GEOTECHNICAL EVALUATION
WOMEN'S CORRECTIONAL
FACILITY ADDITION
178 STREET AND 111 AVENUE
EDMONTON, ALBERTA

Project No. 0104-00-22628

JUNE, 2000

EBA Engineering Consultants Ltd.

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Submitted To:

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Prepared by:

EBA ENGINEERING CONSULTANTS LTD.
EDMONTON, ALBERTA

Project No. 0104-00-22628

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1.0 INTRODUCTION

This report presents the results of a geotechnical evaluation conducted by EBA Engineering Consultants Ltd. (EBA), for the proposed addition to the Women's Correctional Facility in Edmonton, Alberta.

The objective of this work was to ascertain the subsurface conditions in the area of the proposed development and to isolate any factors that may affect design and construction. This report will also provide geotechnical design parameters and recommendations for the proposed construction. Authorization to proceed with the work was provided by Mr. Constantine Lazaridis, M.O.A.Q. of Public Works and Government Services Canada (Public Works).

2.0 PROJECT BACKGROUND

2.1 Project Description

The proposed construction will consist of additional housing units along the centreline of the facility near the east boundary and in the open area at the southeast corner of the facility. An addition to the southeast side of the most southerly building is also proposed. It is understood that grade supported floor slabs are most prevalent within the existing facility and basements are not expected. However, due to cold floor slabs, crawlspaces may be considered for the living space. An asphalt concrete surfaced extension to the roadway will be constructed, as well as extensions to the existing water, gas and electrical systems.

EBA Engineering Consultants Ltd. (EBA) had conducted the original geotechnical evaluation in 1994 (EBA File 0104-20076). The intent of this supplementary evaluation is to confirm that the geotechnical recommendations provided in 1994 are still valid for this development.

2.2 Site Description

The project site is located on the east side of 178 Street, north of 111 Avenue in Edmonton, Alberta (Figure 1). The property is essentially bounded between 111 and 114 Avenues and between 174 and 178 Streets.

The existing facility consists of a large main complex building in the west area and an additional building to the southeast. Two rows of housing are located running west to east along the centre of the property. (See Figure 1). The proposed development areas are within the fenced compound to the east, southeast and south and are currently undeveloped. They are generally grass surfaced and quite flat lying with reasonable drainage into a controlled storm system.

Based on our observations on site with a private utility locator (Promark), the water, telephone, power, gas, storm and sanitary lines appear to be quite close to the locations indicated on the site plan provided by Public Works (Drawing Number C1-01).

3.0 PROJECT WORK METHODOLOGY

3.1 Field Work

On June 1, 2000, field work was carried out using a truck mounted drill rig equipped with 150 mm diameter solid flight augers which was contracted from SPT Drilling Ltd. of St. Albert, Alberta. EBA's field representative was Mr. Jim Ryan, P.Eng.

Four boreholes were drilled in total. These include one deep borehole within the largest proposed new addition building area to the southeast to a depth of 8.8 m and one borehole within the south addition area to a depth of 6.1 m. Two shallow boreholes were drilled within the proposed central and northeast addition areas to a depth of 3.0 m (Boreholes 22628-01 to -04, respectively). It was not considered necessary to drill the fifth shallow borehole as originally proposed. The approximate borehole locations are shown on Figure 1.

In all of the boreholes, disturbed grab samples were obtained at 300 to 750 mm intervals in addition to Standard Penetration Tests (SPTs) which were performed at intervals of 1.5 m in the deep borehole. All samples were visually classified in the field and the individual soil strata and the interfaces between them were noted. The borehole logs are included in Appendix B. An explanation of the terms and symbols used on the borehole logs is also included in Appendix B.

Considering the security precautions and our observations of the soil and groundwater conditions on site, it was not considered necessary to install a groundwater monitoring standpipe in any of the boreholes.

3.2 Laboratory Work

Following the field work, a laboratory testing program was initiated comprising natural moisture contents, Atterberg Limits and detailed visual examinations. Laboratory test results are presented on the borehole logs in Appendix B.

4.0 SUBSURFACE CONDITIONS

4.1 General

The general subsurface stratigraphy comprises clay fill overlying native clay which is underlain by clay till. Specific details of the stratigraphy encountered at each borehole location are presented on the borehole logs in Appendix B and are discussed in the following section.

4.2 Subsoil Profile

The property is generally grass surfaced, with a relatively thin topsoil layer, with a thickness of approximately 100 mm. The proposed addition areas appear to be quite flat lying.

At three of the four borehole locations, a layer of clay fill was noted at surface with a thickness of approximately 750 mm. The surficial clay fill was noted to be moist (wet of optimum moisture content), high in plasticity and stiff in consistency. It appears to be local soils which was reworked and contains trace to some black stained clay inclusions. No buried topsoil was noted underlying the clay fill materials. No clay fill was encountered within the southeast area of the property (borehole 22628-01).

Underlying the clay fill in most areas and at ground surface in the southeast area, the local native lacustrine clay layer was encountered. The native clay was noted to be silty with a trace of sand, moist, high in plasticity and stiff in consistency. There was a distinct increase in moisture content and silt content with depth within this clay layer. The clay was relatively soft below a depth of approximately 4.5 m.

The surficial clay was noted to have a Plastic Limit in the range of 22 to 25 percent and a Liquid Limit ranging between 65 and 72 percent. This is indicative of high plasticity and is in accordance with the ranges noted in the original evaluation. The near surface clay soils are somewhat wet of optimum moisture content.

The local lacustrine clay soil is considered to be moderately compressible. One of the characteristics of the local lacustrine clays is their tendency to swell with increasing moisture content. Experience has noted that the swelling potential tends to decrease as the soil moisture content approaches approximately 38 to 40 percent. The near surface medium to high plastic clay has a moderate swelling potential due to its existing native moisture content of 28 to 33 percent.

At the deep borehole location in the southeast area, glacial clay till was encountered at a depth of approximately 7 m. The clay till was silty and sandy with gravel and coal particles and was moist, medium in plasticity and very stiff in consistency.

It should be noted that the soil conditions are consistent with those encountered during the original geotechnical evaluation. The surficial clay fill materials appear to have been placed at the time of original development.

It should be noted that geological conditions are innately variable. Glacial deposits in particular are seldom spatially uniform. At the time of preparation of this report, information on subsurface stratigraphy is available only at discrete borehole locations. In order to develop recommendations from the information, it is necessary to make some assumptions concerning conditions other than that at borehole locations. Adequate inspection should be provided during construction to check that these assumptions are reasonable.

4.3 Groundwater

Based on the original geotechnical evaluation report as well as our observations on site during this phase of borehole drilling, the groundwater table is estimated to be approximately 3 m below ground surface.

These levels indicate that groundwater should not pose significant problems during shallow excavations for pile caps and grade beams. However, some difficulties should be expected during moderate excavations for service trenches extending to depths of 3.0 to 4.0 m due to the wet and soft clay soils and seepage noted. Additional comments are provided in subsequent sections. For drilled pile foundations, some groundwater seepage and soil sloughing could possibly occur. There is a chance that casing may be required during some of the pile installations.

It should be noted that groundwater levels will fluctuate seasonally and in response to climatic conditions and may be at a different depth when construction commences.

5.0 GEOTECHNICAL EVALUATION AND RECOMMENDATIONS

5.1 General

The property appears to be level and only a limited amount of site grading is expected in order to achieve design grades. The surficial clay fill within most areas poses a slight concern for a grade supported floor slab. The clay fill appears to be of reasonably good quality and there does not appear to be any buried organic layer, but it is high in plasticity and could have a significant swelling potential.

The expected floor slab movements due to swelling soils was a major issue during the original construction of this facility. The local, high plastic clay soil should be thoroughly wetted in order to initiate the swelling before the floor slab construction. As long as they are not allowed to dry out within the building areas and maintained at the moisture content noted above, they would have only a moderate long term swelling potential.

Following a successful proof-roll, it should be acceptable to proceed with normal pavement construction. Provided good weather conditions are available during pavement subgrade preparation, significant complications are not anticipated. However, chemical stabilization with cement has been required during subgrade preparation for some of the neighbouring properties. Stabilization was generally required due to accelerated construction schedules with limited time to allow for effective discing and drying of the subgrade.

The most cost effective foundation system for the building additions will likely be a cast-in-place concrete pile and grade beam arrangement that is most common for this area of Edmonton. Shallow footings are also feasible for the smaller building additions, but are less favoured by local contractors. The best option is to have the same foundation system for the additions as that for the existing buildings. Should any other foundation types be considered suitable for this project, EBA should be contacted to provide additional design parameters. The foundation design and site development are discussed in subsequent sections.

5.2 Site Preparation

All vegetation and topsoil within all development areas including the building additions, exterior concrete slabs and paved areas should be stripped and removed from the site.

For those areas to contain a floor slab, hard surfaced concrete or asphalt concrete pavement, the following procedure is recommended. Following the initial site stripping and cutting to grade, the areas should be scarified to a minimum depth of 150 mm, moisture conditioned to between 0 and 2 percent above optimum moisture content and recompacted to 98 percent of Standard Proctor maximum dry density (SPD). Following compaction, the stripped areas should be proof-rolled to identify loosened or softened areas. Any soft areas should be over-excavated and backfilled to 98 percent SPD using "general engineered fill".

The subgrade assessment should also include any clay fill that may remain in place in the proposed building addition areas. Localized areas of over-excavation may be required.

Should fill be required to raise subgrade elevation, it should be moisture conditioned as noted and compacted to 98 percent of SPD in lifts not greater than 150 mm in compacted thickness. The material should meet the requirements of "general engineered fill" as specified in "Backfill Materials and Compaction" in Appendix C. It should acceptable to use the non-organic site soils as general engineered fill provided they are acceptably moisture conditioned and free of deleterious materials.

For the building areas, it is very important to ensure thorough moisture conditioning in order to minimize the long-term clay swelling potential. It should be noted that moisture conditioning of high plastic clay soil to above optimum moisture content may be quite difficult as the clay will become quite soft. If fill material is required, the best option is to use a low to medium plastic, imported clay fill. Low to medium plastic clay soils are much easier to moisture condition and compact and are much more volumetrically stable. Full-time inspection will be required in order to ensure that acceptable fill material is placed within the building area.

The intent is to provide a more uniform and controlled subgrade condition beneath the floor slab and to keep the resulting floor slab movements and cracking to within locally acceptable standards (less than 20 mm). However, if there is very low tolerance for any slab movement, the best option would be to consider a structurally supported floor slab for the building additions.

As noted, the near surface clay soils are generally high in plasticity and therefore could be sensitive to increases in moisture content. Excessive precipitation after site stripping will cause site development to be more difficult. If good weather conditions are not available during site development, or if difficult conditions are encountered within localized problem areas, it may become necessary to consider cement stabilization of the subgrade at that time.

Any granular or structural fill required for the project should meet the requirements as defined in "Backfill Materials and Compaction" in Appendix C. Structural fill should be placed in lifts not exceeding 150 mm in compacted thickness and at a density of 100 percent of SPD.

