AMERICAN ENGINEERING TESTING, INC.

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REPORT OF GEOTECHNICAL EXPLORATION AND REVIEW

Proposed South 4th Street Road Reconstruction
Marshall, Minnesota

AET Project No. 13-20401

Date: December 6, 2019

Prepared for:

City of Marshall
344 West Main Street
Marshall, MN 56258

www.amengtest.com

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December 6, 2019

City of Marshall
344 West Main Street
Marshall, Minnesota 56258

Attn: Mr. Glenn Olson

RE: Report of Geotechnical Exploration and Review
Proposed South 4th Street Road Reconstruction
Marshall, Minnesota
Report No. 13-20401

Dear Mr. Olson:

American Engineering Testing, Inc. (AET) is pleased to present the results of our subsurface exploration program and geotechnical engineering review for your Proposed South 4th Street Road Reconstruction project in Marshall, Minnesota. These services were performed according to our proposal to you dated October 29, 2019.

We are submitting one (1) electronic copy of the report to you.

Please contact me if you have any questions about the report. I can also be contacted for arranging construction observation and testing services during the earthwork phase.

Sincerely,
American Engineering Testing, Inc.

Tom James
Manager – Marshall
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SIGNATURE PAGE

Prepared for:
City of Marshall
344 West Main Street
Marshall, Minnesota 56258

Attn: Mr. Glenn Olson

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Gregory A. Guyer, PE
Manager, Mankato

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under Minnesota Statute Section 326.02 to 326.15
Name: Steven J. Ruesink
Date: 12/6/19 **License #: 19431**

TABLE OF CONTENTS

TABLE OF CONTENTS

1.0 INTRODUCTION

You are proposing to reconstruct the existing South 4th Street in Marshall, Minnesota. To assist planning and design, you have authorized American Engineering Testing, Inc. (AET) to conduct a subsurface exploration program at the site, conduct soil laboratory testing, and perform a geotechnical engineering review for the project. This report presents the results of the above services and provides our engineering recommendations based on this data.

2.0 SCOPE OF SERVICES

AET's services were performed according to our proposal to you dated October 29, 2019, which you authorized on November 5, 2019. The authorized scope consists of the following:

- Four (4) standard penetration test borings to a depth of 14 ½ feet.
- Soil laboratory testing.
- Geotechnical engineering review based on the gained data and preparation of this report.

These services are intended for geotechnical purposes. The scope is not intended to explore for the presence or extent of environmental contamination.

3.0 PROJECT INFORMATION

We understand that you are planning to reconstruct the bituminous pavement on South 4th Street in Marshall, Minnesota. We understand that the roadway is to be constructed to meet Mn/DOT 10-ton design standards. We also understand that the reconstruction may include new subsurface utilities including water main, storm and sanitary sewer.

The above stated information represents our understanding of the proposed construction. This information is an integral part of our engineering review. It is important that you contact us if there are changes from that described so that we can evaluate whether modifications to our recommendations are appropriate.

4.0 SUBSURFACE EXPLORATION AND TESTING

4.1 Field Exploration Program

The subsurface exploration program conducted for the project consisted of four (4) standard penetration test borings. The logs of the borings and details of the methods used appear in Appendix A. The logs contain information concerning soil layering, soil classification, geologic description, and moisture condition. Relative density or consistency is also noted for the natural soils, which is based on the standard penetration resistance (N-value).

The boring locations are shown on Figure 2 in Appendix A. The borings were located in the field by City of Marshall personnel. Surface elevations were not recorded.

4.2 Laboratory Testing

The laboratory test program included moisture content tests. The test results appear in Appendix A on the individual boring logs adjacent to the samples upon which they were performed.

5.0 SITE CONDITIONS

5.1 Surface Observations

The proposed project site is located on South 4th Street in Marshall, Minnesota. Nearby site features include a residential area of the city. Current site vegetation consists of grass and trees, outside of the paved roads.

5.2 Subsurface Soils/Geology

The site geology consists of surficial fill underlain by glacial till and alluvial deposits.

The surficial fill layer was about 5’ to 7 ½’ deep at the boring locations. At the surface, 5 to 7½ inches of bituminous mat was present. The upper 5 to 7 inches of fill consisted of brown silty sand with gravel (apparent base aggregate). The balance of the fill was variable in nature and consisted of brown, brown and black, clayey sand and sandy lean clay.

At boring 2, we encountered an apparent un-marked storm sewer line between 2’ and 7 ½’ below the surface. The City of Marshall was notified of the possible utility damage.

Sandy lean clay glacial till was encountered at borings 1, 2 and 3. The upper portion of till was somewhat weathered. The till varied in color from brown nearer the surface to grey at depth. Additionally, the till contained some gravel and numerous lenses and layers of sand. Based upon the penetration resistance, N values, the consistency of the till varied from stiff to very stiff.

Underlying the glacial till and/or fill at borings 3 and 4, brown, sand with silt alluvial deposits were encountered. The relative density of the coarse alluvium was medium dense.

5.3 Groundwater

Subsurface water was noted as shallow as 13 feet at the boring locations at the time our field work was performed. The borings were monitored for groundwater seepage during drilling operations and were measured for groundwater accumulation shortly after completion of drilling. Groundwater levels fluctuate due to varying seasonal and annual rainfall and snow melt amounts, as well as other factors.

Based upon our previous experience with clayey alluvial soils in the general project area, it is our opinion that the subsurface water levels at the site could be quite near the ground surface during periods of significant precipitation, particularly during the spring of the year.

5.4 Review of Soil Properties

5.4.1 Undocumented Fill

We have no documentation regarding the extent of excavation made prior to placing the fill, nor do we have reports indicating fill soil density and water content quality control procedures. Fill soils that are placed without density and water content quality control procedures can behave unpredictably when subject to pavement loads. As such, we judge the fill to have unpredictable strength and compressibility characteristics. Lean clay with sand is a fine-grained soil that is slow-draining and susceptible to freeze-thaw movements. The dirtier silty sand soil observed in our borings have a moderate susceptibility to freeze-thaw movements. The silty sand is a moderate to slow-draining soil type.

5.4.2 Glacial Till

The main geologic deposit encountered at the site consisted of sandy lean clay, glacial till. The till varied in color from brown nearer the surface to grey at depth. Additionally, the till contained some gravel and numerous lenses and layers of sand. N-values recorded in the glacial till ranged from 9 to 16 blows per foot (bpf); indicating these soils exhibit stiff to very stiff consistency. Accordingly, we judge the glacial till to have moderate strength and moderately low compressibility when subject to the anticipated structural loads. The sandy lean clay is a slow-draining soil type that is susceptible to freeze-thaw movements when subject to freezing temperatures.

5.4.3 Coarse Alluvium

The coarse alluvial sand with silt soils were encountered at depth within soil borings 3 and 4. The N-values recorded in the coarse alluvium ranged from 16 to 24 bpf, indicating these soils exhibit medium dense relative density. We judge the coarse alluvium to have low to moderate strength and compressibility characteristics. The sand with silt alluvial soils (SP-SM) are generally a moderate draining soil type with low susceptibility to freeze-thaw frost movements.

