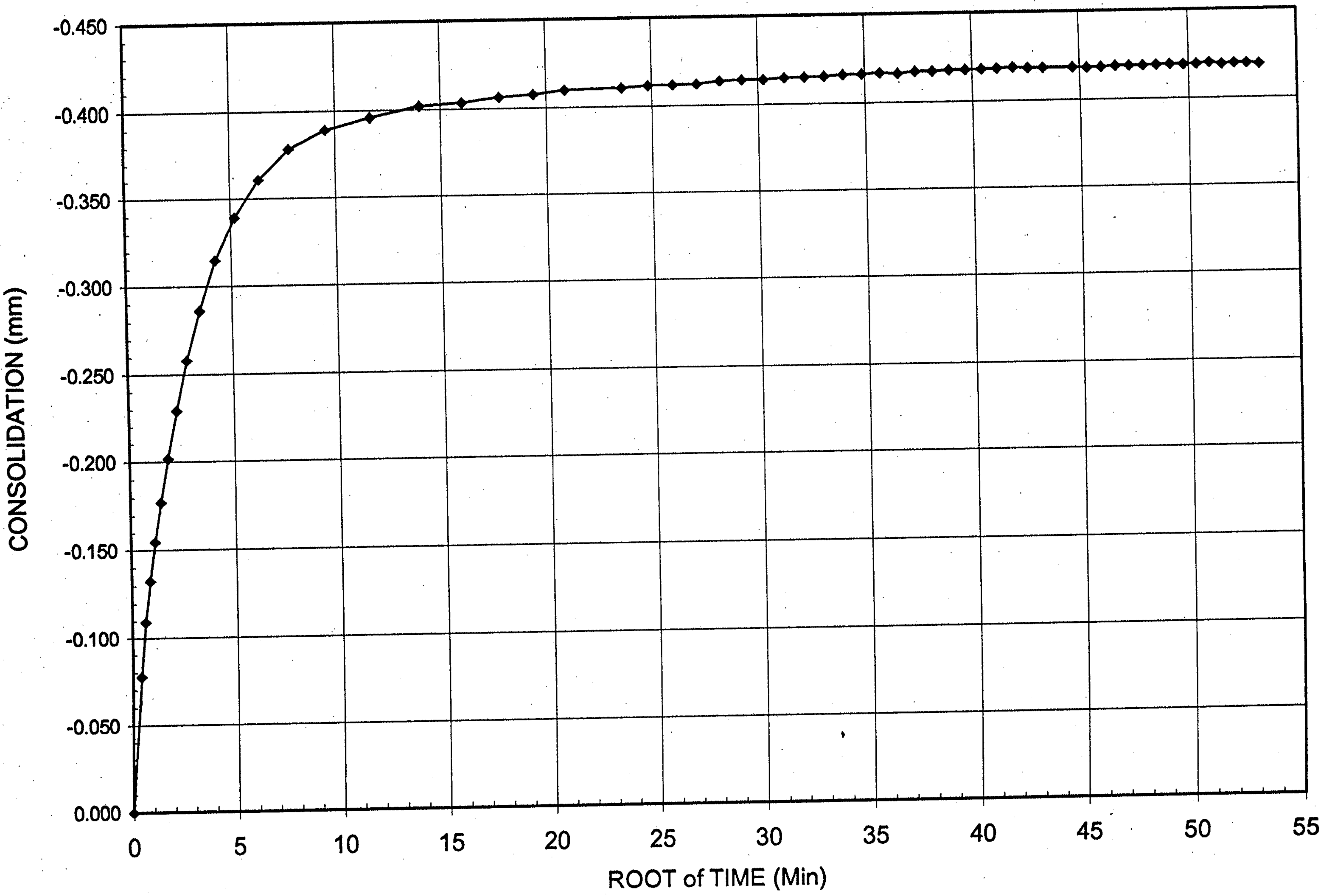
REBOUND # 11

FILE # CONSOLIDATION #10

03 07 26

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.60 - 8.15 m



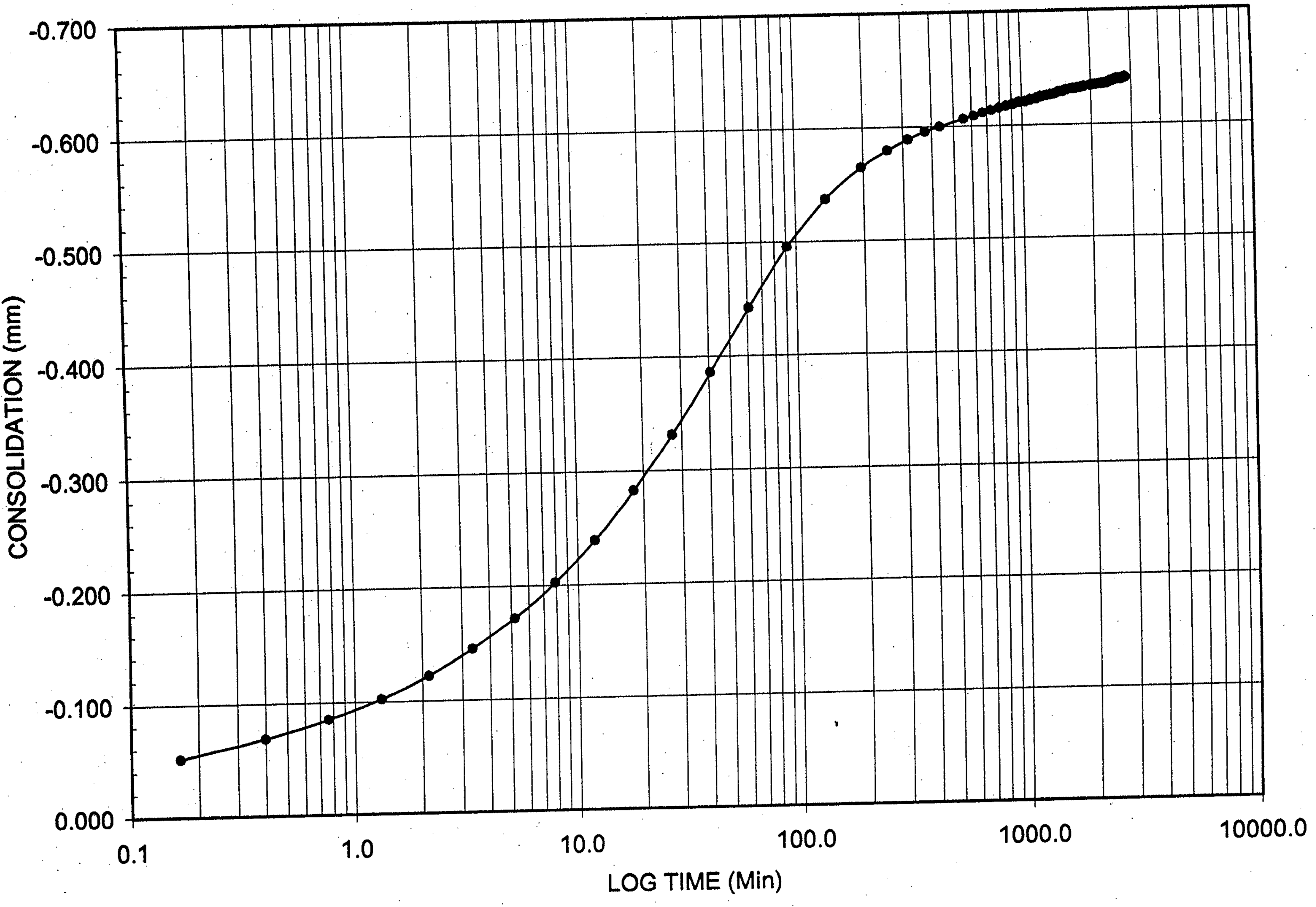