Full time monitoring and compaction testing should be provided during any fill placement to ensure suitable subgrade conditions are prepared. This monitoring should be completed by qualified persons, independent of the contractor.

5.3 Foundations

All foundation design recommendations presented in this report are based on the assumption that an adequate level of construction monitoring during foundation excavation and installation will be provided, and that all construction will be carried out by a suitably qualified, experienced contractor. An adequate level of construction monitoring is considered to be: a) for earthworks; full time monitoring and compaction testing, b) for shallow foundations, bearing surface inspection prior to concrete or mud slab placement and c) for deep foundations; full-time monitoring and design review during construction. All such 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 the recommendations, based on data obtained at discrete borehole locations, are relevant to other areas of the site.

5.3.1 Shallow Foundations

The term "shallow foundations" refers to strip and spread footings which are at a shallow depth below finished exterior grade. Shallow footings for the proposed building should rest on native undisturbed soil or on structural fill as defined in Appendix C, fillcrete or lean mix concrete. Shallow footings are not recommended for perimeter walls of unheated buildings or other locations exposed to frost unless acceptable insulation is placed.

Strip and spread footings may be designed on the basis of an allowable soil bearing pressure of 100 and 125 kPa, respectively, in undisturbed, compact silty clay. Exterior shallow footings for a heated building should be placed at a minimum depth of 1.5 m below final exterior grade. Interior footings are not governed by this depth constraint but they must be founded below any clay fill materials encountered.

The bottoms of footing excavations must be thoroughly cleaned of all loosened or softened soil prior to placing the concrete. Any loose or soft soil removed should be replaced with fillcrete, lean mix concrete or compacted gravel meeting the requirements of "structural fill" given in Appendix C.

Where construction is to take place during the winter or spring months, footings must not be cast on frozen soil. Footings founded on soil frozen during the construction period will settle when the founding soils are weakened by thawing. It is also essential that the foundation soils are not allowed to freeze after the concrete for the footing has been poured.

As noted previously, the groundwater table near the building is currently well below the ground surface. Therefore, water infiltration is not expected to pose a significant problem for shallow footings at this location. However, any water infiltration into the excavation should be diverted away from the foundation soil to avoid softening.

In warm, dry weather, care should be taken to ensure that the soil at the base of the excavation is not allowed to dry and crack. It is good practice to protect the base of the excavation from desiccation with a concrete mud slab or seal coat. This will help to prevent unnecessary disturbance of the sensitive foundation soils during form-work placement. Further recommendations for the design and construction of shallow foundations are provided in Appendix C.

5.3.2 Cast-in-Place Concrete Piles

Because of the groundwater level and the wet silty clay soils at various depths, there is a potential for sloughing and/or seepage during piling in some areas. Therefore, it is recommended to have casing available on site and if necessary, used to seal off sloughing and/or seeping soils. The piling contractor should make his own estimate of casing requirements, considering such factors as construction procedures and bore diameters.

Cast-in-place concrete piles may be designed using the following foundation design parameters.

Depth (m)	Material	Allowable Skin Friction (kPa)	Allowable End-Bearing (kPa)
0.0 – 1.5	Clay	0	0
1.5 – 7.0	Clay	17	0
>7.0	Clay Till	35	500

Shaft friction should be neglected in the upper 1.5 m of the pile below existing grade due to soil desiccation effects. All straight shaft piles should have a minimum diameter of 400 mm. All straight shaft piles subjected to uplift loads including frost should have a minimum length of 6.0 m and should be reinforced over their entire length. For straight shaft cast-in-place concrete piles, no allowance should be made for end-bearing for the pile tip.

Cast-in place concrete belled piles using end bearing resistance may be considered if any seepage and sloughing can be controlled with casing. Belled piles should be founded a minimum of 1.5 m within the very stiff clay till layer (i.e. below a depth of at least 8.0 m). The allowable soil bearing pressure at this depth in the clay till can be taken as 500 kPa.

It is recommended to use a bell diameter which is a minimum of 2 and a maximum of 3 times the shaft diameter. The ratio of the depth to bell base and bell diameter should be a minimum of 2.5. Otherwise the end-bearing value provided will have to be reduced accordingly. Belled piles subjected to uplift loads including frost should have reinforcement which extends to the base of the bell. The belled piles should consider end bearing only and should neglect the effects of shaft friction.

Pile bells cannot be formed within a sloughing silt or sand layer. In order to ensure adequate support for the roof of a bell where wet sloughing layers are encountered, the minimum distance from the underside of a sloughing layer to the top of the roof of a bell should be 0.6 m.

The bases of all end-bearing piles must be thoroughly cleaned of all loosened material by mechanical or, if necessary, hand methods. Following drilling and cleaning, pile holes should be inspected to ensure that an adequate bearing surface has been prepared at an appropriate depth. Full-time pile monitoring is recommended for this project by qualified personnel, independent of the contractor.

General recommendations for the design and construction of cast-in-place concrete piles are included in Appendix C.

5.3.3 Settlement Considerations

Calculations of the settlement pattern is complex and difficult to assess without significant additional laboratory testing and a detailed knowledge of the loading and foundation types. For structures supported on native, undisturbed soil, the following comments may be of some value:

- The settlement of an isolated cast-in-place concrete straight shaft pile should be no more than 5 mm.
- The settlement of a strip or spread footing should be no more than one percent of the width of the footing on plan.
- The settlement of a single, cast-in-place concrete belled pile should be no more than one percent of the bearing surface diameter.

Differential settlements, rather than total settlements, are usually the governing factor in structural and architectural design. Differential settlements between adjacent columns or wall units are typically about one-half of the values given above.

5.4 Basement Construction

5.4.1 Basement Floor Slabs

Detailed recommendations for grade supported floor slabs are provided in subsequent sections. The exposed subgrade at the base of the excavation could be sensitive to disturbance. It is therefore recommended to carry out all excavations remotely with a smooth mouthed bucket at final grade to avoid disturbance. It is good construction practice to place a layer of lean mix concrete or a mud slab in order to allow personnel and light machinery to work on the excavation base.

Basement floor slabs should be supported by a layer of compacted, clean, free-draining granular material with a minimum thickness of 150 mm. In areas where floor slabs bear on a clay subgrade, the clay at this site may experience some volume change following completion of the floor slabs. Therefore, some movement should be anticipated. Any columns in the basement designed to support the upper levels of a building should be of the adjustable "telepost" type construction on an independent footing element.

If partitions are constructed in the basement, provision must be made such that if the basement floor slab moves due to soil moisture content fluctuations, the partitions do not raise the main floor of the building. An allowance of 20 mm should be left between the top plates of basement partitions and the floor joists above them to accommodate any movement of the basement floor slab.

5.4.2 Crawlspace Base

As a minimum, the base of a crawlspace should be covered with a vapor barrier as well as at least 50 mm of sand. The Owner should consider the placement of a thin mud slab on the base of the crawlspace, i.e. a layer of low strength concrete fillcrete or foundation concrete with a thickness of approximately 50 mm. This will allow a working surface for construction personnel and will greatly facilitate the installation of the building services and any future maintenance. In this event, the vapor barrier and sand layer would not be required.

It is also good construction practice to grade the base of the crawlspace towards a common collection point which should drain into the weeping tile collection system.

5.4.3 Basement Walls

All basement walls should be designed to resist lateral earth pressures in an "at-rest" condition. This condition assumes a triangular pressure distribution and may be calculated using the following:

$$P_o = K_o\,(\gamma H+q)$$

where:

P_o	=	lateral earth pressure "at-rest" condition (no wall movement occurs at a given depth)
K_o	=	co-efficient of earth pressure "at-rest" condition (use 0.5 for silt or clay backfill and 0.45 for sand and gravel backfill)
γ	=	bulk unit weight of backfill soil (use 19 or 21 kN/m^3 for clay or sand backfill, respectively)
H	=	depth below final grade (m)
q	=	surcharge pressure at ground level (kPa)

It is assumed that drainage is provided for all basement walls and hydrostatic pressures will not be a factor in design.

Weeping tiles should be installed at or slightly below the base of the footing foundation around the exterior of all basement walls. The weeping tile should consist of a perforated metal or rigid plastic pipe wrapped in a geotextile fabric and surrounded by a 150 mm thick layer of free-draining granular material with a gradation similar to that of a concrete sand. Alternatively, the weeping tile pipe may be surrounded by coarse drainage rock wrapped in a medium weight non-woven geotextile.

Backfill around concrete basement walls should not commence before the concrete has reached a minimum of two-thirds of its 28-day strength and/or first floor framing are in place (wooden walls). Only hand operated compaction equipment should be employed within 600 mm of the concrete walls. Caution should be used when compacting backfill to avoid high lateral loads caused by excessive compactive effort. To avoid differential wall pressures, the backfill should be brought up evenly around the walls. It is preferable to place a clay cap with a minimum thickness of 600 mm at the ground surface to minimize the infiltration of surface water.

5.5 Concrete Floor Slabs

As noted, if a grade supported floor slab is to be considered, detailed recommendations for subgrade preparation have been provided in Section 5.2 "Site Preparation". The subgrade preparation and placement of a limited amount of general engineered fill may still result in floor movements in the order of approximately 10 to 20 mm or greater depending on the quality of moisture conditioning, fill placement and compaction.

The moisture content in soils below a concrete floor also generally increases with time due to the structure sealing the surface and preventing evaporation of moisture. This poses a potential of swelling soils with increasing moisture content in the order of approximately 10 to 20 mm. In addition, water or sewer lines placed under the floor slab may leak. The moisture or additional moisture from improper site grading can significantly compound the problem and swelling or settlement of 50 mm or more is possible in localized areas. These movements are gradual but can often result in some floor cracking or distortion with time.

Such damage due to floor movement may be visible particularly if a brittle surface finishing such as ceramic tiles is adopted. The risk of such damage should be weighed against the additional costs associated with alternative slab support systems, such as structurally supported slabs.

The intent of the subgrade preparation and replacement of engineered fill is to provide a more uniform subgrade condition in order to reduce the risk of differential slab movement. These movements should be addressed in the detailing of interior partitions and floor slabs.

It should be noted that the clay subgrade possesses some potential for volume change if allowed to remain in contact with free water for extended periods of time. Measures should be taken to ensure water is not allowed to pond on the subgrade during or after construction as uncontrolled detrimental swelling may result. Similarly, it is critical to ensure that exposed subgrade is not permitted to dry out during construction prior to floor slab placement.

Loads on slab-on-grade floors are expected to be less than 15 kPa in most areas. Slab-on-grade floors should rest on at least 150 mm of compacted pit run gravel or fill sand as specified in Appendix C (Backfill Materials and Compaction). This granular bedding course should be compacted to 100 percent of Standard Proctor density in lifts not exceeding 150 mm in compacted thickness. Granular general engineered fill is best compacted with vibratory, smooth drum, compaction equipment.

If the floor slab loading is expected to exceed 15 kPa, if the floor slab is to support vibrating equipment or if the floor slab traffic is expected to be high, EBA should be given the opportunity to re-evaluate the recommendations for slab-on-grade construction. However, for design purposes, the subgrade clay soils and properly compacted general engineering fill can be assumed to have a subgrade modulus of 25 MPa/m.

