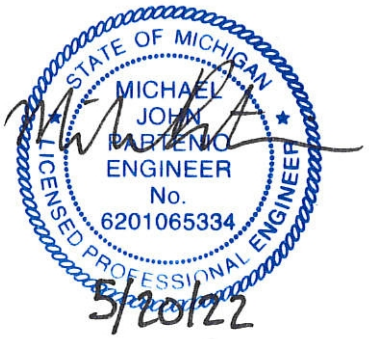
SOILS & STRUCTURES

REPORT OF THE GEOTECHNICAL INVESTIGATION FOR MERCY HEALTH ARENA - PATIO

MUSKEGON
MUSKEGON COUNTY
MICHIGAN

MAY 20, 2022



SPARK43 Architects
859 Fulton Street W
Grand Rapids, Michigan 49504

Project No. 2022.0276

SOILS & STRUCTURES

May 20, 2022

SPARK43 Architects
859 Fulton Street W
Grand Rapids, Michigan 49504

Attention: Mr. John Whitten

Regarding: Mercy Health Arena - Patio
Geotechnical Report
Muskegon, Muskegon County, Michigan
Project No. 2022.0276

Dear Mr. Whitten:

Soils & Structures is pleased to present this geotechnical investigation report for the Mercy Health Arena - Patio project located in Muskegon, Muskegon County, Michigan.

The investigation included one (1) test boring extended to a depth of 20.0 feet. The test boring was conducted in accordance with ASTM D 1586 procedures.

The report, test boring location plan, and test boring logs are enclosed. The report provides recommendations for site preparation, foundations, fill, floor, and pavement.

We appreciate the opportunity to provide engineering services to SPARK43 Architects. If you have any questions regarding this report, please contact our office.

Sincerely,
Soils & Structures, Inc.

Michael J. Partenio, P.E.
MJP/mp

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Table of Contents

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Location of Soil Investigation

The soil investigation was conducted at the site located on the southwest side of Mercy Health Arena at the end of Thayer Avenue in Muskegon, Muskegon County, Michigan. The parcel number for the site is 61-24-205-567-0001-30.

Purpose of Investigation

The purpose of this investigation is to provide geotechnical engineering recommendations for the proposed addition.

Design Information

The project will consist of an addition to the existing Mercy Health Arena. The addition will include a raised and covered outdoor patio, restroom, and storage area. Additionally, the project may include the replacement of utilities and pavement along Thayer Avenue.

The maximum column and wall loads for the addition are anticipated to be less than 50,000 pounds and 3,000 pounds per foot respectively. Allowable settlements of 0.6 inches for total settlement and 0.4 inches for differential settlement are assumed. If the actual design is significantly different than assumed in this report, then Soils & Structures should be contacted so that the recommendations included in this report may be reviewed and revised if necessary.

The existing concrete stair will be removed during site preparation. Fill may be required to establish the required grade following removal. Excavations and backfill will be required for the construction of foundations and utilities. The greatest depth of excavation for construction of the foundations and utilities is anticipated to be less than 4.0 feet below the proposed floor elevation. Groundwater controls and dewatering will probably not be necessary.

Pavement is assumed to be subjected to primarily light automobile traffic. A service life of twenty years was assumed for the pavement subgrade recommendations. The subgrade is assumed to be prepared as recommended in this report.

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Tests Performed

The investigation included one (1) test boring extended to a depth of 20.0 feet. The test boring is designated as Test Boring One (TB-01). The location was determined by Soils & Structures. The test boring was conducted in accordance with ASTM D 1586 procedures. The ASTM D 1586 standard describes the procedure for sampling and testing soil using the Standard Penetration Test. An automatic hammer was used to obtain the soil samples.