CONSOLIDATION PRESSURE = 714.3 kPa

FILE # - CONSOLIDATION #10

03 07 28

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.55 - 8.15 m



CONSOLIDATION PRESSURE = 178.2 kPa

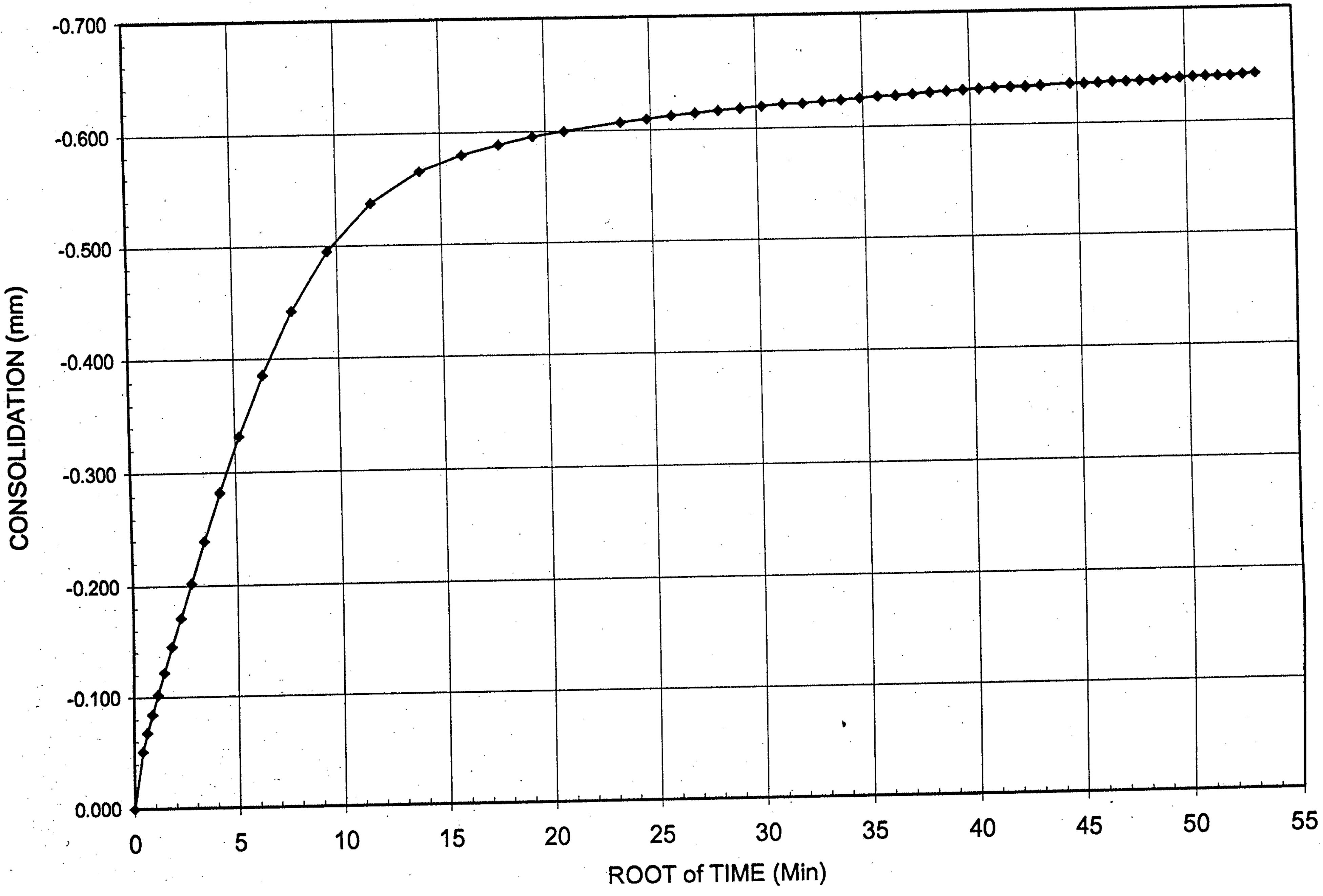
REBOUND # 12

FILE # - CONSOLIDATION #11

03 07 28

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.60 - 8.15 m

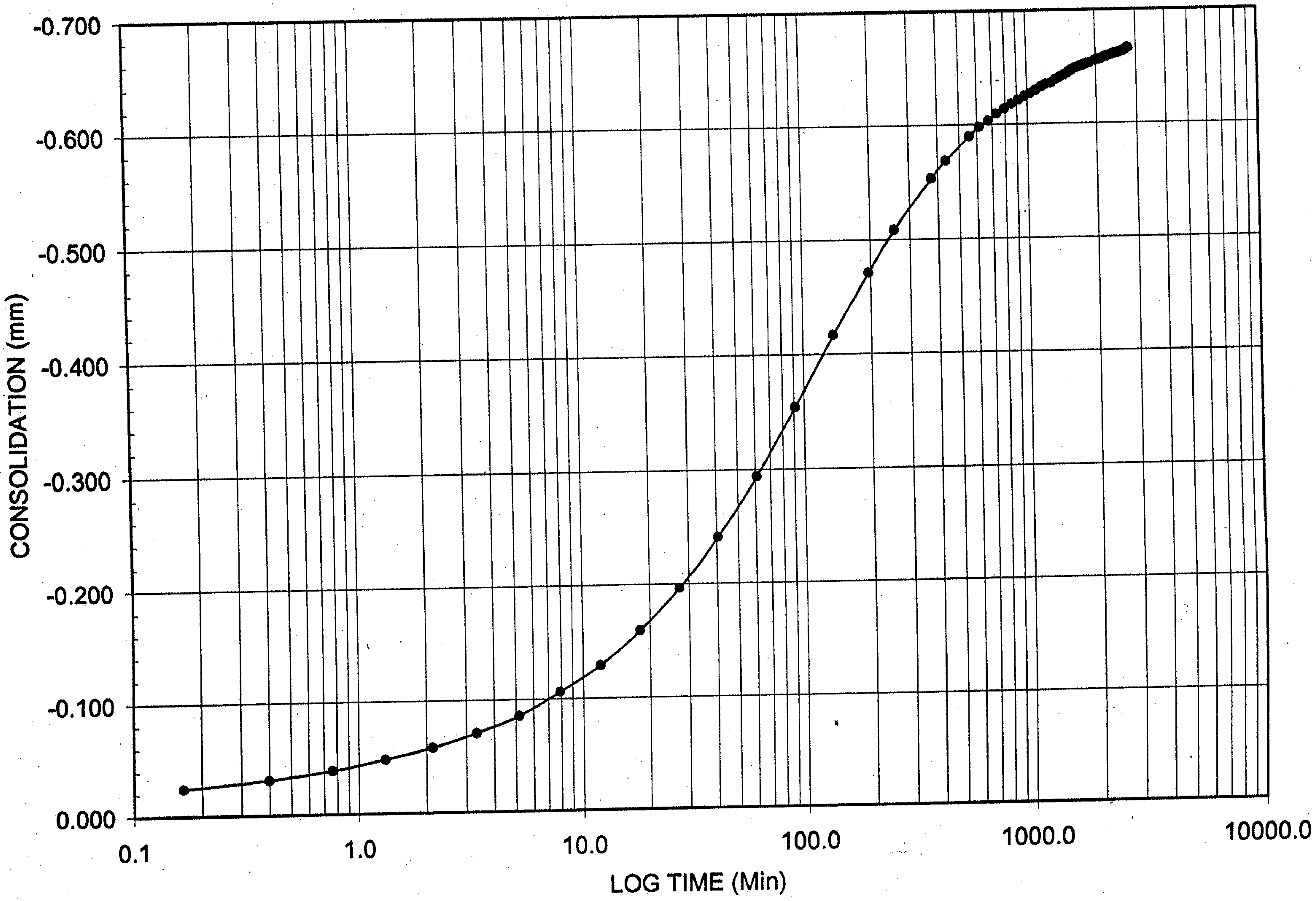