6.0 RECOMMENDATIONS

6.1 Bituminous Pavement

6.1.1 Definitions

The ensuing sections use the following words or phrases, which have the following definitions:

> ***Top of grading grade*** is defined as the grade which contacts the bottom of the aggregate base layer.
>
> ***Sand subbase*** is a uniform thickness sand layer placed as the top of subgrade (directly below top of grading grade) which is intended to improve the frost and drainage characteristics of the pavement system by better draining excess water in the aggregate base and subbase, by reducing and "bridging" frost heaving, and by reducing spring thaw weakening effects.
>
> ***Granular Material*** shall be a pit-run or crusher-run product which shall all pass a 3-inch sieve, and of the portion passing a 1-inch sieve, not more than 10% by weight will pass a #200 sieve and not more than 50% by weight will pass a #40 sieve.
>
> ***Compaction Subcut*** is the construction of a uniform thickness subcut below a designated grade to provide uniformity and compaction within the subcut zone. Replacement fill can be the inorganic materials subcut, although the reused soils should be blended to a uniform soil condition and re-compacted to at least of 95% of the standard Proctor density (ASTM: D698). Compaction may need to be higher in order to pass a test roll.
>
> ***Test roll*** is a means of evaluating the near-surface stability of subgrade soils (usually non-granular). Suitability is determined by the depth of rutting or deflection caused by

passage of heavy rubber-tired construction equipment, such as a loaded dump truck, over the test area. Yielding of less than 1-inch is normally considered acceptable, although engineering judgment may be applied depending on equipment used and soil conditions present.

Organic soils are those soils which have sufficient organic content such that engineering properties/stability are affected (generally more than 3% organic content).

6.1.2 Subgrade Preparation

As a background to this section, we refer you to the attached data sheet entitled “Bituminous Pavement Subgrade Preparation and Design,” which presents considerations and recommendations for pavement subgrade preparation.

To prepare the subgrade for new pavement, we recommend removing any surface vegetation and root structure, if present, along with the existing bituminous pavement. The stability of the exposed soils should then be evaluated using a test roll procedure, as described on the attached sheet. Soils found to be unstable should either be moisture conditioned and compacted back into place, or they should be removed and replaced with compacted fill.

The on-site inorganic soils can be used for subgrade fill, although the use of granular materials is preferred. Compaction of new fill supporting pavements should meet the requirements of Mn/DOT Specification 2105.3F1 (Specified Density Method). This specification requires soils placed within the upper 3’ of the subgrade be compacted to a minimum of 100% of the Standard Proctor Density (ASTM: D698). The soil placed below the upper 3’ zone can have a reduced minimum compaction level of 95%.

Sand Subbase

The existing sandy lean clay present in the pavement areas has at least moderate frost heave potential and is moderately slow to slow draining. Soil with poor drainage characteristics may lead to trapped water within the upper portion of the subgrade or the aggregate base layer. This condition can accelerate subgrade softening, resulting in alligator cracking, frost distortion and pothole formation.

Improved long-term pavement performance can be achieved by placing a draining sand subbase layer as the top portion of the subgrade where granular materials are not already present. The sand subbase layer will better control infiltrating water, as well as the associated frost movements. Placement of a sand subbase layer will increase initial costs. However, the use of a drained sand subbase should reduce future maintenance; extend the pavement life; and improve constructability. The decision to use a sand subbase should take into consideration the initial costs versus the expected pavement performance.

As a minimum, we recommend using a 1' thick sand subbase in areas where granular soils are not already present at pavement subgrade elevations. Where there is a need to vary the thickness of the subbase, we recommend the thickness have a taper of no steeper than 20:1 (horizontal to vertical). The subcut and sand layer placement should extend slightly beyond the outer edge of the curb/paved edge, in order to maintain frost uniformity.

Sand subbase materials should at least meet the requirement of a Select Granular Borrow per Mn/DOT specification 3149.2B2. This refers to sand containing less than 12% by weight passing the #200 sieve. However, this specification allows for the possibility of a fine-grained sand material, which does not necessarily allow for free drainage. Because stability can be affected by the presence of water, we recommend the use of a Modified Select Granular Borrow, if the project budget allows. This includes material which contains less than 5% by weight passing the #200 sieve and less than 40% by weight passing the #40 sieve. Value engineering judgments of intermediate gradation can also be considered; we are available for review on this issue.

The subbase layer should be provided with a means of subsurface drainage, in order to prevent build-up of water within the sand subbase. This can be accomplished by placing “finger drains”, which are segments of properly engineered drainage lines connected to catch basins in low elevation areas. Where grades are relatively level and finger drains are infrequent, consideration should be given to placing a longer parallel drainage line through the level areas, to better remove infiltrating water. Shorter paths to draintile lines should be provided as the subbase materials becomes less permeable. Therefore, less draintile lines will be needed if Modified Select Granular Borrow materials are utilized instead of Select Granular Borrow.

6.1.3 Section Thicknesses

As requested, we are presenting a pavement design based on the Mn/DOT 10-ton design standards. We were also provided an Annual Average Daily Traffic (AADT) count of 2250. We used the State Aid ESAL Traffic Forecast Calculator, which is included in Appendix A, to calculate Equivalent Single Axle Loads (ESALS) for a 20-year design life, assuming approximately 2% growth. The pavement designs are included in Appendix A and are provided in the following table A, with and without a sand sub-base layer.

Table A – Pavement Thickness Designs (10 Ton)

Pavement Material	**10-Ton Section w/o sand sub-base**	**10- Ton Section w/sand sub-base**
Bituminous Wear	2”	2”
Bituminous Base	3”	3”
Aggregate Base (MnDOT Class 5)	25”	17”
Sand Subbase (MnDOT Select Granular Borrow)	---	12”

Again, since subsurface drainage is critical to long term performance, we recommend providing finger drains or tile lines as previously discussed.

The above designs could be reduced if the project owner is willing to assume the additional maintenance costs. Also, the site conditions are suited for the use of an engineering fabric and some reduction in the pavement section may be possible depending on the subgrade conditions encountered and the amount of sand subbase provided.

Estimated Subgrade R-Value

No actual R-value testing was conducted to define subgrade soil strength. However, based on our experience we estimate a conservative R-value for the pavement section thickness design of about 12 for the softer clays present. If you desire additional field and laboratory testing can be performed to better define the R-value for the soils present. Any additional sand provided would increase the estimated R-value or could be accounted for by assigning a granular equivalent (GE) value of about 0.5.

6.2 Concrete Pavement Recommendations

6.2.1 Discussion

Typically, we would not recommend the use of a concrete mat pavement section where frost susceptible, clay or silt subgrade soils are present. The concrete pavements are relatively rigid and any movements in the subgrade soils will tend to crack the pavement; surface repairs are difficult to perform properly and relatively expensive. Bituminous pavements are more flexible and easier to repair if distress does occur. However, a concrete pavement will perform better under higher stress loads, such as point loading from heavy vehicle parking and turning. We suggest using small panel areas (8' to 10') to better deal with any differential movements within the slab. Concrete mat reinforcement and dowel locations should be designed by the project civil engineer.

Based on our soil boring review, the top 2’ to 3’ of the exposed clayey fill soils in the pavement area are wet and easily disturbed. We recommend subcutting to remove these heavily disturbed soils. We recommend adding an additional granular drainage layer below the proposed Mn/DOT Class 5 materials. We further recommend the installation of drain tile to remove subsurface water which can lead to differential frost movements and cracking within the concrete mat.

We would recommend the installation of drain tile at a minimum of 50’ on center or at the edge of the pavement area. The drain tile should be installed at the base of the granular layer. To aid in preventing clogging of the perforated tile lines, we recommend that the lines be wrapped with a geotextile fabric designed for that purpose. Reduced pavement design life and increased maintenance costs may result from reductions in proper pavement section drainage.