The floor slab should be reinforced. The reinforcing steel can be carried through the construction joints. Proper jointing is required to prevent shrinkage cracks.

Heating ducts beneath floor slabs should be insulated with at least 50 mm of rigid insulation to prevent drying and shrinking of the clay. If possible, water lines should not be placed beneath slab-on-grade floors. Waste water lines beneath slab-on-grade floors should be cast iron with caulked bell and spigot joints or of rigid plastic with cemented joints. Waste water lines with butt joints and flexible rubber connections should not be permitted.

Non-load bearing partitions resting on slab-on-grade floors should be designed such that floor movements can be accommodated. It is suggested to use an allowance of 20 mm considering the underlying clay soils.

Partitions should not be tied into the exterior wall or load bearing columns. Mechanical equipment placed on the slab-on-grade floor should be designed to permit some relevelling should the equipment be susceptible to small changes in level. Piping, and electrical conduit connections should be laid out to permit some flexibility, as vertical movement of such equipment as water meters, furnaces and electric equipment may cause distress in the piping. This provision is particularly important where there are short pipe runs between mechanical equipment and points where piping passes through walls or slabs.

Slab-on-grade floors should be tied into the grade beam with dowels at doorways. At all other points, it would be preferable to allow the slab to float. Alternatively, the slab can be tied into the grade beam at all points provided that a construction joint or cut is placed parallel to the grade beam at a distance of approximately 2.0 m. A void form extending out 500 to 600 mm along the inside of the grade beam is recommended to reduce uplift stresses.

5.6 Frost Protection

The local high plastic clay soils are considered to have medium frost susceptibility. Buried water lines should have a minimum frost cover of 3.3 m if granular backfill is used. For cohesive backfill, the frost cover should be a minimum of 2.4 m.

Pipes buried with less than the recommended soil cover should be protected with insulation to avoid frost effects that may cause damage to or breakage of the pipes. Rigid insulation placed under areas subject to vehicular wheel loadings should be provided with a cover of compacted granular base and/or pavement with a minimum cover thickness of 600 mm.

Where pavements are adjacent to foundation walls or grade beams, a separation strip should be installed between the pavement and the foundation walls or grade beams to permit some relative movement due to frost heave or settlement. Insulation can also be used to reduce the depth of frost penetration and the potential for frost heaving of slabs and pavements. At locations such as overhead doors and other entrances where pavement heaving would interfere with building usage, it is recommended to insulate the pavement adjacent to the building with 100 mm of high strength expanded polystyrene. Insulation thickness should be tapered gradually by stepping the thickness at approximately 25 mm per 1.2 m to minimize differential heaving between insulated and uninsulated pavement.

All foundations are expected to be for a heated structure. Perimeter shallow footings for a heated building should be placed at a minimum depth of 1.5 m below exterior grade, unless insulation is considered in the design.

For piles that are placed outside the area of a heated building, some precautions should be taken to avoid frost heaving and frost jacking of piles. In order to resist frost heaving forces on pile foundations, the minimum length of a straight shaft concrete pile should be 6 m. Grade beams and pile caps should be constructed with void forms to prevent transfer of uplift to the piles. Concrete piles subjected to uplift loads including frost effects should be reinforced over their entire length.

Grade beams should be provided with a minimum soil cover of 1.5 m along the exterior perimeter of heated buildings for protection against frost action. Grade beams that do not have adequate soil cover for frost protection should have a 100 mm void space on the underside of the grade beam to reduce the risk of interaction with the underlying soil. It is also preferable to backfill the top 600 mm along the exterior of the grade beam with a high plastic clay material in order to prevent the infiltration of excessive moisture and softening of the soils adjacent to the grade beam.

5.7 Grading and Drainage

Excess water should be drained from the site as quickly as possible both during and after construction. The finished grade should be laid out so that surface waters are drained away from the buildings and other structures by the shortest route. Roof and other drains should discharge well clear of any buildings and equipment.

Caution should be taken where downspouts discharge onto paved areas due to the high probability of ice forming in the winter. Within 2 m of the building perimeter, the pavement should be graded to slope away from the building at a gradient of at least 3 percent.

Downspouts may be discharged onto landscaped areas provided that the water is carried, by means of a concrete splash pad or extendable section so that the point of discharge of the water is at least 1.8 m from the building wall. The landscaped surface should be graded to slope away from the building at a gradient of at least 5 percent within 2 m of the building perimeter. General landscaped areas should have grades of no less than 2.0 percent to minimize ponding. The near surface soils may experience some heaving after construction of hard surface exterior pavements, which will cut off evaporation. Hard surfaced paved areas should be provided with a minimum grade of 1.0 percent to promote runoff and minimize ponding.

5.8 Cement Type

Two tests were conducted to determine the water soluble sulphate content of representative soil samples recovered from site. The test results indicate sulphate concentrations in the range of approximately 0.28 to 0.42 percent.

Based on CSA A23.1, the potential sulphate exposure is therefore classified as severe (Class S-2). Accordingly, the use of Type 50 (Sulphate Resistant) Portland cement at a maximum water/cementing material (W/CM) ratio of 0.45 is recommended for foundation concrete and all concrete exposed to groundwater. If available, a proven flyash should be used as a supplemental cementing material. Based on EBA's experience with Northern Alberta aggregates, a W/CM ratio of 0.45 corresponds to a 28-day compressive strength of 28 MPa or greater. Stricter recommendations may be required due to structural considerations, or for exposure to de-icing chemicals.

Air entrainment of 4 to 6 percent by volume is recommended for all concrete exposed to freezing temperatures, native soils, and/or groundwater. This should be increased to 5 to 7 percent for exterior flatwork.

5.9 Excavations and Trench Backfill

Excavations should be carried out in accordance with Alberta Occupational Health and Safety regulations.

For this project, the depth of excavations are anticipated to be relatively shallow to moderate and will be carried out for such components as shallow footings, grade beams and service trenches. Excavations in stiff clay soil, which are deeper than 1.5 m, should have the sides shored and braced or the slopes cut no steeper than 1.0 horizontal to 1.7 vertical. Where excavations are open for longer than one month or if significant groundwater seepage is encountered, the sideslopes should be cut no steeper than 1.0 horizontal to 1.0 vertical. This may be possible within the near surface wet sandy clay soils.

Temporary surcharge loads, such as construction materials and equipment, should not be allowed within 3.0 m of an unsupported excavated face. Vehicles delivering materials should be kept back from faces by at least 1.0 m. All excavations should be checked regularly for signs of sloughing, especially after periods of rain. Small earth falls from the sideslopes are a potential source of danger to workmen and must be guarded against.

Trenches must be backfilled in such a way as to minimize the potential of differential settlement and frost heave movements. A minimum of 95 percent of Standard Proctor maximum dry density (SPD) is recommended as the preferred option for all trenches, with the exception of the top 600 mm, which should be compacted to 98 percent of SPD.

The native clay soil should be suitable for use as backfill material but may have a variable moisture content. The local clay soil at depth will likely be wet of its optimum moisture value. It should be possible for the contractor to acceptably moisture condition (dry) the soils in order to achieve the recommended level of compaction in most areas.

As an acceptable alternative, if the local soil to be used is somewhat excessively wet of optimum, it may be compacted to at least 97 percent of its One Mould Proctor value. The top 1.5 m of the trench should be compacted to at least 100 percent of One Mould Proctor. EBA would have to make this assessment at the time of trench excavation.

The compacted thickness of each lift of backfill should not exceed 150 mm. The upper 1500 mm of service trenches below paved areas should be cut at a maximum slope of 1.0 horizontal to 1.0 vertical, to avoid an abrupt transition between backfill and in situ soil.

It should be noted that the ultimate performance of the trench backfill is directly related to the uniformity of the backfill compaction. In order to achieve this uniformity, the lift thickness and compaction criteria must be strictly enforced.

General recommendations regarding construction excavation, backfill materials and compaction are contained in Appendix C.

5.10 Paved Areas

5.10.1 Subgrade Preparation

Detailed recommendations for site grading have been provided in Section 5.2 "Site Preparation". The subgrade should be graded to drain towards catch basin locations or the property boundaries as recommended in Section 5.6 "Site Grading".

Subsequent to subgrade preparation to obtain design subgrade elevation as noted in Section 5.2, all loose, soft or organic material should be removed from beneath pavement areas. Proof-rolling of the entire surface area under pavement sections should be carried out to detect any local soft spots. Soft spots detected as a result of proof-rolling should be excavated and backfilled with 'general engineered fill'. Recommended procedures for proof-rolling are presented under a separate section in Appendix C. General engineered fill is defined under the section entitled "Backfill Materials and Compaction" in Appendix C.

Subsequent to proof-rolling and subgrade repair, the subgrade should be scarified to a depth of not less than 150 mm and recompacted to 100 percent of SPD. Moisture conditioning to between 0 and 2 percent above optimum moisture content may be required to achieve this level of compaction.

Options for subgrade preparation should be finalized at the time of construction in order to confirm the subgrade condition. Localized soft areas should be expected. In addition, depending on weather conditions, effective drying to achieve an acceptable subgrade condition may not be possible. It may then become necessary to consider chemical stabilization with lime or cement, at least within localized problem areas.

Preparation of the subgrade should be carried out within restricted areas. This is to avoid loosening of the prepared areas by site traffic before compaction of the subgrade and placement of the granular material have been completed. Protection of the prepared subgrade against precipitation and frost should be undertaken.

5.10.2 Pavement Design

For design purposes, it has been assumed that all hard surface pavement subgrade has been developed in accordance to the procedures outlined above.

Most of the proposed paved areas may be considered to carry mainly light duty traffic with some heavy duty traffic. Light duty traffic areas are assumed to be used only by cars and light trucks (i.e. vans and ½ ton pickups). Heavy traffic areas may be specifically designated for heavier vehicles, such as mainly transport vehicles and delivery trucks.

Using the above noted subgrade conditions and the specified subgrade preparation, the following pavement structures are recommended.

Light Duty Traffic Areas

75 mm of City Type ACR Asphalt Concrete over
200 mm of 20 mm Granular Base

Heavy Traffic Areas

100 mm of Surface Course Asphalt Concrete over
150 mm of 20 mm Granular Base over
250 mm of 63 mm Crushed Gravel

The properties of the material used in the pavement structure should conform to the specifications found in Appendix C.

All asphalt concrete paving lifts should be compacted to a minimum of 97 percent of Marshall density. Additional recommended guidelines for design and construction of parking lots and roadway pavements are found in Appendix C.

If site conditions or traffic loadings change significantly from the assumed conditions prior to the start of construction, the pavement structure must be re-evaluated to consider the effect of the changed conditions on the design. EBA could confirm which structure would be most appropriate if the expected traffic usage were to be provided.

The native high plastic native clays are considered to have medium frost susceptibility. The exact degree of heave cannot be predicted based on the information presently available. However, the amount of movement is expected to be similar to other sites in the area.

