Report of Geotechnical Exploration Program

Proposed Elementary School Addition
Parshall, North Dakota
MTS #G22-029

For

EngTech

May 26, 2022

MATERIAL TESTING SERVICES, LLC

MATERIAL TESTING SERVICES, LLC

May 26, 2022

Attn: Mr. Trevor Huffaker
EngTech
4207 Boulder Ridge Road, Suite 225
Bismarck, ND 58503

ref: **Geotechnical Exploration Program**
Proposed Elementary School Addition
Parshall, North Dakota
Laboratory Number MTS #G22-029

Dear Mr. Huffaker,

Enclosed is the report of the geotechnical exploration that we recently conducted for the proposed project. We are transmitting this report as an electronic file in pdf format. If you require a hard copy, please contact us. The work was conducted in general accordance with our proposal dated March 30, 2022.

Approximately 50 percent of the soil samples will be stored at the laboratory for a period of approximately 30 days from the date of this report. The samples will then be discarded unless we are requested to store them for a longer period of time.

We appreciate the opportunity to be of service to you on this project. If there are questions about the data or our recommendations, please contact us at 701-852-5553. Also, please contact us when you are ready for excavation observations and compaction test of controlled fill.

Sincerely,

MATERIAL TESTING SERVICES, LLC

Anthony Francis, P.E.
Geotechnical Engineer

MINOT
P.O. Box 634
Minot, ND 58702
701.852.5553

WILLISTON
7101 W 2nd Ave
Williston, ND 58801
701.572.4226

materialtestingservicesnd.com

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Report of Geotechnical Exploration

Proposed Elementary School Addition
Parshall, North Dakota
MTS #G22-029

1. INTRODUCTION

1.1. Authorization

This work was conducted in accordance with our proposal dated March 30, 2022.

1.2. Scope of Services

The authorized scope of services included soil borings, laboratory testing and an engineering report.

Authorized drilling included a total of nine soil borings. Four borings were drilled to a nominal depth of 25 feet and five borings were drilled to a nominal depth of 20 feet. The boring locations were selected by EngTech. Soil sampling was to be performed using standard penetration test (SPT) procedures. Laboratory tests in the proposal included moisture content, dry density, gradation through a #200 sieve, Atterberg limits (liquid & plastic limits) and unconfined compression testing. If soft cohesive soils were encountered undisturbed 3-inch diameter thin walled Shelby tubes were to be taken.

The authorized engineering report includes the results of the field and laboratory testing as well as engineering recommendations regarding:

a. Site preparation
b. Foundation types and depths
c. Allowable bearing capacity and estimated potential foundation settlement
d. Potential construction difficulties
e. Potential expansive or compressible soils
f. Site drainage
g. Exterior backfill
h. Floor slabs
i. Frost considerations
j. Lateral Earth Pressures
k. Excavation slopes
l. Construction monitoring

Determining if there is potential on-site contamination is not included in the scope of services.

2. ENGINEERING REVIEW

2.1. Project Data

If the project information presented below is not correct or has been changed, it is necessary that the correct project data be presented to us for further review.

The proposed project will include an elementary school addition to the north and west side of the existing high school building with an option for a library addition on the east side.

The elementary addition will be a one and two-story, slab on grade structure with a finished floor elevation matching the existing building. It is anticipated that the addition will be founded on shallow frost footings with above grade precast concrete and steel stud walls with interior structural steel framing. We understand strip footing loads will range from 4 to 11 kips per foot and the maximum column loads will be approximately 100 kips. We assume the maximum settlement under working load is 1 inch and a maximum differential settlement of ½ inch.

2.2. Special Concerns and Constructability

Uncontrolled fill and topsoil were encountered to depths of approximately 0.5 to 9 feet below grade at our boring locations. The uncontrolled fill and topsoil should not be relied upon for support of the proposed building additions. We recommend that the uncontrolled fill and topsoil be removed from the building areas and replaced with controlled, compacted fill. It may be possible to use the existing non-organic uncontrolled fill as controlled, compacted fill.

The existing high school building was constructed in 2018 and 2019. We understand that soil corrections were done to prepare the building pad for construction at that time. It is likely any fill adjacent to the existing structure was properly placed and compacted. Additional observations and testing of the fill adjacent to the existing structure should be done during excavation procedures to confirm its suitability.

2.3. Excavation and Site Preparation

2.3.1. Building

We recommend that the uncontrolled fill and topsoil in the building area be removed and replaced with controlled, compacted fill. The following tables lists the estimated excavation depths that will be required at the borings for the structures.