6.2.2 Subgrade Preparation

We recommend subgrade preparation be performed in the same manner as outlined in Section 6.1.2 of this report.)

6.2.3 Sand Subbase

We recommend a sand subbase be provided for the concrete pavement areas as outlined in Section 6.1.2 of this report.)

6.2.4 Concrete Pavement Section Thickness Designs

The thicknesses of the pavement sections will depend on the type of materials present within the upper portion of the subgrade and also on the traffic. As previously discussed, we recommend installing a 12" thick, drained sand subbase over the on-site clayey soils.

We understand the concrete pavement will be designed to Mn/DOT 10-ton design standards. We used the PCC Pavement Design for determining the pavement section thicknesses. This information is included in Appendix A. The ESAL information was obtained from the State Aid ESAL Traffic Forecast Calculator.

Table B – Concrete Pavement Thickness Design (10 Ton)

Pavement Material	**Thicknesses**
Concrete Mat	6"
Aggregate Base (MnDOT Class 5)	6"
Sand Subbase (MnDOT Select Granular Borrow)	12"

If the recommended 12” sand subbase layer is reduced, additional methods of providing drainage should be considered. Wherever free draining sand layers overlie clay layers, it is important that subsurface drainage be provided for the sand layer to prevent buildup of water. Subsurface drainage can be provided by either installing finger drains, parallel draintile lines or premanufactured edge drains.

Subsurface drainage should be provided. Joint spacings should be limited to 8' to 10' on center to better deal with differential movements. Depending upon the applied loadings, greased dowels at the joints may be warranted.

The above designs could be reduced if the project owner is willing to assume the additional maintenance costs.

To aid in preventing clogging of the perforated tile lines, we recommend that the lines be wrapped with a geotextile fabric designed for that purpose. Reduced pavement design life and increased maintenance costs may result from reductions in proper pavement section drainage.

6.3 Utility Construction

The utility construction within the roadway should encounter suitable natural or fill soil at planned invert levels. It is possible that some softer, water-bearing or disturbed soils may be encountered which may not provide sufficient stability. In this case, some sub-cutting may be needed to provide proper support. The thickness of the sub-cut would be dependent on conditions, although we suspect it should not be necessary to sub-cut more than 1’ to 2’ below invert. If the instability extends below the 2’ sub-cut depth, further evaluation should be performed. The placement of a geotextile fabric can aid in providing improved stability.

All sub-cuts below the pipe/manhole locations should include 1:1 lateral oversizing.

In addition to the sub-cutting, the trench bottoms should be properly dewatered to reduce the potential for further disturbance and to allow bedding and utility placement. Control of subsurface water in the excavation would be dependent upon the static subsurface water level at the time the trenching is performed and the amount of coarse-grained soils which are encountered. It may be possible to control water entering into the excavation with normal sump pumping procedures. If the flow cannot be controlled with normal sump pumping procedures, we suggest considering some method of cutting off the flow through the more pervious sand layers found at the project site. Well pointing or other dewatering systems which could result in lowering the local groundwater table in the general area should be avoided to prevent settlement damage to nearby structures.

Following trenching and sub-cutting as needed, we recommend the following soil types be used for bedding/ refilling:

- In the case of competent trench bottoms, several inches of granular bedding should be provided for uniform pipe support. Per MN/DOT Specifications 3149.2F, granular bedding material should have no more than 10.5% passing the #200 sieve, and no particles larger than 1".

- In the case of a special bedding needed to re-attain grade after sub-cuts or for stability reasons, it may be possible to simply use a thicker "granular bedding", although in this case, we would suggest the use of mostly coarse sand material. In more extreme stability cases, it is preferable that rock bedding be used such as the coarse filter aggregate material designated by MN/DOT Specification 3149.2H. When using a coarser material such as this, which includes larger void space, we feel it is important to envelope the layer within a geotextile fabric to act as a separator which prevents the intrusion of fines into the rock void space.

Thinner granular bedding should be tamped into place. In those areas where fill thicknesses become on the order of 1’ or more due to deeper sub-cuts, the soils should be compacted to a minimum of 95% of the standard Proctor density (ASTM: D698). In the case where granular bedding is not compactable due to poor stability, rock bedding should be used (which is usually not compacted and tested).

Any bedding which is provided should be interrupted at a minimum of every 500 feet with a clay seal to prevent the transmission of subsurface water.

6.3.1 Utility Backfilling

All backfill should be compacted to a minimum of 95% of Standard Proctor density (ASTM: D698). The upper 3’ of subgrade below roadways should be compacted to a minimum of 100% of Standard Proctor density.

It is important to note that the on-site soils may be somewhat difficult to compact. Because of the poor draining nature of the soils, perched water will create variable, and often high, moisture levels within the fill. Clayey and silty soils need to be worked within a certain range of moisture content to attain desired compaction levels. Moisture conditioning to within this range can be time consuming labor intensive and requires favorable weather.

6.3.2 Cathodic Protection

The clayey soils encountered by the borings have a moderate to high corrosion potential. Suitable cathodic protection should be provided if Ductile Iron Pipe (DIP) is used. If you desire additional field and laboratory studies could be performed to better judge corrosion potential of the subgrade soils and provide specific recommendations.

7.0 CONSTRUCTION CONSIDERATIONS

7.1 Potential Difficulties

7.1.1 Runoff Water in Excavation

Water can be expected to collect in the excavation bottom during times of inclement weather or snow melt. To allow observation of the excavation bottom, to reduce the potential for soil disturbance, and to facilitate filling operations, we recommend water be removed from within the excavation during construction. Based on the soils encountered, we anticipate the ground water can be handled with conventional sump pumping.

7.1.2 Disturbance of Soils

The on-site soils can become disturbed under construction traffic, especially if the soils are wet. If soils become disturbed, they should be subcut to the underlying undisturbed soils. The subcut soils can then be dried and recompacted back into place, or they should be removed and replaced with drier imported fill.

7.1.3 Winter Construction

If construction occurs during the winter, it is necessary for the contractor to protect the base soils from freezing each day and each night before new fill is placed. Fill should not be placed over frozen soils, snow, or ice, nor should the use of frozen fill soils be permitted. The contractor must protect base soils from freezing before and after fill placement. We recommend that a special pre-construction meeting be held to discuss the procedures and precautions that must be followed.

7.2 Excavation Backsloping

If excavation faces are not retained, the excavations should maintain maximum allowable slopes in accordance with *OSHA Regulations (Standards 29 CFR), Part 1926, Subpart P,* *"Excavations"* (can be found on www.osha.gov). Even with the required OSHA sloping, water seepage or surface runoff can potentially induce sideslope erosion or running which could require slope maintenance.

7.3 Observation and Testing

The recommendations in this report are based on the subsurface conditions found at our test boring locations. Since the soil conditions can be expected to vary away from the soil boring locations, we recommend on-site observation by a geotechnical engineer/technician during construction to evaluate these potential changes. Soil density testing should also be performed on new fill placed in order to document that project specifications for compaction have been satisfied.

8.0 ASTM STANDARDS

When we refer to an ASTM Standard in this report, we mean that our services were performed in general accordance with that standard. Compliance with any other standards referenced within the specified standard is neither inferred nor implied.

9.0 LIMITATIONS

Within the limitations of scope, budget, and schedule, we have endeavored to provide our services according to generally accepted geotechnical engineering practices at this time and location. Other than this, no warranty, either expressed or implied, is intended.

Important information regarding risk management and proper use of this report is given in Appendix B entitled "Geotechnical Report Limitations and Guidelines for Use".