CONSOLIDATION PRESSURE = 178.2 kPa

03 07 30

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.55 - 8.15 m



CONSOLIDATION PRESSURE = 44.5 kPa

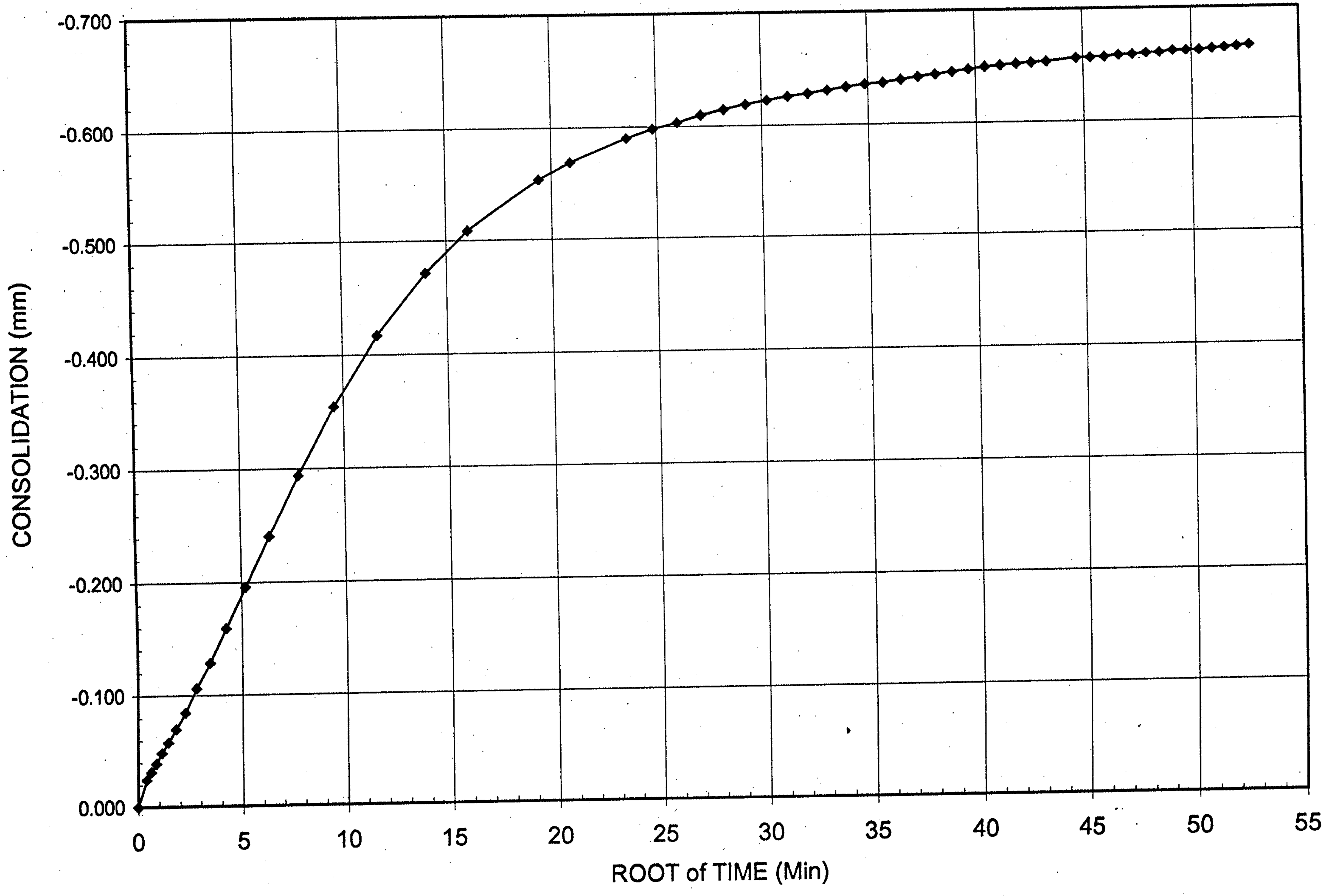