The surface elevations at the test boring locations and additional points of reference were obtained with a Global Navigation Satellite System (GNSS) Receiver. The receiver was connected to the local MDOT CORS base station. Through this system, vertical measurements are obtained and referenced to the North American Vertical Datum (NAVD88). Horizontal measurements are also obtained at the test boring locations which are referenced to the Michigan State Plane Coordinate System. Measurements of additional site-specific reference points were also obtained. Both the vertical and horizontal measurements typically have an accuracy of approximately 0.5 inches. The measured test boring locations and surface elevations can be found in Table 1.

Table 1: Measured Test Boring and Points of Reference Locations and Surface Elevations

Test Boring / Location	Elevation (feet)	Northing (feet)	Easting (feet)	Surface Cover
Test Boring One	591.2	637734.1	12619957.9	Concrete
Base Setup	649.2	626295.6	12621445.8	-

Soil samples were classified according to the Unified Soil Classification System. This method is a standardized system for classifying soil according to its engineering properties. Please refer to the appendix of this report for the Unified Classification System Chart. The classification is shown in the "Material Description" column of the test boring logs.

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The soil strength and the allowable soil bearing value were evaluated using the "N" value. The "N" value is the number of blows required to drive a soil sampler one foot with a standard 140-pound drop hammer. The sampler is driven a distance of 18.0 inches. The number of blows for each 6.0-inch increment is recorded. The sum of the second and third intervals is the "N" value. The number of blows for each 6.0-inch interval is shown on the test boring logs under the column labeled "Blow Counts". The "N" value for each sample is shown in the adjacent column.

Laboratory testing consisted of natural moisture content (ASTM D 2216) and particle size (sieve) analysis (ASTM D 6913). The tests were performed on representative soil samples. The tests were performed in accordance with the ASTM standards listed above. The moisture content documents the presence of groundwater in the soil. The sieve analysis determines the particle distribution which is used to classify the soil and estimate its properties.

The U.S. Geological Survey Topographic map and the Quaternary Geology map of Southern Michigan were reviewed. These maps provide general geological information about the region. Publicly available well logs from the Michigan Department of Environmental Quality of the surrounding area were reviewed to determine the depth of bedrock.

Description of Soil

The general soil profile consists of a layer of sand which extends to a depth of at least 20.0 feet. The soil profile is a deposit of lacustrine sand and gravel. Lacustrine deposits are soil deposits near lakes formed by glacial activity. These deposits are typically uniform in gradation and other properties.

Pavement is present at the surface of the site. The pavement consists of 5.0 inches of concrete directly overlying the sand layer.

The upper portion of the sand layer consists of brown, fine to medium sand and extends to a depth of 6.0 feet. The "N" values of upper portion of the sand layer range from 2 to 3, indicating that the sand is in a loose state. The "N" values correspond to an internal friction angle of 27 degrees. The upper portion of the sand layer will support the foundations, floor, and pavement following site preparation.

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The lower portion of the sand layer consists of brown, fine to medium sand and extends to a depth of at least 20.0 feet. The "N" values of the lower portion of the clay layer range from 14 to 44, increasing with depth, indicating that the sand is in a compact to very compact state. The "N" values correspond to an internal friction angle between 32 and 36 degrees.

Bedrock is present below a depth of 130.0 feet. The bedrock is part of the Coldwater Shale formation which consists of primarily bluish gray shale. The Coldwater Shale formation originated during the Mississippian period which ended approximately 323.2 million years ago.

Description of Groundwater Conditions

The water table is present at a depth of 6.0 feet. This depth corresponds to an elevation of 585.2 feet. Long-term groundwater monitoring was not included as a part of the investigation.

Description of Site

The soil investigation was conducted at the site located on the southwest side of Mercy Health Arena at the end of Thayer Avenue in Muskegon, Muskegon County, Michigan. The site consists of an alleyway with an existing set of concrete stairs leading up the concourse level of Mercy Health Arena. The site is surrounded on all sides by commercial buildings and is accessible to the southwest off of 5th Street. The surface elevation of the site at Thayer Avenue is approximately 591.2 feet. Photographs #1 and #2 show the site conditions at the time of the investigation.