DEFINITIONS RELATING TO PAVEMENT CONSTRUCTION

TOP OF SUBGRADE
Grade which contacts the bottom of the aggregate base layer.

SAND SUBBASE
Uniform thickness sand layer placed as the top of subgrade which is intended to improve the frost and drainage characteristics of the pavement system by better draining excess water in the base/subbase, by reducing and "bridging" frost heaving and by reducing spring thaw weakening effects.

CRITICAL SUBGRADE ZONE
The subgrade portion beneath and within three vertical feet of the top of subgrade. A sand subbase, if placed, would be considered the upper portion of the critical subgrade zone.

GRANULAR BORROW
Soils meeting Mn/DOT Specification 3149.2B1. This refers to granular soils which, of the portion passing the 1" sieve, contain less than 20% by weight passing the #200 sieve.

SELECT GRANULAR BORROW
Soils meeting Mn/DOT Specification 3149.2B2. This refers to granular soils which, of the portion passing the 1" sieve, contain less than 12% by weight passing the #200 sieve.

MODIFIED SELECT GRANULAR BORROW
Clean, medium grained sands which, of the portion passing the 1" sieve, contain less than 5% by weight passing the #200 sieve and less than 40% by weight passing the #40 sieve.

GEOTEXTILE STABILIZATION FABRIC
Geotextile meeting Type V requirements defined in Mn/DOT Specification 3733. When using fabric, installation should also meet the requirements outlined in Mn/DOT Specification 3733.

COMPACTION SUBCUT
Construction of a uniform thickness subcut below a designated grade to provide uniformity and compaction within the subcut zone. Replacement fill can be the materials subcut, although the reused soils should be blended to a uniform soil condition and recompacted per the Specified Density Method (Mn/DOT Specification 2105.3F1).

TEST ROLL
A means of evaluating the near-surface stability of subgrade soils (usually non-granular). Suitability is determined by the depth of rutting or deflection caused by passage of heavy rubber-tired construction equipment, such as a loaded dump truck, over the test area. Yielding of less than 1" is normally considered acceptable, although engineering judgment may be applied depending on equipment used, soil conditions present, and/or pavement performance expectations.

UNSTABLE SOILS
Subgrade soils which do not pass a test roll. Unstable soils typically have water content exceeding the "standard optimum water content" defined in ASTM: D698 (Standard Proctor test).

ORGANIC SOILS
Soils which have sufficient organic content such that engineering properties/stability are affected. These soils are usually black to dark brown in color.

Appendix A

Geotechnical Field Exploration and Testing
Boring Log Notes
Unified Soil Classification System
Figure 1 – Site Location
Figure 2 – Boring Locations
Subsurface Boring Logs
State Aid ESAL Traffic Forecast Calculator
PCC Pavement Design
Bituminous Pavement Designs

Appendix A
Geotechnical Field Exploration and Testing
Report No. 13-20401

A.1 FIELD EXPLORATION

The subsurface conditions at the site were explored by drilling and sampling four (4) standard penetration test borings. The locations of the borings appear on Figure 2 and 3, preceding the Subsurface Boring Logs in this appendix.

A.2 SAMPLING METHODS

A.2.1 Split-Spoon Samples (SS) - Calibrated to N_{60} Values

Standard penetration (split-spoon) samples were collected in general accordance with ASTM: D1586 with one primary modification. The ASTM test method consists of driving a 2-inch O.D. split-barrel sampler into the in-situ soil with a 140-pound hammer dropped from a height of 30 inches. The sampler is driven a total of 18 inches into the soil. After an initial set of 6 inches, the number of hammer blows to drive the sampler the final 12 inches is known as the standard penetration resistance or N-value. Our method uses a modified hammer weight, which is determined by measuring the system energy using a Pile Driving Analyzer (PDA) and an instrumented rod.

In the past, standard penetration N-value tests were performed using a rope and cathead for the lift and drop system. The energy transferred to the split-spoon sampler was typically limited to about 60% of its potential energy due to the friction inherent in this system. This converted energy then provides what is known as an N_{60} blow count.

The most recent drill rigs incorporate an automatic hammer lift and drop system, which has higher energy efficiency and subsequently results in lower N-values than the traditional N_{60} values. By using the PDA energy measurement equipment, we are able to determine actual energy generated by the drop hammer. With the various hammer systems available, we have found highly variable energies ranging from 55% to over 100%. Therefore, the intent of AET's hammer calibrations is to vary the hammer weight such that hammer energies lie within about 60% to 65% of the theoretical energy of a 140-pound weight falling 30 inches. The current ASTM procedure acknowledges the wide variation in N-values, stating that N-values of 100% or more have been observed. Although we have not yet determined the statistical measurement uncertainty of our calibrated method to date, we can state that the accuracy deviation of the N-values using this method is significantly better than the standard ASTM Method.

A.2.2 Disturbed Samples (DS)/Spin-up Samples (SU)

Sample types described as "DS" or "SU" on the boring logs are disturbed samples, which are taken from the flights of the auger. Because the auger disturbs the samples, possible soil layering and contact depths should be considered approximate.

A.2.3 Sampling Limitations

Unless actually observed in a sample, contacts between soil layers are estimated based on the spacing of samples and the action of drilling tools. Cobbles, boulders, and other large objects generally cannot be recovered from test borings, and they may be present in the ground even if they are not noted on the boring logs.

Determining the thickness of "topsoil" layers is usually limited, due to variations in topsoil definition, sample recovery, and other factors. Visual-manual description often relies on color for determination, and transitioning changes can account for significant variation in thickness judgment. Accordingly, the topsoil thickness presented on the logs should not be the sole basis for calculating topsoil stripping depths and volumes. If more accurate information is needed relating to thickness and topsoil quality definition, alternate methods of sample retrieval and testing should be employed.

A.3 CLASSIFICATION METHODS

Soil descriptions shown on the boring logs are based on the Unified Soil Classification (USC) system. The USC system is described in ASTM: D2487 and D2488. Where laboratory classification tests (sieve analysis or Atterberg Limits) have been performed, accurate classifications per ASTM: D2487 are possible. Otherwise, soil descriptions shown on the boring logs are visual-manual judgments. Charts are attached which provide information on the USC system, the descriptive terminology, and the symbols used on the boring logs.

Visual-manual judgment of the AASHTO Soil Group is also noted as a part of the soil description. A chart presenting details of the AASHTO Soil Classification System is also attached.

The boring logs include descriptions of apparent geology. The geologic depositional origin of each soil layer is interpreted primarily by observation of the soil samples, which can be limited. Observations of the surrounding topography, vegetation, and development can sometimes aid this judgment.

A.4 WATER LEVEL MEASUREMENTS

The ground water level measurements are shown at the bottom of the boring logs. The following information appears under "Water Level Measurements" on the logs:

- Date and Time of measurement
- Sampled Depth: lowest depth of soil sampling at the time of measurement
- Casing Depth: depth to bottom of casing or hollow-stem auger at time of measurement
- Cave-in Depth: depth at which measuring tape stops in the borehole
- Water Level: depth in the borehole where free water is encountered
- Drilling Fluid Level: same as Water Level, except that the liquid in the borehole is drilling fluid

The true location of the water table at the boring locations may be different than the water levels measured in the boreholes. This is possible because there are several factors that can affect the water level measurements in the borehole. Some of these factors include: permeability of each soil layer in profile, presence of perched water, amount of time between water level readings, presence of drilling fluid, weather conditions, and use of borehole casing.