REBOUND # 13

FILE # - CONSOLIDATION #12

03 07 30

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.60 - 8.15 m



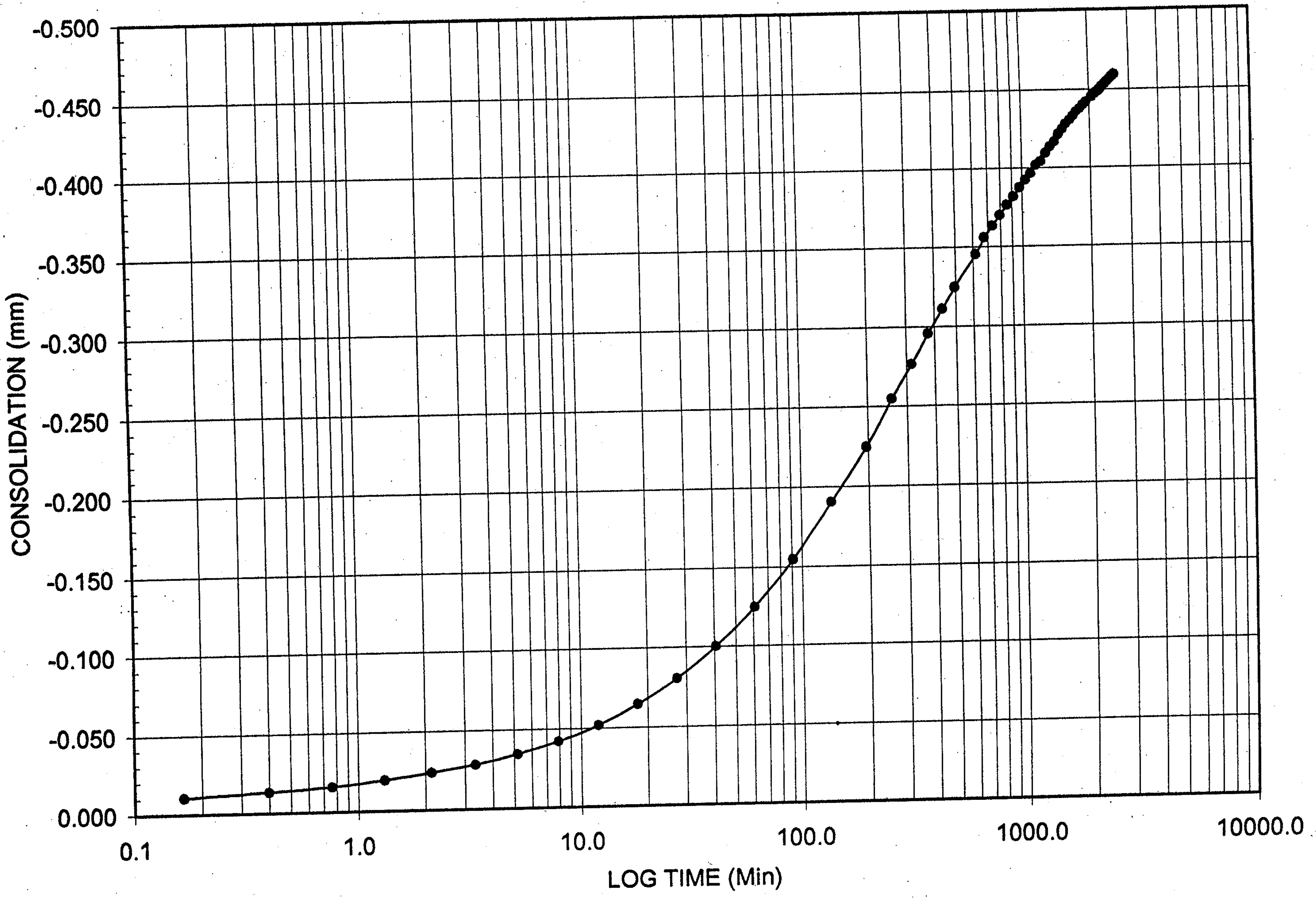