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Photograph #1: Center portion of the site. View is to the northeast. (Project No. 2022.0276, Mercy Health Arena - Patio, Muskegon, Muskegon County, Michigan, March 2022)

Photograph #2: View of test boring location. View is to the north. (Project No. 2022.0276, Mercy Health Arena - Patio, Muskegon, Muskegon County, Michigan, March 2022)

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Recommendations

Site & Subgrade Preparation

The existing concrete stair will be removed as a part of site preparation. Excavations resulting from removal should be backfilled as necessary. Utility replacement along Thayer Avenue may be included which will necessitate the removal of a significant amount of pavement as well. Excavation will be required for construction of the foundations and utilities. Excavations for foundations and utilities are anticipated to extend less than 4.0 feet below the proposed floor elevations. Excavated sand may be retained for use as fill. Backfill will be required over foundations and utilities.

Fill should be placed following the recommendations in the "Fill" section of this report. Fill should be compacted to 95.0 percent of the soil's maximum density to its full depth. In-situ sand should be compacted to 95.0 percent of the soil's maximum density. Compaction tests are recommended to verify the level of compaction.

Soil brought to the site for fill should be clean sand and gravel meeting MDOT specifications. The soil which will be used for fill should be kept free of topsoil and other organic materials. Compaction tests are recommended to check the compaction of the new fill.

Foundations

Spread foundations are recommended to support the addition provided the subgrade is prepared as discussed in this section as well as the "Site & Subgrade Preparation" and "Fill" sections of this report including compaction. The foundations are anticipated to bear on the in-situ sand or fill following site preparation.

Fill below the addition should be compacted to a density of 95.0 percent of the soil's maximum density to its full depth. In-situ sand should be compacted to 95.0 percent of the sand's maximum density below the foundations. Compaction tests should be performed in the foundation subgrade to verify these levels of compaction. Soils not exceeding the minimum density should be recompacted.

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The recommended minimum cover over exterior foundations is 42 inches for protection against frost heave. Foundations should not be constructed on frozen soil. During cold weather construction, the foundation subgrade and foundations should be protected from freezing with insulated blankets until backfill is placed over both sides of the foundation. Foundations that are damaged by frost heave should be replaced.

The site classification for seismic design is "D" based on the Michigan Building Code provided the recommendations in this report are observed. The site has a peak ground acceleration of 0.075g with a 2.0 percent probability of exceedance in 50 years. The design spectral response acceleration parameters (S_D) are 0.113g for the short-term response and 0.106g for the one second response. The corresponding numeric seismic design values for the spectral response acceleration parameters above are 0.076 and 0.071 respectively.

Spread foundations may be designed using an allowable bearing value of 2,500 pounds per square foot for column foundations and 2,000 pounds per square foot for continuous foundations provided the recommendations for site preparation in the previous section are observed including compaction. A minimum width of 16.0 inches is recommended for new continuous foundations. The allowable bearing values may be increased 25.0 percent when considering transient loads such as earthquakes and wind.

Settlement

The maximum settlement of the addition is anticipated to be less than 0.4 inches provided the recommendations in this report are observed. Differential settlement will be approximately one half of the maximum value. These levels of settlement are within the recommended acceptable limits of 0.6 inches of total settlement and 0.4 inches of differential settlement.

Floors

A slab on grade is recommended for the floor.

A base of 6.0 inches of clean sand is recommended under the floor. The sand should meet MDOT Class II specifications. Fill under floors should be compacted as specified in the "Fill" section of this report. The in-situ sand is suitable for use as a base.

A modulus of subgrade reaction of 130 pounds per cubic inch is recommended for the design of slabs on grade.