Table 1 – Excavation Depths

Boring	Ground Elevation	Depth to Bottom of Excavation (ft)	Elev of Bottom of Excavation (ft)
SB-1	98.7	0.5	98.2
SB-2	99.3	5.0	94.3
SB-3	99.2	5.0	94.2
SB-4	98.6	4.0	94.6
SB-5	99.1	6.0	93.1
SB-6	99.2	9.0	90.2
SB-7	99.7	6.0	93.7
SB-8	98.6	0.9	97.9
SB-9	99.3	11.0	88.3

If excavations extend below the bottom of footing depth, we recommend providing a lateral excavation oversize of 1 foot for each 1 foot of fill required below the bottom of the new foundations. The oversize should be measured from the bottom and outside edge of the foundations.

Care should be taken not to undermine the footings for the existing building. If excavations to extend below the bottom of the existing footings, the excavation should be sloped at 2:1, horizonal to vertical, from the edge of the existing footing to the bottom of excavation. An expansion joint should be provided between the existing structure and the new addition to allow for differential movement between the two structures.

We recommend that the excavated areas be observed by the geotechnical engineer of record or their representative prior to the placement of concrete or controlled, compacted fill. The purpose of the observations would be to make sure that no existing fill or soft natural soil is left in place and that the exposed natural soils are capable of supporting the proposed fill and structural loads. We wish to point out that there could be deeper excavations required away from the boring locations.

We recommend that a hydraulic excavator be used for foundation excavation. It should have a smooth cutting edge on the bucket. If the bottom of the excavation exposes the native clay soil it should not be surface compacted prior to placement of controlled, compacted fill. However, any loose materials should be removed as much as possible. Exposed sands should be surface compacted with a minimum of three passes with a heavy vibratory roller.

After the excavations are complete, backfill should be placed as soon as possible. Also, care should be taken so that the grades slope away from the excavations in the event that rainfall is experienced. Although it is impossible to completely keep rain water from the site, provisions must be made to protect the excavations as much as possible from the influx of rainwater or surface runoff both during and after construction. Water and any soft/saturated soils should be removed as soon as possible.

The on-site sandy lean clay that is free of organic material may be used as controlled, compacted fill. Any import fill needed for the building pad can consist of non-expansive, non-organic lean clay, or pit-run sand or sand with gravel. Any gravel in the fill should have 100 percent passing the 2-inch sieve. If lean clay is used it should have a liquid limit of 40 or less. We would not recommend using fat clay (CH) for fill below the building. All clays should be placed at a moisture content of minus 2 to plus 3 percent of optimum moisture content. Sand should be moisture conditioned as necessary to facilitate compaction.

Loose lift thicknesses of new fill should be no more than 8 inches. Any fill that is to support footings should be compacted to at least 98 percent of maximum dry density as determined according to ASTM D 698 (standard Proctor). Any fill below the floor slab should be compacted to at least 95 percent of the standard Proctor.

If earthwork is done during periods of freezing temperatures, we recommend protecting the fill from freezing once it has been placed. No frozen soils should be used as fill and fill should not be placed on frozen ground. Earthwork could be difficult in the spring or late fall when conditions are often cool and wet.

2.4. Frost Considerations

Footings should be carried to frost depth as indicated in the following sections. Also, no frozen soils should be used as fill and no fill should be placed on frozen ground. Furthermore, the soils should be protected from freezing once they have been placed and compacted and until the building can be heated. Please note the attached information sheet "***Precautions for Excavating and Refilling During Cold Weather***" in Appendix C.

2.5. Foundation Recommendations

2.5.1. Footing Depths

Perimeter footings for heated buildings should be carried to a frost depth of 5 feet. The frost depth should be considered from final grade to the bottom of the footing. Interior footings can be placed at a convenient depth below the floor slab.

For footings which will be in an unheated environment, we recommend using a frost depth of 7 feet.

2.5.2. Bearing Capacity and Settlement

With the recommended site preparation, on-site observations by the geotechnical engineer and adequate compaction testing of the new fill, it is our opinion that continuous strip and column footings can be proportioned for a net allowable soil bearing capacity of up to 2000 psf. Isolated column footings can be proportioned for a net allowable soil bearing capacity of up to 2400 psf. This loading should provide a theoretical safety factor of 3 or more with respect to punching shear failure.

Our calculations suggest that total settlements should be 1 inch or less and that the differential settlement should be ½ inch or less.