A.5 LABORATORY TEST METHODS

A.5.1 Water Content Tests
Conducted per AET Procedure 01-LAB-010, which is performed in general accordance with ASTM: D2216 and AASHTO: T265.

A.5.2 Atterberg Limits Tests
Conducted per AET Procedure 01-LAB-030, which is performed in general accordance with ASTM: D4318 and AASHTO: T89, T90.

A.5.3 Sieve Analysis of Soils (thru #200 Sieve)
Conducted per AET Procedure 01-LAB-040, which is performed in general conformance with ASTM: D6913, Method A.

A.5.4 Particle Size Analysis of Soils (with hydrometer)
Conducted per AET Procedure 01-LAB-050, which is performed in general accordance with ASTM: D422 and AASHTO: T88.

A.5.5 Unconfined Compressive Strength of Cohesive Soil
Conducted per AET Procedure 01-LAB-080, which is performed in general accordance with ASTM: D2166 and AASHTO: T208.

A.5.6 Laboratory Soil Resistivity using the Wenner Four-Electrode Method
Conducted per AET Procedure 01-LAB-090, which is performed using Soil Box apparatus in the laboratory in general accordance with ASTM: G57

A.6 TEST STANDARD LIMITATIONS

Field and laboratory testing is done in general conformance with the described procedures. Compliance with any other standards referenced within the specified standard is neither inferred nor implied.

A.7 SAMPLE STORAGE

Unless notified to do otherwise, we routinely retain representative samples of the soils recovered from the borings for a period of 30 days.

BORING LOG NOTES

DRILLING AND SAMPLING SYMBOLS

Symbol	Definition
AR:	Sample of material obtained from cuttings blown out the top of the borehole during air rotary procedure.
B, H, N:	Size of flush-joint casing
CAS:	Pipe casing, number indicates nominal diameter in inches
COT:	Clean-out tube
DC:	Drive casing; number indicates diameter in inches
DM:	Drilling mud or bentonite slurry
DR:	Driller (initials)
DS:	Disturbed sample from auger flights
DP:	Direct push drilling; a 2.125 inch OD outer casing with an inner 1½ inch ID plastic tube is driven continuously into the ground.
FA:	Flight auger; number indicates outside diameter in inches
HA:	Hand auger; number indicates outside diameter
HSA:	Hollow stem auger; number indicates inside diameter in inches
LG:	Field logger (initials)
MC:	Column used to describe moisture condition of samples and for the ground water level symbols
N (BPF):	Standard penetration resistance (N-value) in blows per foot (see notes)
NQ:	NQ wireline core barrel
PQ:	PQ wireline core barrel
RDA:	Rotary drilling with compressed air and roller or drag bit.
RDF:	Rotary drilling with drilling fluid and roller or drag bit
REC:	In split-spoon (see notes), direct push and thin-walled tube sampling, the recovered length (in inches) of sample. In rock coring, the length of core recovered (expressed as percent of the total core run). Zero indicates no sample recovered.
SS:	Standard split-spoon sampler (steel; 1.5" is inside diameter; 2" outside diameter); unless indicated otherwise
SU	Spin-up sample from hollow stem auger
TW:	Thin-walled tube; number indicates inside diameter in inches
WASH:	Sample of material obtained by screening returning rotary drilling fluid or by which has collected inside the borehole after "falling" through drilling fluid
WH:	Sampler advanced by static weight of drill rod and hammer
WR:	Sampler advanced by static weight of drill rod
94mm:	94 millimeter wireline core barrel
▼:	Water level directly measured in boring
▽:	Estimated water level based solely on sample appearance

TEST SYMBOLS

Symbol	Definition
CONS:	One-dimensional consolidation test
DEN:	Dry density, pcf
DST:	Direct shear test
E:	Pressuremeter Modulus, tsf
HYD:	Hydrometer analysis
LL:	Liquid Limit, %
LP:	Pressuremeter Limit Pressure, tsf
OC:	Organic Content, %
PERM:	Coefficient of permeability (K) test; F - Field; L - Laboratory
PL:	Plastic Limit, %
q_p:	Pocket Penetrometer strength, tsf (<u>approximate</u>)
q_c:	Static cone bearing pressure, tsf
q_u:	Unconfined compressive strength, psf
R:	Electrical Resistivity, ohm-cms
RQD:	Rock Quality Designation of Rock Core, in percent (aggregate length of core pieces 4" or more in length as a percent of total core run)
SA:	Sieve analysis
TRX:	Triaxial compression test
VSR:	Vane shear strength, remolded (field), psf
VSU:	Vane shear strength, undisturbed (field), psf
WC:	Water content, as percent of dry weight
%-200:	Percent of material finer than #200 sieve

STANDARD PENETRATION TEST NOTES
(Calibrated Hammer Weight)

The standard penetration test consists of driving a split-spoon sampler with a drop hammer (calibrated weight varies to provide N_{60} values) and counting the number of blows applied in each of three 6" increments of penetration. If the sampler is driven less than 18" (usually in highly resistant material), permitted in ASTM: D1586, the blows for each complete 6" increment and for each partial increment is on the boring log. For partial increments, the number of blows is shown to the nearest 0.1' below the slash.

The length of sample recovered, as shown on the "REC" column, may be greater than the distance indicated in the N column. The disparity is because the N-value is recorded below the initial 6" set (unless partial penetration defined in ASTM: D1586 is encountered) whereas the length of sample recovered is for the entire sampler drive (which may even extend more than 18").

UNIFIED SOIL CLASSIFICATION SYSTEM
ASTM Designations: D 2487, D2488

AMERICAN ENGINEERING TESTING, INC.

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: Group Name[B]
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	Cu≥4 and 1≤Cc≤3[E]	GW	Well graded gravel[F]
			Cu<4 and/or 1>Cc>3[E]	GP	Poorly graded gravel[F]
		Gravels with Fines more than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	Cu≥6 and 1≤Cc≤3[E]	SW	Well-graded sand[I]
			Cu<6 and/or 1>Cc>3[E]	SP	Poorly-graded sand[I]
		Sands with Fines more than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve (see Plasticity Chart below)	Silts and Clays Liquid limit less than 50	inorganic	PI>7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI<4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	Liquid limit–oven dried / Liquid limit – not dried <0.75	OL	Organic clay[K,L,M,N] Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	Liquid limit–oven dried / Liquid limit – not dried <0.75	OH	Organic clay[K,L,M,P] Organic silt[K,L,M,Q]
Highly organic soil			Primarily organic matter, dark in color, and organic in odor	PT	Peat[R]

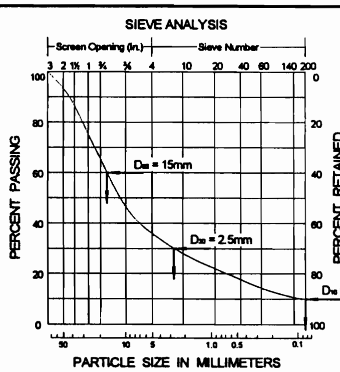
Notes

[A]Based on the material passing the 3-in (75-mm) sieve.
[B]If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C]Gravels with 5 to 12% fines require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