Lateral Earth Pressure

Foundation walls with different soil levels on either side should be designed as retaining walls. Sand should be used as backfill behind retaining and foundation walls. The sand should meet MDOT Class II specifications. The walls should be designed using a soil density of 120 pounds per cubic foot, a coefficient of active earth pressure of 0.35 for level sand backfill and a coefficient of at rest earth pressure of 0.50. The effects of any surcharge or sloping backfill should also be included in the design. The passive resistance of the in-situ sand should be calculated using an earth pressure coefficient of 2.7.

Excavations

The in-situ soils are OSHA type "C" soils. Excavations that will be entered by personnel should be based on OSHA requirements for a type "C" soil. Based on OSHA requirements, a maximum allowable side slope of 34 degrees (1.5H:1V) is recommended for excavations 4.0 to 15.0 feet deep. Excavations less than 4.0 feet deep may have vertical side slopes. Excavations near existing building or property lines may require temporary shoring.

Fill

Fill, including the aggregate layers under pavement, should be compacted to a density of 95.0 percent of its maximum density. The maximum density should be determined in accordance with the ASTM D 1557 standard. A maximum thickness per layer of 6.0 inches is recommended. Compaction tests are recommended to confirm that the fill is compacted to the required density.

Soil brought to the site for structural fill should be sand meeting MDOT Class II requirements or ASTM requirements for a SP or SW which are the designations for clean sand. If the amount of fill required to achieve the desired grade exceeds the amount of material available on site, clean sand will probably have to be imported.

Fill should not be placed over frozen ground, snow or ice. Soil which contains frozen material should not be used as fill. During winter construction, removal of frozen ground may be necessary prior to placing fill.

Groundwater Management

Dewatering will probably not be necessary for construction of the foundations and groundwater will probably not be encountered in excavations. If water is encountered in excavations for utilities and foundations, the excavation bottom may be stabilized by placing a 6.0 to 8.0-inch layer of porous aggregate over the bottom of the excavation. The aggregate will stabilize the bottom of the excavation.

A vapor barrier is recommended under the floor in areas that will be enclosed and heated. The vapor barrier should consist of a 10-mil polyethylene sheet and should be located immediately below the floor slab. The vapor barrier may be omitted in portions of the addition that will not be heated.

The infiltration rate of the in-situ sand is anticipated to be at least 20.0 inches per hour which will be suitable for internal drainage of the site.

Drains around the foundations may be omitted. The in-situ sand meets the exception in Section 1805.4 of the Michigan Building Code to the requirements for drains. If required by others, the drains should consist of a 4.0-inch diameter slotted plastic pipe surrounded with pea gravel and wrapped in filter fabric. The pea gravel should extend 6.0 inches around the pipe.

Pavement areas should be properly drained to minimize the effects of frost heaving and the loss of subgrade due to water infiltration. Parking areas should be sloped toward regional low points with catch basins or curb inlets.

Hot Mix Asphalt (HMA) Pavement

The recommended preliminary HMA pavement sections listed in Table 2 were developed based on the discussions and assumptions included in this report and the design procedures outlined in the "AASHTO Guide for Design of Pavement Structures." The subgrade should be prepared as described in the "Site & Pavement Subgrade Preparation" and "Fill" sections of this report. The recommended pavement section materials listed in Table 2 refer to and should comply with the standard material designations included in applicable MDOT specifications and guidelines including the 2012 MDOT "Standard Specifications for Construction."

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The following recommendations assumes that maintenance repairs such as joint sealing, patching, and overlays are regularly performed throughout the lifespan of the pavement and that proper drainage has been established throughout the site. Proper drainage includes the installation of stormwater controls, underdrains, and establishing positive drainage in the subgrade and pavement layers.

Table 2: Recommended Pavement Sections

Pavement Cross Section Materials	Standard Duty		Heavy Duty	
	Material	Thickness (in)	Material	Thickness (in)
HMA Wearing Coarse	5E1	1.5	4E1	2.0
HMA Base Coarse	4E1, 13A	2.0	4E1, 13A	2.5
Aggregate Base	21AA Crushed Limestone	8.0	21AA Crushed Limestone	10.0
Sand Subbase	Class II	12.0	Class II	12.0

The recommended asphaltic binders are PG 58-28 for 13A mixes and PG 64-28 for "E" mixes. The compacted asphalt should be between 94.0 and 97.0 percent of the Theoretical Maximum Density, as determined via the Superpave "Rice" Method. A tack or "bond coat" of SS-1h emulsion shall be applied between the leveling and earing course layers at a rate of 0.1 gallons per square yard.