It is imperative that positive surface drainage of pavement be established to prevent ponding of water. As mentioned previously in Section 5.6, recommended minimum grades of 1.0 percent should be used in paved areas, where possible. Surrounding landscaping should be such that run-off water is prevented from ponding beside buildings or pavement areas. Ingress of surface moisture can cause increased moisture contents which may result in swelling, softening and premature failure of the paved surface.

6.0 DESIGN AND CONSTRUCTION GUIDELINES

Recommended general design and construction guidelines are provided in Appendix C, under the following headings:

- Backfill Materials and Compaction (4 pages)
- Construction Excavations (1 page)
- Floor Slabs-on-Grade (1 page)
- Pavements (2 pages)
- Proof-rolling (1 page)
- Shallow Foundations (1 page)
- Bored Cast-in-Place Piles (3 pages)

These guidelines are intended to present standards of good practice. Although supplemental to the main text of this report, they should be interpreted as part of the report. Design recommendations presented herein are based on the premise that these guidelines will be followed.

The design and construction guidelines are not intended to represent detailed specifications for the works although they may prove useful in the preparation of such specifications.

In the event of any discrepancy between the main text of this report and Appendix C, the main text should govern.

7.0 LIMITATIONS OF LIABILITY

Recommendations presented herein are based on a geotechnical evaluation of the findings in four supplementary boreholes and a review of the geotechnical information from the geotechnical evaluation (EBA File 0104-20076). The conditions encountered during the fieldwork are considered to be reasonably representative of the site. If, however, conditions other than those reported are noted during subsequent phases of the project, EBA should be notified and given the opportunity to review our current recommendations in light of new findings. Recommendations presented herein may not be valid if an adequate level of monitoring is not provided during construction, or if relevant building code requirements are not met.

This report has been prepared for the exclusive use of Public Works Government Services Canada and their agent, Wood, O'Neill, O'Neill, Architects Ltd., for specific application to the development described in this report. It has been prepared in accordance with generally accepted geotechnical engineering practices. No other warranty is made, either expressed or implied.

For further limitations, reference should be made to the General Conditions in Appendix A.

8.0 CLOSURE

We trust this report meets your present requirements. We would be pleased to provide any further information that may be needed during design and to advise on the geotechnical aspects of specifications for inclusion in contract documents. Should you require any additional information or monitoring services please do not hesitate to contact our office.

Yours truly,
EBA ENGINEERING CONSULTANTS LTD. Reviewed by:

PROFESSIONAL ENGINEER
JAMES A. RYAN
ALBERTA
2000/06/13

PROFESSIONAL ENGINEER
B.C.M. PULLES
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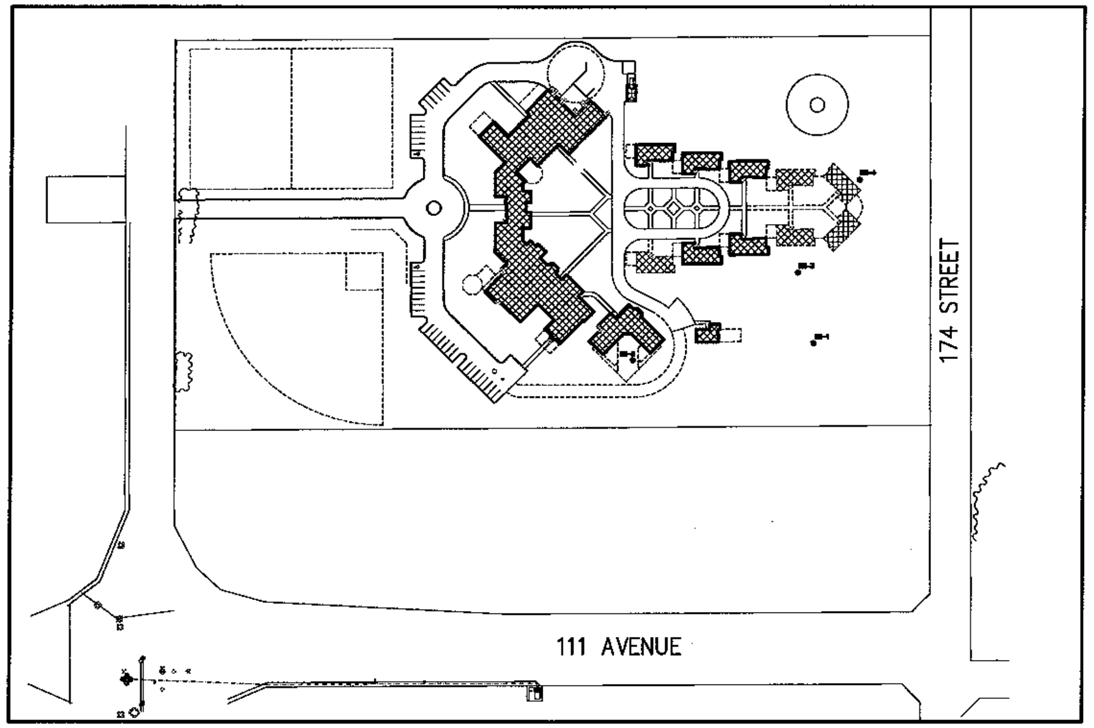
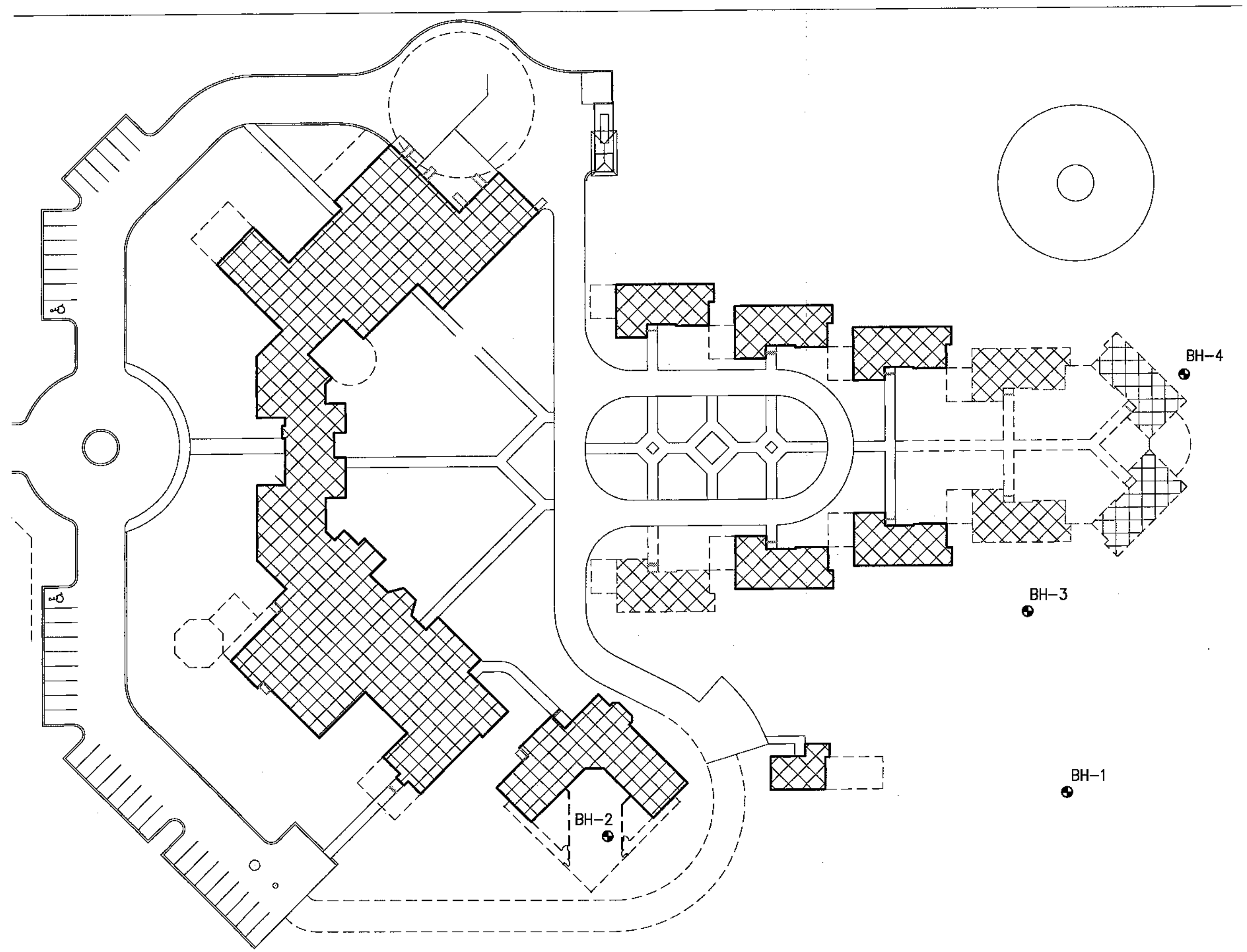
PERMIT TO PRACTICE
EBA ENGINEERING CONSULTANTS LTD.
Signature
Date 2000.06.13
PERMIT NUMBER: P245
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

FIGURES



KEY PLAN



LEGEND:

⊗ – BOREHOLE LOCATIONS

0 50
metres

Figure 1
Site Plan
Borehole Locations

22628D02A.dwg

APPENDIX A

GENERAL CONDITIONS

This report incorporates and is subject to these "General Conditions".

A.1 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of EBA's client. EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than EBA's client unless otherwise authorized in writing by EBA. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of EBA. Additional copies of the report, if required, may be obtained upon request.

A.2 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

A.3 LOGS OF TEST HOLES

The test hole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

A.4 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

A.5 SURFACE WATER AND GROUNDWATER CONDITIONS

Surface and groundwater conditions mentioned in this report are those observed at the times recorded in the report. These conditions vary with geological detail between observation sites; annual, seasonal and special meteorologic conditions; and with development activity. Interpretation of water conditions from observations and records is judgmental and constitutes an evaluation of circumstances as influenced by geology, meteorology and development activity. Deviations from these observations may occur during the course of development activities.

A.6 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

A.7 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

A.8 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

A.9 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

A.10 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

A.11 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

A.12 SAMPLES

EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the client's expense upon written request, otherwise samples will be discarded.

A.13 STANDARD OF CARE

Services performed by EBA for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practising under similar conditions in the jurisdiction in which the services are provided. Engineering judgement has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of this report.

A.14 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

A.15 ALTERNATE REPORT FORMAT

Where EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed EBA's instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding. The hard copy versions submitted by EBA shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancies, the hard copy versions shall govern over the electronic versions. Furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed version archived by EBA shall be deemed to be the overall original for the Project.

The Client agrees that both electronic file and hard copy versions of EBA's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except EBA. The Client warrants that EBA's instruments of professional service will be used only and exactly as submitted by EBA.

The Client recognizes and agrees that electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. EBA makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

APPENDIX B

BOREHOLE LOGS

TERMS USED ON BOREHOLE LOGS

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE GRAINED SOILS (major portion retained on 0.075mm sieve): includes (1) clean gravels and sands, and (2) silty or clayey gravels and sands. Condition is rated according to relative density, as inferred from laboratory or in situ tests.