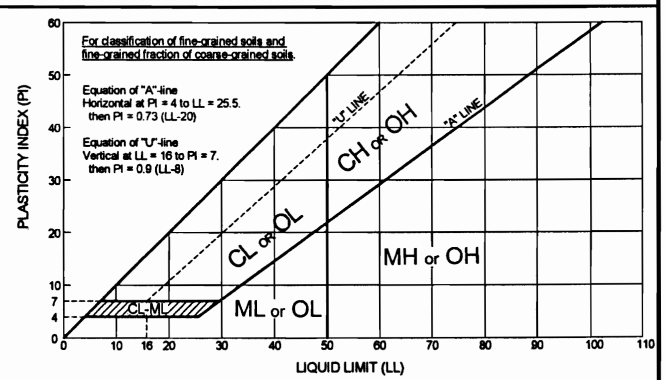
[D]Sands with 5 to 12% fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly graded sand with silt
- SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$, $Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F]If soil contains ≥15% sand, add "with sand" to group name.
[G]If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H]If fines are organic, add "with organic fines" to group name.
[I]If soil contains ≥15% gravel, add "with gravel" to group name.
[J]If Atterberg limits plot is hatched area, soils is a CL-ML silty clay.
[K]If soil contains 15 to 29% plus No. 200 add "with sand" or "with gravel", whichever is predominant.
[L]If soil contains ≥30% plus No. 200, predominantly sand, add "sandy" to group name.
[M]If soil contains ≥30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N]PI≥4 and plots on or above "A" line.
[O]PI<4 or plots below "A" line.
[P]PI plots on or above "A" line.
[Q]PI plots below "A" line.
[R]Fiber Content description shown below.



$C_u = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{2.5^2}{0.075 \times 15} = 5.6$



Plasticity Chart

ADDITIONAL TERMINOLOGY NOTES USED BY AET FOR SOIL IDENTIFICATION AND DESCRIPTION

Grain Size

Term	Particle Size
Boulders	Over 12"
Cobbles	3" to 12"
Gravel	#4 sieve to 3"
Sand	#200 to #4 sieve
Fines (silt & clay)	Pass #200 sieve

Gravel Percentages

Term	Percent
A Little Gravel	3% - 14%
With Gravel	15% - 29%
Gravelly	30% - 50%

Consistency of Plastic Soils

Term	N-Value, BPF
Very Soft	less than 2
Soft	2 - 4
Firm	5 - 8
Stiff	9 - 15
Very Stiff	16 - 30
Hard	Greater than 30

Relative Density of Non-Plastic Soils

Term	N-Value, BPF
Very Loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	Greater than 50

Moisture/Frost Condition (MC Column)

- D (Dry): Absense of moisture, dusty, dry to touch.
- M (Moist): Damp, although free water not visible. Soil may still have a high water content (over "optimum").
- W (Wet/ Waterbearing): Free water visible intended to describe non-plastic soils. Waterbearing usually relates to sands and sand with silt.
- F (Frozen): Soil frozen

Layering Notes

- Laminations: Layers less than ½" thick of differing material or color.
- Lenses: Pockets or layers greater than ½" thick of differing material or color.

Peat Description

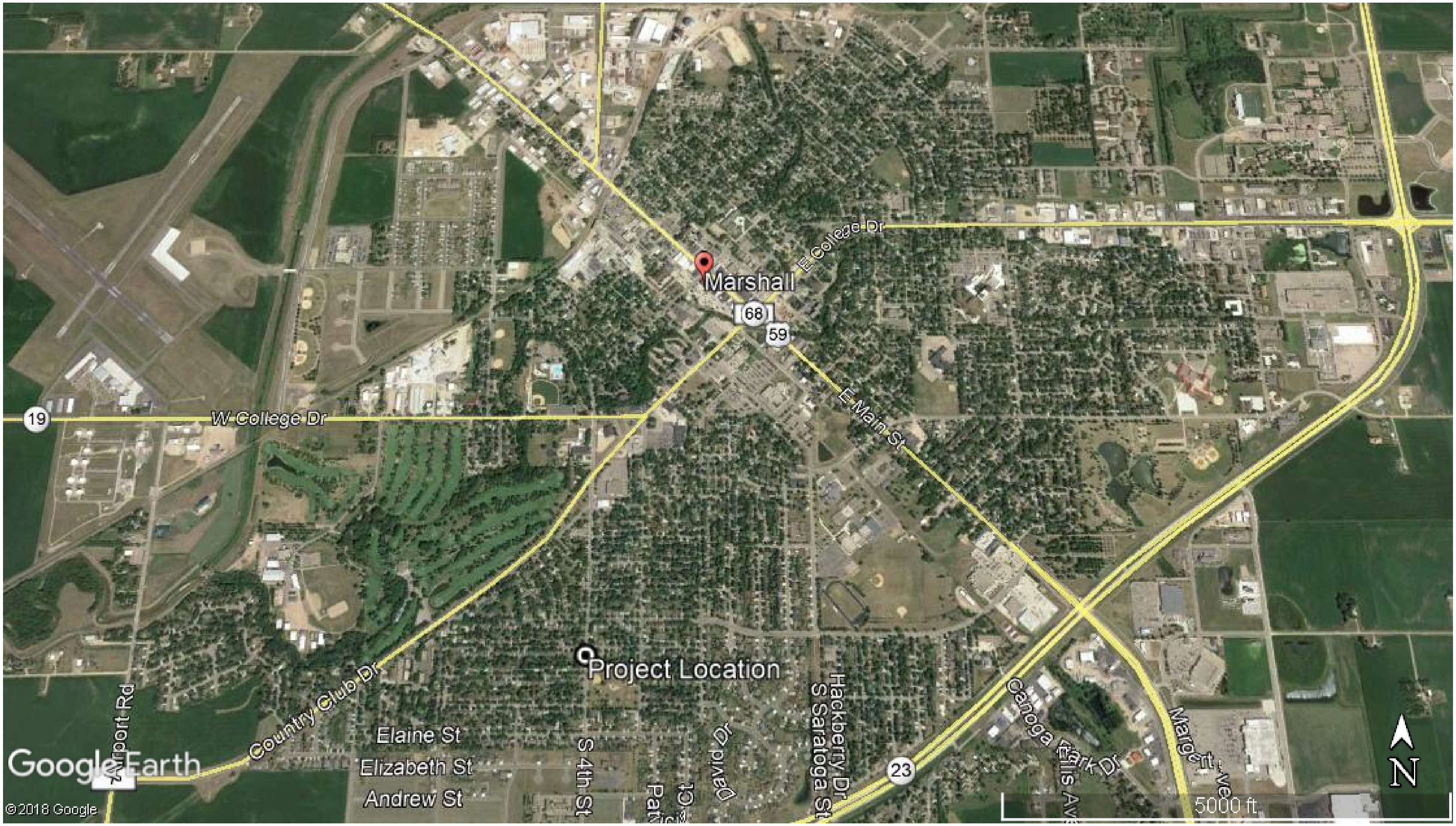
Term	Fiber Content (Visual Estimate)
Fibric Peat:	Greater than 67%
Hemic Peat:	33 – 67%
Sapric Peat:	Less than 33%

Organic Description (if no lab tests)

Soils are described as *organic*, if soil is not peat and is judged to have sufficient organic fines content to influence the Liquid Limit properties. *Slightly organic* used for borderline cases.

Root Inclusions

- With roots: Judged to have sufficient quantity of roots to influence the soil properties.
- Trace roots: Small roots present, but not judged to be in sufficient quantity to significantly affect soil properties.



AMERICAN ENGINEERING TESTING, INC.	Project	Proposed South 4th Street Road Reconstruction Marshall, MN	Subject:	Project Location	AET Job No:	13-20401	Date:	November 26, 2019
	Scale:	As shown above	Drawn By:	AS	Checked By:	TJ	Figure 1	

CITY ENGINEERS OFFICE
344 WEST MAIN STREET
MARSHALL, MINNESOTA
56258

Soil Borings

DATE 9/10/19

SOUTH 4TH STREET
ROAD RECONSTRUCTION

SHEET NO. 1 OF 1

AMERICAN ENGINEERING TESTING, INC.