The paving contractor should submit the proposed mix design to the owner for review and approval prior to placement. The HMA pavement should be placed in at least two lifts. The pavement section should be constructed in accordance with MDOT guidelines and specifications as well as applicable state and local requirements.

Paved areas that display poor workmanship, which may include segregation, "cold screed scrapes", wearing courses not flush with curbs or rims, roller marks, shoving, smearing or tearing of the mat, flushing, or excessive cold joints should be repaired or replaced by the contractor immediately.

Pavement subgrade, subbase, and aggregate base should be proof rolled prior to aggregate base and pavement placement. The in-situ sand is suitable for use as a base material.

The subgrade, sand subbase and aggregate base should be constructed and prepared in accordance with the "Site & Subgrade Preparation" and "Fill" sections of this report and applicable MDOT guidelines and specifications.

Portland Cement Concrete (PCC) Pavement

The subgrade should be prepared in accordance with the "Site & Subgrade Preparation" and "Fill" sections of this report.

A base of 12.0 inches of clean sand or aggregate is recommended under slab on grade concrete pavement. For sidewalk slabs, the thickness may be reduced to 6.0 inches. The sand or aggregate should meet MDOT Class II or 21AA specifications respectively. The in-situ sand is suitable for use as a base material. A minimum slab on grade concrete pavement thickness of 4.0 to 6.0 inches is recommended. In areas of dumpster pads, the minimum concrete thickness should be increased to 8.0 inches and should be reinforced. The reinforcing should be designed by a licensed structural engineer. The recommended minimum concrete pavement thickness is 4.0 inches for sidewalks surrounded by greenbelt and 5.0 inches for revealed-face slabs.

A modulus of subgrade reaction of 130 pounds per cubic inch is recommended for the design of slabs on grade, provided the recommendations in this report are observed. The paving contractor should submit the proposed mix design to the owner for review and approval prior to concrete placement.

Quality Control Testing

Compaction tests are recommended to confirm that sand and fill are compacted to the specified density. The tests should be performed in accordance with the ASTM D 6938 standard. While fill is being placed, compaction tests should be performed at the rate of one test per 400 cubic yards of fill and throughout the depth of the fill with a minimum of five tests at each 1.0-foot elevation interval. Full time inspection is recommended while sand and fill are compacted in the addition area. Compaction tests should be performed under foundations at the rate of one test per 50 linear feet for wall foundations and one test per column foundation. The recommended testing frequency in the floor and pavement subgrade is one test per 2,500 square feet. Tests should also be performed in the backfill over foundations and utilities. The maximum density should be determined in accordance with ASTM D 1557 or ASTM D 4253 procedures.

Asphalt quality control testing should adhere to the 2012 MDOT Standards for Construction. Asphalt temperatures during placement should be at least 275 degrees Fahrenheit; material that arrives at temperatures below 250 degrees Fahrenheit shall be rejected. Asphalt density testing should be performed with a nuclear density gauge at a minimum rate of one test per 500 square feet of pavement. At least five total verification cores in each course are recommended to assess relative compaction, calibrate the nuclear density gauge, and evaluate thickness. A minimum of two loose mix samples per mix per day should be taken at the plant and delivered to the quality-assurance firm's laboratory for vacuum extraction-gradations. The asphalt contractor should provide a minimum of two (2) theoretical maximum density verifications per day.

A smooth 0.5 to 0.75-inch diameter rod should be used in conjunction with compaction tests to probe for loose areas under foundations, in fill, and under floors. A dynamic cone should not be substituted for compaction tests for evaluating fill. Testing should be performed by technicians supervised by a registered geotechnical engineer.