DESCRIPTIVE TERM	RELATIVE DENSITY	N (blows per 0.3m)
Very Loose	0 to 20%	0 to 4
Loose	20 to 40%	4 to 10
Compact	40 to 75%	10 to 30
Dense	75 to 90%	30 to 50
Very Dense	90 to 100%	greater than 50

The number of blows, N, on a 51mm O.D. split spoon sampler of a 63.5kg weight falling 0.76m, required to drive the sampler a distance of 0.3m from 0.15m to 0.45m.

FINE GRAINED SOILS (major portion passing 0.075mm sieve): includes (1) inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as estimated from laboratory or in situ tests.

DESCRIPTIVE TERM	UNCONFINED COMPRESSIVE STRENGTH (kPa)
Very Soft	Less Than 25
Soft	25 to 50
Firm	50 to 100
Stiff	100 to 200
Very Stiff	200 to 400
Hard	Greater Than 400

NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above, because of planes of weakness or cracks in the soil.

GENERAL DESCRIPTIVE TERMS

Slickensided	- having inclined planes of weakness that are slick and glossy in appearance.
Fissured	- containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.
Laminated	- composed of thin layers of varying colour and texture.
Interbedded	- composed of alternate layers of different soil types.
Calcareous	- containing appreciable quantities of calcium carbonate.
Well Graded	- having wide range in grain sizes and substantial amounts of intermediate particle sizes.
Poorly graded	- predominantly of one grain size, or having a range of sizes with some intermediate size missing.

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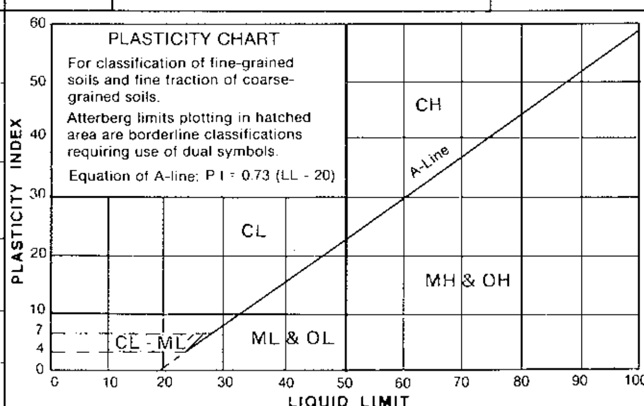
UNIFIED SOIL CLASSIFICATION †

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES	CLASSIFICATION CRITERIA		
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve *	GRAVELS 50% or more of coarse fraction retained on No. 4 sieve	CLEAN GRAVELS	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	Classification on basis of percentage of fines Less than 5% Pass No. 200 sieve: GW, GP, SW, SP More than 12% Pass No. 200 sieve: GM, GC, SM, SC 5% to 12% Pass No. 200 sieve: Borderline Classification requiring use of dual symbols.	$C_u = D_{60}/D_{10}$ Greater than 4 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines		Not meeting both criteria for GW	
		GRAVELS WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures		Atterberg limits plot below "A" line or plasticity index less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits plot above "A" line and plasticity index greater than 7	
	SANDS More than 50% of coarse fraction passes No. 4 sieve	CLEAN SANDS	SW	Well-graded sands and gravelly sands, little or no fines.		$C_u = D_{60}/D_{10}$ Greater than 6 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			SP	Poorly graded sands and gravelly sands, little or no fines		Not meeting both criteria for SW	
		SANDS WITH FINES	SM	Silty sands, sand-silt mixtures		Atterberg limits plot below "A" line or plasticity index less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		Atterberg limits plot above "A" line and plasticity index greater than 7	
FINE-GRAINED SOILS 50% or more passes No. 200 sieve *	SILTS AND CLAYS Liquid limit 50% or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands	PLASTICITY CHART (see below)		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL	Organic silts and organic silty clays of low plasticity			
	SILTS AND CLAYS Liquid limit greater than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts			
			CH	Inorganic clays of high plasticity, fat clays			
			OH	Organic clays of medium to high plasticity			
HIGHLY ORGANIC SOILS			Pt	Peat, muck and other highly organic soils			



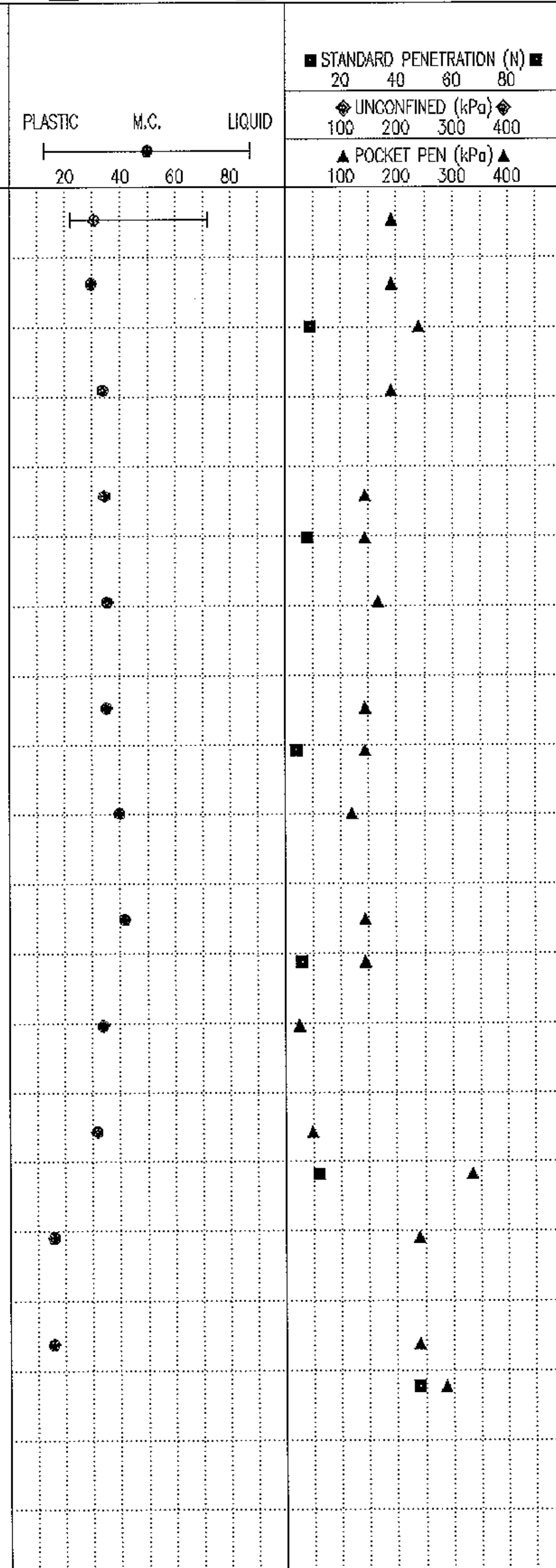
* Based on the material passing the 3-in. (75-mm) sieve
† ASTM Designation D 2487

WOMEN'S CORRECTIONAL FACILITY ADDITION	PUBLIC WORKS CANADA	BOREHOLE NO: 22628-01
111 AVENUE AND 178 STREET	DRILL: SOLID STEM AUGER	PROJECT NO: 0104-00-22628
EDMONTON, ALBERTA		ELEVATION:

SAMPLE TYPE: DISTURBED, NO RECOVERY, SPT, A-CASING, SHELBY TUBE, CORE

BACKFILL TYPE: BENTONITE, PEA GRAVEL, SLOUGH, GROUT, DRILL CUTTINGS, SAND

Depth(m)	SOIL DESCRIPTION	SPT(N)	Depth(ft)
0.0	TOPSOIL – sod cover, (100mm thick)		0.0
	CLAY – silty, trace of sand, sand stringers and gypsum crystals, moist, stiff, high plastic, mottled grey brown		
1.0		9	
			5.0
2.0			
		8	
3.0			10.0
	– very silty inclusion, wet, trace of free water, soft		
4.0		4	
	– brown		15.0
5.0			
		6	
6.0	SILT AND CLAY – trace of fine grained sand, very moist, firm, low to medium plastic		20.0
7.0	CLAY (TILL) – silty, sandy, trace of gravel and coal particles, moist, very stiff, low to medium plastic, brown	12	
			25.0
8.0			
		48	
9.0	END OF BOREHOLE (8.84 metres) slough – none at 0 hrs. water – trace at 0 hrs.		30.0
10.0			



INSTRUMENTATION DATA

EBA ENGINEERING CONSULTANTS LTD.
EDMONTON, ALBERTA

LOGGED BY: JAR	COMPLETION DEPTH: 8.84 m
REVIEWED BY: JAR	COMPLETE: 00/06/01
Fig. No: 22628-01	Page 1 of 1

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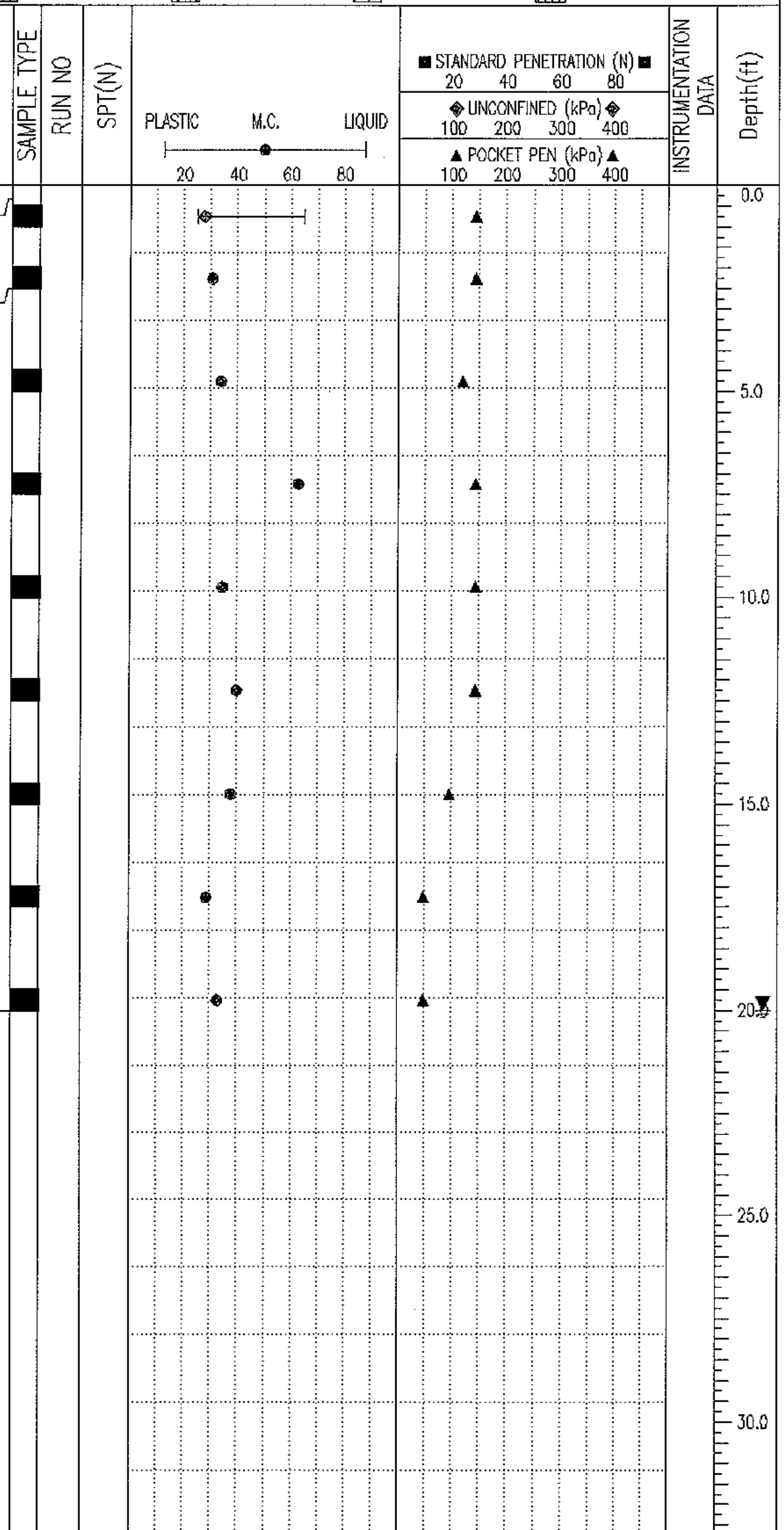
WOMEN'S CORRECTIONAL FACILITY ADDITION	PUBLIC WORKS CANADA	BOREHOLE NO: 22628-02
111 AVENUE AND 178 STREET	DRILL: SOLID STEM AUGER	PROJECT NO: 0104-00-22628
EDMONTON, ALBERTA		ELEVATION:

SAMPLE TYPE: DISTURBED, NO RECOVERY, SPT, A-CASING, SHELBY TUBE, CORE

BACKFILL TYPE: BENTONITE, PEA GRAVEL, SLOUGH, GROUT, DRILL CUTTINGS, SAND

Depth(m)	SOIL DESCRIPTION
0.0	TOPSOIL – sod cover, (100mm thick)
	CLAY (FILL) – silty, trace of organic staining, moist, stiff, high plastic, mottled grey brown
1.0	CLAY – silty, trace of sand stringers and gypsum crystals, moist, stiff, high plastic, mottled grey brown
3.0	– trace of seepage, brown
4.0	– very moist, firm to stiff
5.0	– very silty, some sand, firm, low plastic
	– clay (till) inclusion, very stiff
6.0	END OF BOREHOLE (6.10 metres)
	slough – none at 0 hrs.
	water – trace at 0 hrs.



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	REVIEWED BY: JAR	COMPLETE: 00/06/01
	Fig. No: 22628-02	Page 1 of 1

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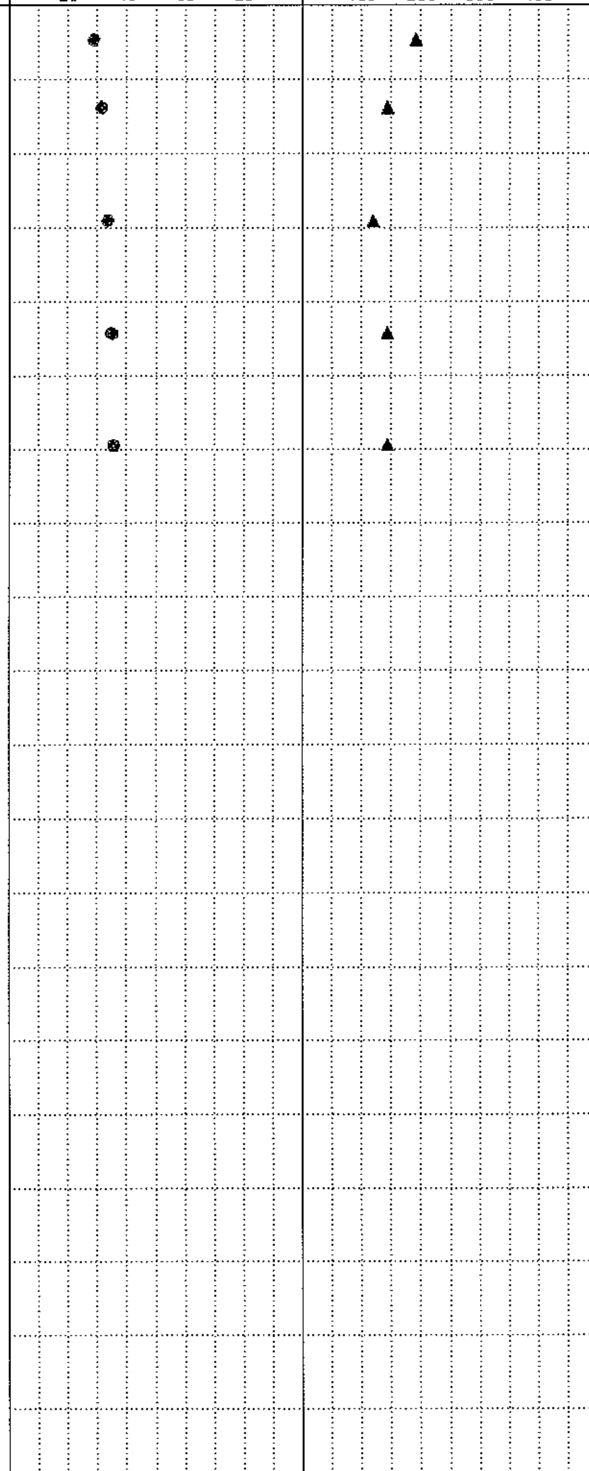
WOMEN'S CORRECTIONAL FACILITY ADDITION	PUBLIC WORKS CANADA	BOREHOLE NO: 22628-03
111 AVENUE AND 178 STREET	DRILL: SOLID STEM AUGER	PROJECT NO: 0104-00-22628
EDMONTON, ALBERTA		ELEVATION:

SAMPLE TYPE: DISTURBED, NO RECOVERY, SPT, A-CASING, SHELBY TUBE, CORE

BACKFILL TYPE: BENTONITE, PEA GRAVEL, SLOUGH, GROUT, DRILL CUTTINGS, SAND

Depth(m)	SOIL DESCRIPTION	SAMPLE TYPE	RUN NO	SPT(N)	PLASTIC M.C. LIQUID (20 40 60 80)	STANDARD PENETRATION (N) 20 40 60 80 / UNCONFINED (kPa) 100 200 300 400 / POCKET PEN (kPa) 100 200 300 400	INSTRUMENTATION DATA	Depth(ft)
0.0	TOPSOIL – sod cover, (100mm thick)							0.0
	CLAY (FILL) – silty, trace of organic staining, moist, stiff, high plastic, mottled grey brown							
1.0	CLAY – silty, trace of sand stringers and gypsum crystals, moist, stiff, high plastic, mottled grey brown							5.0
2.0								
3.0	END OF BOREHOLE (3.05 metres) slough – none at 0 hrs. water – dry at 0 hrs.							10.0
4.0								
5.0								15.0
6.0								20.0
7.0								
8.0								25.0
9.0								30.0
10.0								



EBA ENGINEERING CONSULTANTS LTD. EDMONTON, ALBERTA	LOGGED BY: JAR	COMPLETION DEPTH: 3.05 m
	REVIEWED BY: JAR	COMPLETE: 00/06/01
	Fig. No: 22628-03	Page 1 of 1

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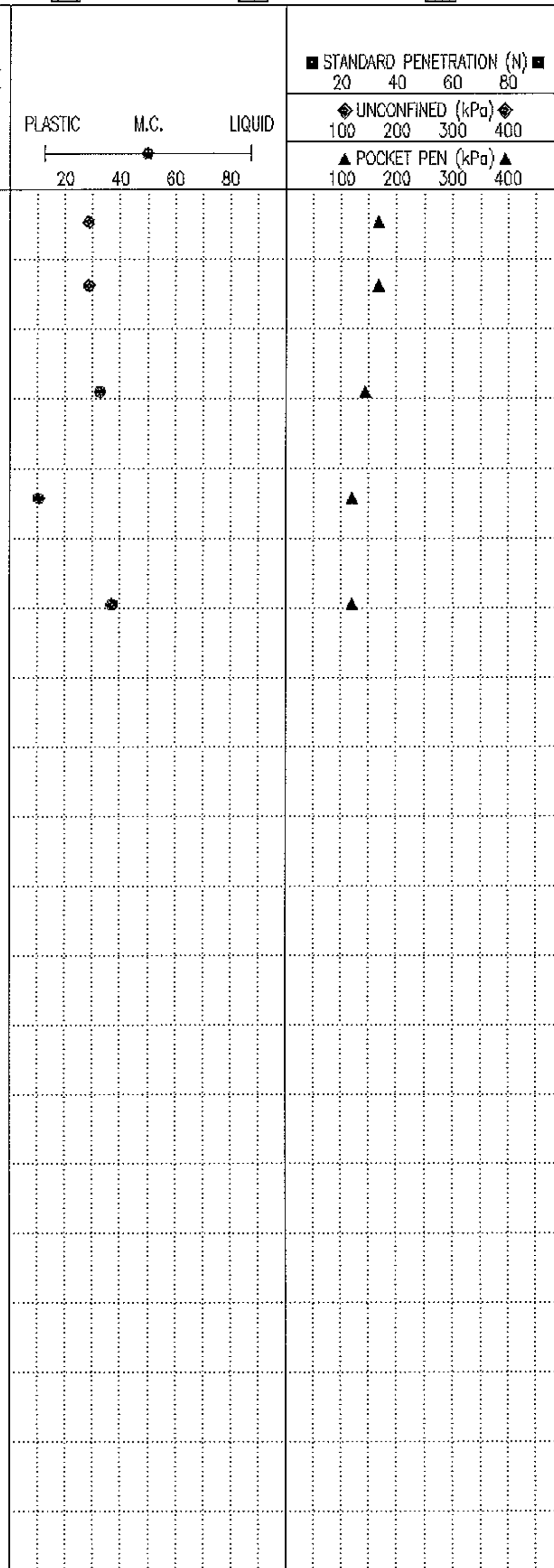
WOMEN'S CORRECTIONAL FACILITY ADDITION	PUBLIC WORKS CANADA	BOREHOLE NO: 22628-04
111 AVENUE AND 178 STREET	DRILL: SOLID STEM AUGER	PROJECT NO: 0104-00-22628
EDMONTON, ALBERTA		ELEVATION:

SAMPLE TYPE: DISTURBED, NO RECOVERY, SPT, A-CASING, SHELBY TUBE, CORE

BACKFILL TYPE: BENTONITE, PEA GRAVEL, SLOUGH, GROUT, DRILL CUTTINGS, SAND

Depth(m)	SOIL DESCRIPTION	SAMPLE TYPE	RUN NO	SPT(N)	Depth(ft)
0.0	TOPSOIL – sod cover, (100mm thick)				0.0
	CLAY (FILL) – silty, trace of organic staining, moist, stiff, high plastic, mottled grey brown				
1.0	CLAY – silty, some sand stringers, moist, stiff, high plastic, mottled grey brown				5.0
2.0	– occasional sand stringers				
3.0	END OF BOREHOLE (3.05 metres) slough – none at 0 hrs. water – dry at 0 hrs.				10.0
4.0					15.0
5.0					
6.0					20.0
7.0					25.0
8.0					
9.0					30.0
10.0					



EBA ENGINEERING CONSULTANTS LTD.	LOGGED BY: JAR	COMPLETION DEPTH: 3.05 m
	REVIEWED BY: JAR	COMPLETE: 00/06/01
EDMONTON, ALBERTA	Fig. No: 22628-04	Page 1 of 1

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APPENDIX C

CONSTRUCTION GUIDELINES

BACKFILL MATERIALS AND COMPACTION

Maximum density as used in this section means Standard Proctor Maximum Dry Density (ASTM Test Method D698) unless specifically noted otherwise. Optimum moisture content is as defined in this test.