2.5.3. Lateral Earth Pressures

Walls that must retain earth should be designed for the at-rest lateral earth pressure. For the clays at this site we recommend that the at-rest pressure be considered equivalent to that generated by a fluid with a total unit weight of 65 pcf above groundwater levels. For active loads, we recommend using 45 pcf for the on-site clays above groundwater levels.

To resist lateral loads, we recommend assuming that the natural undisturbed clays have an ultimate passive pressure equivalent to that generated by a fluid having a total unit weight of 375 pcf. If compacted fill is placed on the passive side next to the foundation resisting lateral loads, it should be compacted to at least 95 percent of maximum density as determined by ASTM D 698. In addition, those portions of the foundations within five feet of final grade in unheated areas should be ignored when calculating passive resistance due to frost softening. An ultimate friction factor of 0.30 can be used between the bottom of the footing and the foundation soils. We wish to point out that these values will give the ultimate resistance to lateral loads. We recommend that a theoretical safety factor of 2.0 be applied for a safe design.

2.5.4. Methods of Analysis

The allowable foundation loading recommended was arrived at using the Terzaghi-Meyerhof bearing capacity equation with estimates using empirical correlations with the "N" values, as well as our experience with similar site and soil conditions.

Settlements were estimated using empirical correlations between the "N" values and the pressuremeter modulus, with consideration given to soil type. The pressuremeter modulus is determined with in-situ pressuremeter testing. The pressuremeter method of analysis was then used.

The equivalent passive, at-rest and active earth pressures were calculated using estimated unit weights and estimated angles of internal friction based on our experience, the laboratory testing and correlations with the Atterberg limits and soil type.

2.6. Floor Slabs

We recommend that the site be prepared as stated in ***Section 2.3***. We recommend that slabs-on-grade be constructed structurally independent of foundation walls and columns. We also recommend a minimum 6-inch layer of free draining sand be placed directly below the slabs. The sand should have less than seven percent passing the #200 sieve by weight. If it contains gravel, the gravel should have a maximum size of one inch. The sandy layer will be used to provide a working surface for concrete placement and serve as a capillary break.

With the site prepared as recommended, it is our opinion that the subgrade modulus of 200 pci can be used if a minimum of 18 inches of granular fill is used below the slab. A subgrade modulus of 150 pci can be used if clay fill is used to within 6 inches of the bottom of the slab.

2.7. Exterior Foundation Backfill

The exterior foundation backfill above the footings could consist of the on-site non-organic sandy lean clay fill, or off-site lean clay or pit-run sand and gravel. The exterior backfill should be placed in loose lift thicknesses not to exceed 8 inches. Compaction should be to a minimum of 92 percent of the standard Proctor density in lawn areas. For sidewalks or lightly loaded structures such as air conditioning units, the compaction should be increased to 95 percent. If there will be driveways or parking areas within the backfill zone the fill 1 foot or more below the bottom of pavements should be compacted to at least 95 percent and fill within 1 foot should be compacted to at least 98 percent. Clay fill should be placed at a moisture content of -2 to +3 percent of the optimum moisture content and sand fill should be moisture conditioned as required to facilitate compaction.

2.8. Surface Drainage

We advise that adequate drainage be maintained during and after construction. Unless roof drainage is internal, we also recommend that downspouts and gutters or an appropriate closed conduit system be used to control roof drainage. Downspouts should have extensions that carry roof water well past the backfill line. Splash pads should also be provided at the end of the extensions, if applicable.

If sand is used as exterior backfill, we recommend providing at least a 2-foot thick clay cap in green areas at the surface to divert surface water away from the building.

The exterior clay backfill should slope away from the buildings at a rate of 1 inch per foot or greater for a distance of at least 10 feet from the building in lawn areas. In parking areas much positive surface drainage should be provided as practical.

2.9. Exterior Slabs

Due to the potential for frost movement for exterior slabs, precautions should be taken to minimize future post construction movement of sensitive slabs due to frost action. Options available include excavating frost susceptible soils to a depth of 5 feet below the slabs and replacing them with non-frost susceptible sand containing less than 5 percent passing the #200 sieve by weight. Another option would be to place at least 4 inches of extruded polystyrene foam insulation below the slabs and extend it at least 8 feet laterally past the edge of the slabs. Typically, 6 to 12 inches of sand is placed above the insulation for protection. A third option is to support the slabs or steps on foundations taken to frost depth. At least a 4-inch void should be provided below the slabs if this option is used.