Project: Proposed South 4th Street Road Reconstruction, Marshall, MN			AET Job No. 13-20401
Subject: Boring Locations			Date: November 26, 2019
Scale: NTS	Drawn By: City of Marshall	Checked By: TJ	Figure: 2

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **13-20401** Log of Boring No. **1 (p. 1 of 1)**

Project: **Proposed South 4th Street Road Reconstruction; Marshall, Minnesota**

DEPTH IN FEET	Surface Elevation ______ MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0	7" bituminous material	PAVEMENT									
~0.5–1	5 1/2" FILL, silty sand with gravel, brown	FILL		M	BULK						
1–7	FILL, sandy lean clay, a little gravel, brown and black										
3			8	M	SS	10	18				
5.5			9	M	SS	10	15				
7–13	SANDY LEAN CLAY, a little gravel, brown, stiff (CL)	TILL									
8			9	M	SS	12	22				
10.5			11	M	SS	12	26				
13–14.5	SANDY LEAN CLAY, a little gravel, gray, very stiff (CL)		16	M	SS	12					
	END OF BORING										

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
0-14½'	**3.25" HSA**	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
		11/19/19		**14.5'**	**12.5'**	**-**	**-**	**None**	
		11/19/19		**14.5'**	**-**	**11.7'**	**-**	**None**	
BORING COMPLETED: **11/19/19**									
DR: **BK** LG: **BM** Rig: **4**									

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **13-20401** Log of Boring No. **2 (p. 1 of 1)**

Project: **Proposed South 4th Street Road Reconstruction; Marshall, Minnesota**

DEPTH IN FEET	Surface Elevation ____ MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	5 1/2" bituminous pavement	PAVEMENT									
	5" FILL, silty sand with gravel, brown	FILL									
1	FILL, sandy lean clay, brown			M	BULK						
2	FILL, sandy lean clay, a little gravel, brown and black, existing storm sewer at 5'										
3			7	M	SS	10	23				
4											
5			8	M	SS	12	23				
6											
7											
8	SANDY LEAN CLAY, a little gravel, brown, stiff to very stiff (CL) sand seam at 13'	TILL	11	M	SS	12	22				
9											
10			12	M	SS	12	14				
11											
12											
13				▽							
14			16	W	SS	12					
	END OF BORING										

DEPTH: DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-14½' **3.25" HSA**							
	11/19/19		**14.5'**	**12.5'**	**-**	**-**	**13.0'**
	11/19/19		**14.5'**	**-**	**11.7'**	**-**	**None**
BORING COMPLETED: **11/19/19**							
DR: **BK** LG: **BM** Rig: **4**							

(WATER LEVEL MEASUREMENTS)

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP 13-20401.GPJ AET+CPT+WELL.GDT 12/6/19

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **13-20401** Log of Boring No. **3 (p. 1 of 1)**

Project: **Proposed South 4th Street Road Reconstruction; Marshall, Minnesota**

DEPTH IN FEET	Surface Elevation ___ MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	5" bituminous material	PAVEMENT									
	6" FILL, silty sand with gravel, brown	FILL									
1	FILL, sandy lean clay, brown and black			M	BULK						
2											
3	FILL, clayey sand with a little gravel, brown		8	M	SS	10	18				
4											
5	SANDY LEAN CLAY, a little gravel, brown, stiff (CL)	TILL	12	M	SS	8	18				
6											
7											
8			12	M	SS	12	21				
9											
10			15	M	SS	12	20				
11											
12											
13	SAND with SILT, medium to fine grained, brown, medium dense (SP-SM)	COARSE ALLUVIUM		▽							
14			16	W	SS	10					
	END OF BORING										

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS						
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-14½'	**3.25" HSA**	**11/19/19**		**14.5'**	**12.5'**	**-**	**-**	**13.0'**
		11/19/19		**14.5'**	**-**	**10.7'**	**-**	**None**
BORING COMPLETED: **11/19/19**								
DR: **BK** LG: **BM** Rig: **4**								

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP 13-20401.GPJ AET+CPT+WELL.GDT 12/6/19

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **13-20401** Log of Boring No. **4 (p. 1 of 1)**

Project: **Proposed South 4th Street Road Reconstruction; Marshall, Minnesota**

DEPTH IN FEET	Surface Elevation ___ MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	5" bituminous material	PAVEMENT									
	7" FILL, silty sand with gravel, brown	FILL									
1	FILL, sandy lean clay with a little gravel, brown			M	BULK		19				
2											
3	FILL, sandy lean clay, a little gravel, brown		7	M	SS	12	28				
4											
5											
6			10	M	SS	12	23				
7	SAND with SILT, medium to fine grained, brown, medium dense (SP-SM)	COARSE ALLUVIUM									
8			18	M	SS	10					
9											
10			24	M	SS	10					
11											
12											
13			16	W	SS	8					
14											
	END OF BORING										

DEPTH: DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-14½' 3.25" HSA							
	11/19/19		**14.5'**	**12.5'**	**-**	**-**	**14.0'**
	11/19/19		**14.5'**	**-**	**9.8'**	**-**	**None**
BORING COMPLETED: **11/19/19**							
DR: **BK** LG: **BM** Rig: **4**							

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP 13-20401.GPJ AET+CPT+WELL.GDT 12/6/19

State Aid ESAL Traffic Forecast Calculator - 11/15/2010

This ESAL calculator is for use with default Heavy Commerical Traffic values; click sheet "2" below if you wish to enter your own Heavy Commercial Traffic values.

Instructions: All yellow boxes require an input value.
Dropdown choices are provided for Base Year (C18), Number of Lanes (C19), and AADT Range (C20).
You must click on cell (C18) or (C19) or (C20) to access the dropdown choices.

General Information		
Date	12-3-19	
Forecast Performed by	SJR	
Name of County or City	Marshall, Minnesota	
Project Number	13-20401	
Project Description	4th Street Road Reconstruction	
Route Number		
Base Year (i.e. opening to traffic)	2020	
Number of Lanes (both directions)	1	
AADT Range	Rural: >1500	
Historical AADT (enter a minimum of two years)	**Year**	**AADT**
Enter oldest traffic data here	2012	1,850
Enter second oldest traffic data here	2014	1,950
Enter third oldest traffic data here	2016	2,050
Enter fourth oldest traffic data here	2018	2,150
Base Year AADT	2020	2,250
20-Year AADT	2040	3,250
35-Year AADT	2055	4,000
Growth Rate	2.22%	

Vehicle Type	**Vehicle Class %**	**ESAL Factors**	
		Flexible	**Rigid**
2AX-6TIRE SU	2.32%	0.25	0.24
3AX+SU	1.24%	0.58	0.85
3AX TST	0.16%	0.39	0.37
4AX TST	0.32%	0.51	0.53
5AX+TST	3.33%	1.13	1.89
TR TR, BUSES	1.23%	0.57	0.74
TWIN TRAILERS	0.01%	2.40	2.33
Total	**8.61%**	**NA**	**NA**

20-Year Flexible Forecast = **1,420,000**
20-Year Rigid Forecast = **2,142,000**
35-Year Flexible Forecast = **2,767,000**
35-Year Rigid Forecast = **4,173,000**

For State Aid questions and information, please contact Malaki Ruranika (MnDOT State Aid) at 651-366-3825 or Paul Stine (MnDOT State Aid) at 651-366-3830.