General Conditions & Reliance

The report was prepared in accordance with generally accepted practices of the geotechnical engineering profession. The scope of work consisted of performing one (1) test boring and providing soil related recommendations for the design and construction of the proposed addition. The scope of work did not include an environmental study or wetland determination.

The report and the associated test boring were prepared specifically for the previously described project and site. Soils & Structures should be consulted if a significant change in the scope of the project is made.

The test boring represents point information and may not have encountered all of the soil types and materials present on this site. This report does not constitute a guarantee of the soil or groundwater conditions or that the test boring is an exact representation of the soil or groundwater conditions at all points on this site.

The descriptions and recommendations contained in this report are based on an interpretation of the test boring and laboratory tests. The test boring should not be used independently of the report. If soil conditions are encountered which are significantly different from the test boring, Soils & Structures should be consulted for additional recommendations.

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The report and test boring may be relied upon by SPARK43 Architects for the design, construction, permitting, and financing associated with the Mercy Health Arena – Patio project located on Thayer Avenue in Muskegon, Muskegon County, Michigan. The use of the report and test boring by third parties not associated with this project or for other sites has not been agreed upon by Soils & Structures. Soils & Structures does not recommend or consent to third party use or reliance of the report or test boring unless allowed to review the proposed use of these materials. Unless obtained in writing, consent to third party use should not be assumed. Third parties using the report or test boring log do so at their own risk and are offered no guarantee or promise of indemnity.

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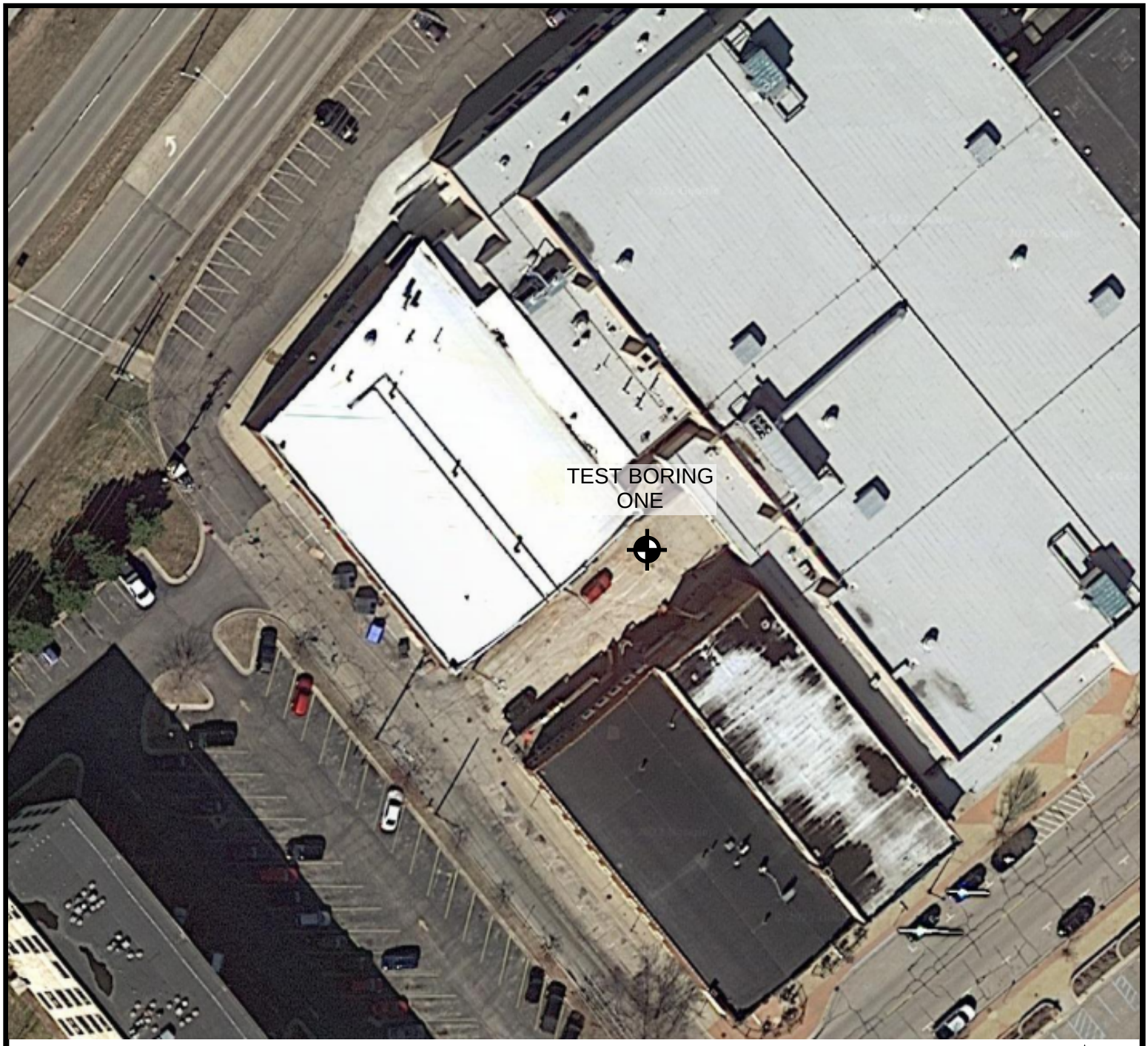
Appendix