"General engineered fill" materials should comprise clean, well-graded granular soils or inorganic low plastic clay soils. Fill materials should be placed in layers of 150 millimetres compacted thickness. General engineered fills should be compacted to 98 percent of maximum density.

Granular soils used for general engineered fills should consist of relatively clean, well graded, sand or mixture of sand and gravel (maximum size 75 mm).

Low plastic clay with the following range of Atterberg limits is generally considered suitable for use as engineered fill.

Liquid Limit	= 20 to 40%
Plastic Limit	= 10 to 20%
Plasticity Index	= 10 to 30%

Clay fill material should be compacted at or slightly above the optimum moisture content.

"Structural fill" materials should comprise clean, well-graded inorganic granular soils. Such fill should be placed in compacted lifts not exceeding 150 mm and compacted to not less than 100 percent of maximum density, at a moisture content at or slightly above optimum.

"Landscape fill" material may comprise soils without regard to engineering quality. Such soils should be placed in compacted lifts not exceeding 300 mm and compacted to a density of not less than 90 percent of maximum density.

Backfill adjacent to and above footings, abutment walls, basement walls, grade beams and pile caps or below highway, street or parking lot pavement sections and base courses should comprise "general engineered fill" materials as defined above.

Backfill supporting structural loads should comprise "structural fill" materials as defined above.

Backfill adjacent to exterior footings, foundation walls, grade beams and pile caps and within 300 mm of final grade should comprise inorganic low plastic clay “general engineered” fill as defined above. Such backfill should provide a relatively impervious surface layer to reduce seepage into the subsoil.

Backfill should not be placed against a foundation structure until the structure has sufficient strength to withstand the earth pressures resulting from placement and compaction. During compaction, careful observation of the foundation wall for deflection should be carried out continuously. Where deflections are apparent, the compactive effort should be reduced accordingly.

In order to reduce potential compaction induced stresses, only hand held compaction equipment should be used in the compaction of fill within 500 mm of retaining walls or basement walls.

Backfill materials should not be placed in a frozen state, or placed on a frozen subgrade. All lumps of materials should be broken down during placement.

Where the maximum-sized particles in any backfill material exceed 50 percent of the minimum dimension of the cross-section to be backfilled, such particles should be removed and placed at other more suitable locations on-site or screened off prior to delivery to site.

Bonding should be provided between backfill lifts, if the previous lift has become desiccated. For fine-grained materials the previous lift should be scarified to the base of the desiccated layer, properly moisture-conditioned and recompacted and bonded thoroughly to the succeeding lift. For granular materials, the surface of the previous lift should be scarified to about a 75 mm depth followed by proper moisture-conditioning and recompaction.

Recommendations for specifications for various backfill types are presented below.

“Pit-Run gravel” and fill sand shall be reasonably well graded and should conform to the following gradings:

SIEVE SIZE	PERCENT PASSING BY WEIGHT PIT RUN GRAVEL	FILL SAND
75.0 mm	100	--
25.0 mm	--	100
5.0 mm	25 - 50	80 - 100
630 μm	--	45 - 80
80 μm	2 - 8	2 - 10

The Pit-Run gravel should be free of any form of coating and any gravel or sand containing clay, loam or other deleterious materials should be rejected. No oversize material should be tolerated. The percent of material passing the 80 μm sieve should not exceed 2/3 of the material passing the 315 m sieve.

20 mm and 63 mm crushed gravel should be hard, clean, well graded, crushed aggregate, free of organics, coal, clay lumps, coatings of clay, silt and other deleterious materials. The aggregates should conform to the following gradation requirement when tested in accordance with ASTM C136:

SIEVE SIZE	PERCENT PASSING BY WEIGHT 20 mm CRUSH	63 mm CRUSH
63 mm	--	100
40 mm	--	80 - 100
20 mm	100	60 - 85
12.5 mm	60 - 92	50 - 75
5.0 mm	37 - 62	25 - 50
2.0 mm	26 - 44	20 - 45
400 μm	12 - 27	10 - 30
160 μm	7 - 18	5 - 15
80 μm	2 - 8	2 - 8

A minimum of 60 percent of the material retained on the 5 mm sieve for the 20 mm crushed gravel should have at least two freshly crushed faces. Not less than 40 percent of the material retained on the 5 mm sieve for the 63 mm crushed gravel should have at least two freshly crushed faces.

The 20 mm granular course should be compacted in lifts not exceeding 150 millimetres to 100 percent of Standard Proctor maximum dry density.

"Coarse gravel" for bedding and drainage should conform to the following grading:

SIEVE SIZE	PERCENT PASSING BY WEIGHT 40 mm GRAVEL	28 mm GRAVEL
56 mm	100	--
40 mm	90 - 100	100
28 mm	--	95 - 100
20 mm	35 - 70	--
14 mm	--	25 - 60
10 mm	10 - 30	--
5 mm	0 - 5	0 - 10
2.5 mm	--	0 - 5

"Coarse sand" for bedding and drainage should conform to the following grading:

SIEVE SIZE (Square Openings)	PERCENT PASSING (By Weight)
10 mm	100
5 mm	95 - 100
2.5 mm	80 - 100
1.25 mm	50 - 90
630 µm	25 - 65
315 µm	10 - 35
160 µm	2 - 10

"Lean-mix concrete" should be low strength concrete having a minimum 28-day compressive strength of 3.5 MPa.

CONSTRUCTION EXCAVATIONS

Construction should be in accordance with good practice and comply with the requirements of the responsible regulatory agencies.

All excavations greater than 1.5 m deep should be sloped or shored for worker protection.

Shallow excavations up to about 3 m depth may use temporary sideslopes of 1H:1V. A flatter slope of 2H:1V should be used if groundwater is encountered. Localized sloughing can be expected from these slopes.

Deep excavations or trenches may require temporary support if space limitations or economic considerations preclude the use of sloped excavations.

For excavations greater than 3 m depth, temporary support should be designed by a qualified geotechnical engineer. The design and proposed installation and construction procedures should be submitted to EBA for review.

The construction of a temporary support system should be monitored. Detailed records should be taken of installation methods, materials, in situ conditions and the movement of the system. If anchors are used, they should be load tested. EBA can provide further information on monitoring and testing procedures if required.

Attention should be paid to structures or buried service lines close to the excavation. For structures, a general guideline is that if a line projected down, at 45 degrees from the horizontal from the base of foundations of adjacent structures intersects the extent of the proposed excavation, these structures may require underpinning or special shoring techniques to avoid damaging earth movements. The need for any underpinning or special shoring techniques and the scope of monitoring required can be determined when details of the service ducts and vaults, foundation configuration of existing buildings and final design excavation levels are known.

No surface surcharges should be placed closer to the edge of the excavation than a distance equal to the depth of the excavation, unless the excavation support system has been designed to accommodate such surcharge.

FLOOR SLABS-ON-GRADE

All soft, loose or organic material should be removed from beneath slab areas. If any local 'hard spots' such as old basement walls are revealed beneath the slab area, these should be overexcavated and removed to not less than 0.9 m below underside of slab level. The exposed soil should be proof-rolled and the final grade restored by general engineered fill placement. If proof-rolling reveals any soft or loose spots, these should be excavated and the desired grade restored by general engineered fill placement. Proof-rolling should be carried out in accordance with the recommendations given elsewhere in this Appendix. The subgrade should be compacted to a depth of not less than 0.3 m to a density of not less than 98 percent Standard Proctor Maximum Dry Density (ASTM Test Method D698).

If, for economic reasons, it is considered desirable to leave low quality material in-place beneath a slab-on-grade, special ground treatment procedures may be considered, EBA could provide additional advice on this aspect if required.

A levelling course of 20 mm crushed gravel at least 150 mm in compacted thickness, is recommended directly beneath all slabs-on-grade. Alternatively a minimum thickness of 150 mm of pit-run gravel overlain by a minimum thickness of 50 mm of 20 mm crushed gravel may be used. Very coarse material (larger than 25 mm diameter) should be avoided directly beneath the slab-on-grade to limit potential stress concentrations within the slab. All levelling courses directly under floor slabs should be compacted to 100 percent of Standard Proctor maximum dry density.

General engineered fill, pit-run gravel and crushed gravel are defined under the heading 'Backfill Materials and Compaction' elsewhere in this Appendix.

The slab should be structurally independent from walls and columns supported on foundations. This is to reduce any structural distress that may occur as a result of differential soil movements. If it is intended to place any internal non-load bearing partition walls directly on a slab-on-grade, such walls should also be structurally independent from other elements of the building founded on a conventional foundation system so that some relative vertical movement of the walls can occur freely.

The excavated subgrade beneath slabs-on-grade should be protected at all times from rain, snow, freezing temperatures, excessive drying and the ingress of free water. This applies during and after the construction period.

A minimum slab concrete thickness of 100 mm is recommended. Control joints should be provided in all slabs. Typically for a 125 mm slab thickness; control joints should be placed on a 3 m square grid, should be sawn to a depth of one-quarter the slab thickness and have a width of approximately 3 mm.

Wire mesh reinforcement, 150 mm square grid, should be provided to reduce the possibility of uncontrolled slab cracking. The mesh should be adequately supported and should be located at mid-height of the slab with adequate cover.

PAVEMENTS

The following recommended procedures for pavements have been based on the use of the area generally by cars with some light truck traffic, as is normal for parking lot areas and access roadways. Recommendations for occasional heavy truck access areas are also presented. These recommendations are intended as minimums only for subgrades having a California Bearing Ratio (CBR) value of 2 or higher, under saturated conditions.

Maximum density as used in this section means Standard Proctor Maximum Dry Density (ASTM Test Method D698) unless specifically noted otherwise.

The subgrade should be graded to drain towards catch basin locations. All loose, soft or organic material should be removed from beneath pavement areas. The subgrade should be scarified to a depth of not less than 150 mm below the surface and recompacted. In areas where general engineered fill is placed to achieve design grades, the subgrade should be compacted to 98 percent of maximum density and proof-rolled prior to placing fill. The upper 150 mm of subgrade (and/or general engineered fill) under pavement sections should be compacted to not less than 100 percent of maximum density.