CONSOLIDATION PRESSURE = 44.5 kPa

FILE # - CONSOLIDATION #12

03 08 01

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.[illegible] - 8.15 m



CONSOLIDATION PRESSURE = 11.1 kPa

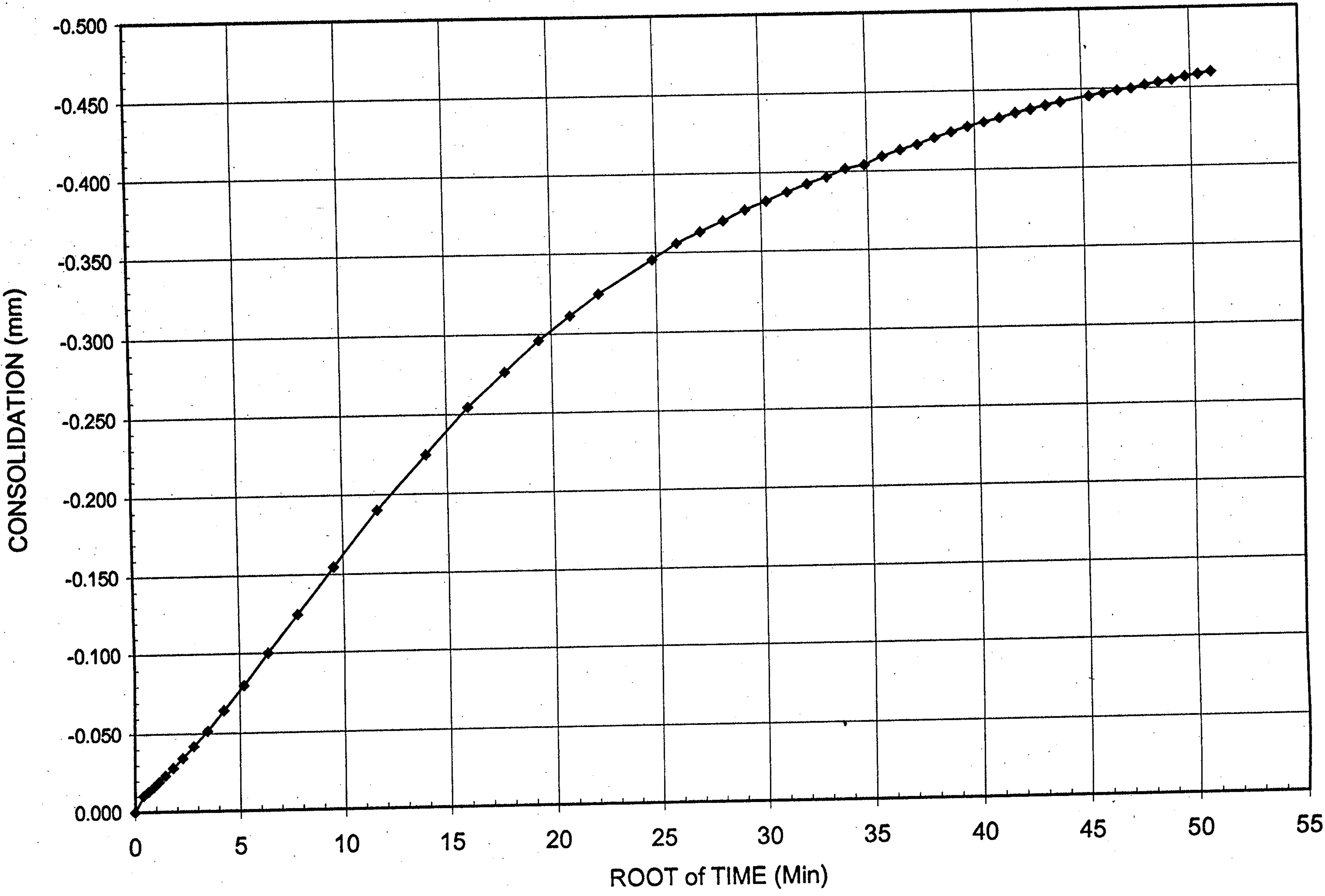
REBOUND # 14

FILE # - CONSOLIDATION #13

03 08 01

NAT. TEST LAB AO023A01

S - 9 AH03 - 06 7.60 - 8.15 m



CONSOLIDATION PRESSURE = 11.1 kPa

FILE # CONSOLIDATION #13