Sensitive slabs are slabs that cannot tolerate much movement without causing some difficulties. An example would be the sidewalk or steps in front of a doorway. It is ***not*** intended to include all exterior sidewalks and driveways, etc.

2.10. Excavation Slopes

Safe excavations must be maintained at all times. The excavation contractor is responsible for the safety of the excavations. Current OSHA requirements should be carefully followed when excavating for the back slope of the excavation. The OSHA soil type and excavation requirements must be verified by a competent person for the contractor at the time of construction. MTS does not assume responsibility for site safety or the contractors' activities.

3. CONSTRUCTION OBSERVATION AND TESTING

The recommendations contained in this report have been made based on the subsurface conditions found at the boring locations. It is possible that there are soil conditions on site that were not represented by the borings. Also, in order to use shallow foundations on the soils at this site, we presumed that close construction monitoring during excavation and backfilling would be authorized. Consequently, on-site observation during construction is considered integral to the successful implementation of the recommendations.

It is imperative that the geotechnical engineer be on site at the following times to observe the site conditions and effectiveness of the construction. We recommend that the testing be performed by the geotechnical engineer as the **Owner's** representative during construction.

3.1. Excavation Observations

The geotechnical engineer should observe the entire excavation bottom of the excavation prior to the placement of engineered fill and/or concrete. He would also be available for additional consultation and recommendations if necessary.

3.2. Placement of Fill

It will also be necessary to perform a representative number of compaction tests during placement of engineered fill. The tests should be performed to determine if the required compaction was achieved. As a general guideline, tests should be taken for each 2,500 square feet embankment fill, every 75 to 100 feet in trench fill, and for each 2-foot thickness of fill. The actual number of tests should be left to the discretion of the geotechnical engineer. n

4. EXPLORATION LIMITATIONS

The recommendations contained in this report represent our professional opinions. These opinions were arrived at according to currently accepted engineering practices at this time and location. Other than this, no warranty is intended or implied.

This report is written by:

Anthony Francis, P.E.
Geotechnical Engineer

ANTHONY P. FRANCIS
REGISTERED
PROFESSIONAL
8204
ENGINEER
NORTH DAKOTA

Reviewed by:

Steve Wald, P.E.
President

Anthony Francis, P.E.
Date: 05/26/22

APPENDIX A – FIELD EXPLORATION PROGRAM

Attachments to Appendix A

Location Maps
Soil Profile Drawing
Boring Logs
Symbols & Descriptive Terminology on Test Boring Logs
Soil Classification Sheet

A. FIELD EXPLORATION PROGRAM

A.1 Exploration Scope

Four borings were drilled to a nominal depth of 25 feet and five borings were drilled to a nominal depth of 20 feet for the project. They were drilled on May 18, 2022. The boring locations are illustrated on the attached drawings at the back of this Appendix.

The subsurface conditions encountered at the site are noted on the attached boring logs and soil profile drawing.

The borings were backfilled with on-site materials and some settlement of these materials can be expected to occur. The final closure of the holes is the responsibility of the client or property owner.

A.2 Surface Observations

The surface elevations at the test boring locations were obtained using a temporary benchmark (TBM), the top of the floor slab at the northwest entrance of the existing building. The TBM was assigned elevation 100.0 feet, assumed datum.

The site was located south of 7th Avenue NE and west of Main Street in Parshall, ND. The area for the proposed addition is currently green space around the existing school. Grade elevations at the boring locations ranged from 99.7 at SB-7 to 98.6 feet at SB-4 and SB-8.

A.3 Subsurface Conditions

The subsurface conditions encountered at the test locations are illustrated by means of the attached boring logs. We wish to point out that the subsurface conditions at other times and locations at the site may differ from those found at our test boring locations. If different conditions are encountered during construction, it is necessary that you contact us so that our recommendations can be reviewed. The test boring log also shows the possible geologic origin of the materials encountered.

Topsoil and fill were encountered at the boring locations to depths of approximately 0.5 to 11 feet below existing grade. Below the topsoil and fill, the borings encountered naturally deposited sandy lean clay, fat clay, lignite, silty sand, and silt to the termination depths.

Based on the standard penetration resistance ("N" values), the clayey soils were typically soft to hard in consistency. The sand and silt were typically loose to medium dense.

A.4 <u>Water Levels</u>

Groundwater measurements were made in the test borings during drilling and at completion of drilling before the borings were backfilled. This information is shown at bottom of the attached boring logs.