Proof-rolling of the entire surface area under pavement sections should be carried out to detect any local soft spots. Soft spots detected as a result of proof-rolling should be excavated and backfilled with 'general engineered fill'. Recommended procedures for proof-rolling are presented under a separate section in Appendix C. General engineered fill is defined under the section entitled "Backfill Materials and Compaction" in Appendix C.

The parking area and roadways base course should comprise a layer of compacted cement stabilized aggregate or crushed gravel of nominal size equal to 20 mm placed on top of the compacted subgrade. The base course should have a compacted thickness of not less than 100 mm. The base course should be compacted to not less than 100 percent of maximum density.

The surface of the final lift of base course must have an asphalt prime coat of SS-1, or its equivalent, applied prior to the placement of asphaltic concrete.

The asphalt thickness is dependent on asphalt mix specifications and should be reviewed when details of the mix are available. Minimum surface lift thickness in multiple-lift construction should be not less than 50 mm.

Preparation of the subgrade should be carried out within restricted areas. This is to avoid loosening of the prepared areas by site traffic before compaction of the subgrade and placement of the granular material have been completed. Protection of the prepared subgrade against precipitation and frost should be undertaken.

Observation of compaction and asphalt laying operations should be carried out by staff of EBA Engineering Consultants Ltd.

Where there is risk of gasoline or diesel oil spillage, such as in the vicinity of pump islands, concrete pavements are preferred to asphalt.

PROOF-ROLLING

Proof-rolling is a method of detecting soft areas in an 'as-excavated' subgrade for fill, pavement, floor or foundations or detecting non-uniformity of compacted embankment. The intent is to detect soft areas or areas of low shear strength not otherwise revealed by means of testholes, density testing, or visual examination of the site surface and to check that any fill placed or subgrade meets the necessary design strength requirements.

Proof-rolling should be observed by qualified geotechnical personnel.

Proof-rolling is generally accomplished by the use of a heavy (15 to 60 tonne) rubber-tired roller having 4 wheels abreast on independent axles with high contact wheel pressures (inflation pressures ranging from 550 kPa (80 psi) up to 1030 kPa (150 psi).

A heavily loaded tandem axle gravel truck may be used in lieu of the equipment described in the paragraph above. The truck should be loaded to approximately 10 tonnes per axle and a minimum tire pressure of 550 kPa (80 psi).

Ground speed - maximum 8 km/hr., recommended 4 km/hr.

The recommended procedure is two complete coverages with the proof-rolling equipment in one direction and a second series of two coverages made at right angles to the first series; one 'coverage' means that every point of the proof-rolled surface has been subjected to the tire pressure of a loaded wheel. Less rigorous procedures may be acceptable under certain conditions subject to the approval of an engineer.

Any areas of soft, rutted, or displaced materials detected should be either recompacted with additional fill or the existing material removed and replaced with general engineered fill, or properly moisture conditioned as necessary.

The surface of the grade under the action of the proof-roller should be observed, noting; visible deflection and rebound of the surface, formation of a crack pattern in the compacted surface or shear failure in the surface of granular soils as ridging between wheel tracks.

If any part of an area indicates significantly more distress than other parts, the cause should be investigated, by, for example, shallow auger holes.

In the case of granular subgrades, distress will generally consist of either compression due to insufficient compaction or shearing under the tires. In the first case, rolling should be continued until no further compression occurs. In the second case, the tire pressure should be reduced to a point where the subgrade can carry the load without significant deflection and subsequently gradually increased to its specified pressure as the subgrade increases in shear strength under this compaction.

SHALLOW FOUNDATIONS

Design and construction of shallow foundations should comply with relevant Building Code requirements.

The term 'shallow foundations' includes strip and spread footings, mat slab and raft foundations.

Minimum footing dimensions in plan should be 0.45 m and 0.9 m for strip and square footings respectively.

No loose, disturbed or sloughed material should be allowed to remain in open foundation excavations. Hand cleaning should be undertaken to prepare an acceptable bearing surface. Recompaction of disturbed or loosened bearing surface may be required.

Foundation excavations and bearing surfaces should be protected from rain, snow, freezing temperatures, excessive drying and the ingress of free water before, during and after footing construction.

Footing excavations should be carried down into the designated bearing stratum.

After the bearing surface is approved, a mud slab should be poured to protect the soil and provide a working surface for construction, should immediate foundation construction not be intended.

All constructed foundations should be placed on unfrozen soils, which should be at all times protected from frost penetration.

All foundation excavations and bearing surfaces should be inspected by a qualified geotechnical engineer to check that the recommendations contained in this report have been followed.

Where over-excavation has been carried out through a weak or unsuitable stratum to reach into a suitable bearing stratum or where a foundation pad is to be placed above stripped natural ground surface such over-excavation may be backfilled to subgrade elevation utilizing either structural fill or lean-mix concrete. These materials are defined under the separate heading 'Backfill Materials and Compaction'.

BORED CAST-IN-PLACE CONCRETE PILES

Design and construction of piles should comply with relevant Building Code requirements.

Piles should be installed under full-time inspection of geotechnical personnel. Pile design parameters should be reviewed in light of the findings of the initial bored shafts drilled on a site. Further design review may be necessary if conditions observed during site construction do not conform to design assumptions.

Where fill material or lenses or strata of sand, silt or gravel are present within the designed pile depth, these may be incompetent and/or water bearing and may cause sloughing. Casing should be on hand before drilling starts and be used, if necessary, to seal off water and/or prevent sloughing of the hole.

If piles are to be underreamed (belled), the underreams should be formed entirely in self supporting soil and entirely within the competent bearing stratum. Where caving occurs at design elevation it may be necessary to extend the base of the pile bell to a greater depth. Piles may be constructed with bells having outside diameters up to approximately three times the diameters of their shafts. Piles with shaft diameters of less than 400 mm should not be underreamed due to difficulties associated with ensuring a clean base.

Prior to pouring concrete, bottoms of pile bells or of straight-shaft end-bearing piles should be cleaned of all disturbed material.

Pile excavations should be visually inspected after completion to ensure that disturbed materials and/or water are not present on the base so that recommended allowable bearing and skin friction parameters may apply.

Visual inspection may be accomplished by the inspector descending into the pile shaft (shaft diameter of 760 mm (30 inch) or greater). A protective cage and other safety equipment required by government regulations should be provided by the contractor to facilitate downhole inspection.

Other procedures to inspect the pile shafts may be used where shaft diameters of less than 760 mm (30 inch) are constructed, such as, inspection with a light.

For safety reasons, where hand cleaning and/or 'down shaft' inspection by personnel are required, the pile shaft must be cased full-length prior to personnel entering the shaft.

Reinforcing steel should be on hand and should be placed as soon as the bore has been completed and approved.

Longitudinal reinforcing steel is recommended to counteract the possible tensile stresses induced by frost action and should extend to a minimum depth of 3.5 m. A minimum steel of 0.5 percent of the gross shaft area is recommended.

Where a limited quantity of water is present on the pile base, when permitted or directed by a geotechnical engineer, it should be either removed or absorbed by the addition of dry cement, which should then be thoroughly mixed as an in situ slurry by means of the belling tool, using reverse rotation of the tool. Where significant quantities of water are present and it is impracticable to exclude water from the pile bore, concrete should be placed by tremie techniques or concrete pump.

A “dry” pile should be poured by “free fall” of concrete only where impact of the concrete against the reinforcing cage, which can cause segregation of the concrete, will not occur. A hopper should be used to direct concrete down the centre of the pile base and to prevent impact of concrete against reinforcing steel.

Concrete used for “dry” uncased piles should be self compacting and should have a slump of between 100 mm and 130 mm. Where casing is required to prevent sloughing or seepage, the slump should be increased to 150 mm. In order to comply with maximum water:cement ratios for the concrete, the use of chemicals (or superplasticizers) to temporarily increase the slump may be required. Concrete for each pile should be poured in one continuous operation and should be placed immediately after excavation and inspection of piles, to reduce the opportunity for the ingress of free water or deterioration of the exposed soil or rock.

If piles cannot be formed in dry conditions then the concrete should be placed by tremie tube or concrete pump. Concrete placed by tremie should have a slump of not less than 150 mm. A ball or float should be used in the tremie tube to separate the initial charge of concrete from the water in the pile hole. The outlet of the tremie tube should be maintained at all times 1.0 m to 2.0 m below the surface of the concrete. The diameter of the tremie tube should be at least 200 mm. The tube should be water tight and not be made of aluminum. Smaller diameter pipes may be used with a concrete pump. The surface of the concrete should be allowed to rise above the cut off level of the pile, so that when the temporary casing is withdrawn and the surface level of the concrete adjusts to the new volume, the top of the uncontaminated concrete is at or above the cut off level. The concrete should be placed in one continuous smooth operation without any halts or delays. Placing the lower portion of the pile by tremie tube and placing the upper portion of the pile by “free fall” should not be permitted, to ensure that defects in the pile shaft at the top of the tremie concrete do not occur. As the surface of the concrete rises in the pile bore the water in the pile bore will be displaced upwards and out of the top of the pile casing. It may be necessary to pump off this water to a container or temporary ditch drain to prevent the formation of ice or flooding conditions, and possibly damage to existing structures.

When concreting piles by tremie techniques allowance should be made for the removal of contaminated or otherwise defective concrete at the tops of the piles.

The casing should be filled with concrete and then the casing should be withdrawn smoothly and continuously. Sufficient concrete should be placed to allow for the additional volume of the casing and reduction in level of the concrete as the casing is withdrawn. Concrete should not be poured on top of previously poured concrete, after the casing is withdrawn.

An accurate record of the volume of concrete placed should be maintained as a check that a continuous pile had been formed.

Concrete should not be placed if its temperature is less than 5°C or exceeds 30°C, or if it is more than 2.0 hours old.

Where tension, horizontal or bending moment loading on the pile is foreseen, steel reinforcing should be extended and tied into the grade beam or pile cap. The steel should be designed to transfer loads to the required depth in the pile and to resist resultant bending moments and shear forces.

Void formers should be placed beneath all grade beams to reduce the risk of damage due to frost effects or soil moisture changes.

Where the drilling operation might affect the concrete in an adjacent pile (i.e.; where pile spacing is less than about three diameters) drilling should not be carried out before the previously poured pile concrete has set for at least 24 hours.

Where a group of four or more piles are used the allowable working load on the piles may need to be modified to allow for group effects.

Piles should be spaced no closer than 2.5 times the pile shaft diameter, measured centre-to-centre. Strict control of pile location and verticality should be exercised to provide accurate locations and spacings of piles. In general, piles should be constructed within a tolerance of 75 mm plan distance in any direction and within a verticality of 1 in 75.

A detailed record should be kept of pile construction; the following information should be included, pile number, shaft/base diameter, date and time bored, date and time concreted, elevation of piling platform, depths (from piling platform level) to pile base and to concrete cut-off level, length of casing used, details of reinforcement, details of any obstructions, details of any groundwater inflows, brief description of soils encountered in the bore and details of any unusual occurrences during construction.

If a large number of piles are to be installed, it may be possible to optimize the design on the basis of pile load tests.