PCC Pavement Design

Project Number

13-20401

Designer

SJR

Date

12/3/2019

Inputs

20-year Design Lane BESALs =	1,420,000	
20-year Design Lane CESALs =	2,142,000	
35-year Design Lane CESALs =	4,173,000	
Design Life =	20	
In-situ soil R-value =	12	
Load Transfer, J =	2.6 (widened)	[1]
Thickness of Agg. Base Class 5/6 =	6.0	in.
Thickness of Agg. Base Class 3/4 =	0.0	in.
Thickness of Select Granular =	12.0	in.
In-place GE =	12.0	

Calculated Inputs

Adjusted R-value =	38
20 Year Design CESALS =	2,142,000
Adjusted CESALs (CESALs x .93) =	1,992,100

Standard Inputs

Modulus of Subgrade Reaction, k =	387	psi/in
Terminal Serviceability, P_t =	2.5	
Modulus of Rupture, S'_c =	500	psi
Modulus of Elasticity, E_c =	4,200,000	psi

PCC Thickness

Calculated PCC Thickness:	**5.92**	in.
PCC Thickness with OGAB	**5.42**	in.

Notes:

"Standard"- (i.e. unprotected edge) includes 12' wide pavement lane widths.
"Widened" - (i.e. protected edge) includes pavements that extend ≥1' past the marked travel lane or pavements tied to adjacent concrete shoulders, lanes, or curb & gutter.

Last updated 7/1/13

Bituminous Pavement With Aggregate Base

Inputs

20 Yr Design Lane BESALs = 1,420,000
Design R-value = 12.0

GE Values from R-Value Chart

Minimum Bit (GE) = 10.60
Min. Agg. Base (GE) = 6.00
Total Required GE = 33.54

Project Number
13-20401
Designer
SJR
Date
12/3/2019

Calculated Pavement Thickness to Meet GE Requirement

		Thickness (in)	GE	Layer GE
(2360) Wearing Course		4.00	2.25	9.00
(2360) Non-wearing Course		0.71	2.25	1.60
Bituminous Total		4.71	2.25	10.60
		Thickness (in)	GE	Layer GE
Aggregate Base	Class 5 or 6	6.00	1.00	6.00
Sub Base	Class 3 or 4	12.00	0.75	9.00
Select Granular		15.88	0.50	7.94
	Total	38.59	Total	33.54
	Required*	30.00	Required	33.54

Proposed Pavement Thickness

		Thickness (in)	GE	Layer GE
(2360) Wearing Course		2.00	2.25	4.50
(2360) Non-wearing Course		3.00	2.25	6.75
Bituminous Total		5.00		11.25
	Class	Thickness (in)	GE	Layer GE
Aggregate Layer 1	Class 5	25.00	1.00	25.00
Aggregate Layer 2			0.00	0.00
Aggregate Layer 3			0.00	0.00
Select Granular		0.00	0.50	0.00
Aggregate Total		25.00		25.00
	Total	30.00	Total	36.25
	Required*	30.00	Required	33.54

Messages

Total Thickness: GOOD
Total GE: GOOD
Bituminous Thickness: GOOD
Total Aggregate Base Thickness: GOOD

* Requirement to meet the pavement thickness requirement of Mn/DOT Tech Memo No. 09-12-MAT-03 "Pavement Selection Process"

Instructions

Blue cells are available for input.
Red font is a caution that a value doesn't meet policy requirements.
The upper box calculates pavement layer thicknesses to meet the minimum GE requirement.
The Lower box calculates the total GE and Thickness from layer thicknesses proposed by the designer.

Last Edited 1/26/12

Bituminous Pavement With Aggregate Base

Inputs

20 Yr Design Lane BESALs =	1,420,000
Design R-value =	12.0

Project Number
13-20401
Designer
SJR
Date
12/3/2019

GE Values from R-Value Chart

Minimum Bit (GE) =	10.60
Min. Agg. Base (GE) =	6.00
Total Required GE =	33.54

Calculated Pavement Thickness to Meet GE Requirement

		Thickness (in)	GE	Layer GE
(2360) Wearing Course		4.00	2.25	9.00
(2360) Non-wearing Course		0.71	2.25	1.60
Bituminous Total		4.71	2.25	10.60
		Thickness (in)	GE	Layer GE
Aggregate Base	Class 5 or 6	6.00	1.00	6.00
Sub Base	Class 3 or 4	12.00	0.75	9.00
Select Granular		15.88	0.50	7.94
	Total	38.59	Total	33.54
	Required*	30.00	Required	33.54

Proposed Pavement Thickness

		Thickness (in)	GE	Layer GE
(2360) Wearing Course		2.00	2.25	4.50
(2360) Non-wearing Course		3.00	2.25	6.75
Bituminous Total		5.00		11.25
	Class	Thickness (in)	GE	Layer GE
Aggregate Layer 1	Class 5	17.00	1.00	17.00
Aggregate Layer 2			0.00	0.00
Aggregate Layer 3			0.00	0.00
Select Granular		12.00	0.50	6.00
Aggregate Total		29.00		23.00
	Total	34.00	Total	34.25
	Required*	30.00	Required	33.54

Messages

Total Thickness: GOOD
Total GE: GOOD
Bituminous Thickness: GOOD
Total Aggregate Base Thickness: GOOD

* Requirement to meet the pavement thickness requirement of Mn/DOT Tech Memo No. 09-12-MAT-03 "Pavement Selection Process"

Instructions

Blue cells are available for input.
Red font is a caution that a value doesn't meet policy requirements.
The upper box calculates pavement layer thicknesses to meet the minimum GE requirement.
The Lower box calculates the total GE and Thickness from layer thicknesses proposed by the designer.

Last Edited 1/26/12

Appendix B

Geotechnical Report Limitations and Guidelines for Use

Appendix B
Geotechnical Report Limitations and Guidelines for Use
Report No. 13-20401

B.1 REFERENCE

This appendix provides information to help you manage your risks relating to subsurface problems which are caused by construction delays, cost overruns, claims, and disputes. This information was developed and provided by ASFE[1], of which, we are a member firm.

B.2 RISK MANAGEMENT INFORMATION

B.2.1 Geotechnical Services are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared solely for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. And no one, not even you, should apply the report for any purpose or project except the one originally contemplated.

B.2.2 Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

B.2.3 A Geotechnical Engineering Report is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typically factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, always inform your geotechnical engineer of project changes, even minor ones, and request an assessment of their impact. Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.

B.2.4 Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. Do not rely on a geotechnical engineering report whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. Always contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

1 ASFE, 8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733: www.asfe.org

B.2.5 Most Geotechnical Findings Are Professional Opinions

Site exploration identified subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ, sometimes significantly, from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

B.2.6 A Report's Recommendations Are Not Final

Do not overrely on the construction recommendations included in your report. Those recommendations are not final, because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.

B.2.7 A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

B.2.8 Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should never be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, but recognizes that separating logs from the report can elevate risk.

B.2.9 Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, but preface it with a clearly written letter of transmittal. In the letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. Be sure contractors have sufficient time to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

B.2.10 Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their report. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. Read these provisions closely. Ask questions. Your geotechnical engineer should respond fully and frankly.

B.2.11 Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a geoenvironmental study differ significantly from those used to perform a geotechnical study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. Unanticipated environmental problems have led to numerous project failures. If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. Do not rely on an environmental report prepared for someone else.