Groundwater was observed at approximately 8.5 to 14.5 feet below existing grade.

Water levels should be expected to fluctuate seasonally and annually. The water levels at the time of construction could be significantly different than what was recorded on the boring logs. The time of year the borings were drilled and the history of precipitation prior to drilling should be known when using the groundwater readings on the boring logs to extrapolate water levels at other points in time.

A.5 <u>Soil Sampling</u>

Soil sampling was done according to the procedures described by ASTM D1586. Using this procedure, a 2-inch O.D. split barrel sampler is driven into the soil by a 140-lb weight falling 30 inches. After an initial set of 6 inches, the number of blows required to drive the sampler an additional 12 inches is known as penetration resistance or "N" value. The "N" value is an index of the relative density of cohesionless soils and the consistency of cohesive soils.

We are retaining representative samples of the soil obtained during our field operations for approximately one month. We will then discard them unless we are notified further as to their disposition.

A.6 <u>Soil Classification Procedure</u>

As the samples were obtained in the field they were visually and manually classified by the crew chief according to ASTM D 2488. Representative portions of all samples were then sealed and returned to the laboratory for further examination and for verification of the field classification. In addition, selected samples were then submitted to a program of laboratory tests. Logs of the borings indicating the depth and identification of the various strata, the "N" value, the laboratory test data, water level information and pertinent information regarding the method of maintaining and advancing the drill holes are also attached. Charts illustrating the soil classification procedures, the descriptive terminology and symbols used on the boring logs are also attached.

APPENDIX B – LABORATORY TEST PROGRAM

Attachments to Appendix B

B. LABORATORY TEST RESULTS

B.1 Testing Scope

Laboratory testing was proposed to characterize soils index properties including Atterberg limits (liquid and plastic limits), mechanical sieve analysis, and moisture content.

B.2 Index Properties

Testing and classification of soils was performed in accordance with the Unified Soil Classification System as described in ASTM D 2487. Atterberg limits were performed according to ASTM D 4318. Moisture content was determined in accordance with ASTM D 2216. The dry density was determined with direct measurement procedures. Mechanical sieve analysis was performed in accordance with ASTM D 422.

B.3 Strength Testing

No additional strength testing was performed.

APPENDIX C

Precautions for Excavating & Refilling During Cold Weather

PRECAUTIONS FOR EXCAVATING AND REFILLING DURING COLD WEATHER

The winter season North Dakota presents specific problems for foundation construction. Soils which are allowed to freeze undergo a moisture volume expansion, resulting in a loss of density. These frost-expanded soils will consolidate upon thawing, causing settlement of any structure supported on them. To prevent this settlement, frost should not be allowed to penetrate into the soils below any proposed structure.

Ideally, winter excavation should be limited to areas small enough to be refilled to a grade higher than footing grade on the same day. Typically, these areas should be filled to floor grade. Trenching back down to unfrozen soils for foundation construction can then be performed just prior to footing placement. The excavated trenches should be protected from freezing by means of insulating or heating during foundation construction. Backfilling of the foundation trenches should be performed immediately after the below-grade foundation construction is finished. In addition, any interior footings, or footings designed without frost protection should be extended below frost depth, unless adequate precautions are taken to prevent frost intrusion until the building can be enclosed and heated.

In many cases, final grade cannot be attained in one day's time, even though small areas are worked. In the event final grade cannot be attained in one day's time, frost can be expected to develop overnight. The depth of frost penetration can be minimized by leaving a layer of loose soil on top of the compacted material overnight. However, any frost which forms in this loose layer, or snow, should never be used as fill material.

After the structure has been enclosed, all floor slab areas should be subjected to ample periods of heating to allow thawing of the soil system. Alternatively, the frozen soils can be completely removed and be replaced with an engineered fill. The floor slab areas should be checked at random and representative locations for remnant areas of frost, and density tests should be performed to document fill compaction prior to slab placement.

Due to the potential problems associated with fill placement during cold weather, any filling operations should be monitored by a full-time, on-site soils technician. Full-time monitoring aids in detecting areas of frozen material, or potential problems with frozen material within the fill, so that appropriate measures can be taken. The choice of fill material is particularly important during cold weather, since clean granular fill materials can be placed and compacted more efficiently than silty or clayey soils. In addition, greater magnitudes of heaving can be expected with freezing of the more frost susceptible silts and clays.

If more specific frost information or cold weather data concerning other construction materials is required, please contact us.