Test Boring Location Plan
Test Boring Logs
Laboratory Tests
General Soil Information



VICINITY MAP (NTS)

TEST BORING LOCATION PLAN

NTS

Note: The background of the test boring plan is a portion of an aerial photograph from Google Earth.

Mercy Health Arena - Patio

Muskegon, Muskegon County, Michigan

Soils & Structures, Inc.
6480 Grand Haven Road
Muskegon, Michigan 49441

JOB NO.: 2022.0276 DATE: 05-20-2022

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Borehole ID: TB-01

Sheet 1 of 1

Project Name:	Mercy Health Arena - Patio	**Project Number:**	2022.0276
Project Location:	Muskegon, Michigan	**Logged By:**	H Chase Scharphorn
Reviewed By:	K Martella		
Client:	Spark43 Architects	**Survey Datum:**	NAD 1983 StatePlane Michigan South
Hole Depth:	20.00		
Date Started:	Mar 23 2022	**Completed:**	Mar 23 2022
Northing:	637734.1	**Easting:**	12619957.9
Elevation:	591.18		
Drilling Method:	3.25" Hollow Stem Auger	**Ground Water Levels**	
Equipment:	Diedrich D-25	At Time of Drilling	6.00 on Mar 23 2022
Hammer Type:	Automatic Hammer	End of Drilling	6.00 on Mar 23 2022
Notes:			

Depth	Material Description	Sample Type	Number	Recovery % RQD	Blow Counts	N-Value	Pocket Pen (tsf)	Shear Strength (tsf)	Moisture Content (%)	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Limit	Atterberg Limits: Plasticity Index	USCS
0	CONCRETE - (5.0")												
1	SAND - loose brown fine to medium												
2													
3			SPT-A	100	4-2-1	3			8.1				SP
4													
5			SPT-B	100	2-1-1	2			4.1				SP
6	SAND - compact brown fine to medium												
7													
8			SPT-C	100	5-6-8	14			22.2				SP
9													
10			SPT-D	100	2-6-9	15							SP
11													
12													
13	SAND - very compact brown fine to medium												
14													
15			SPT-E	100	10-19-25	44			20.4				SP
16													
17													
18													
19			SPT-F	100	8-11-14	25							SP
20													
21													
22													
23													
24													
25													
26													
27													
28													
29													
30													

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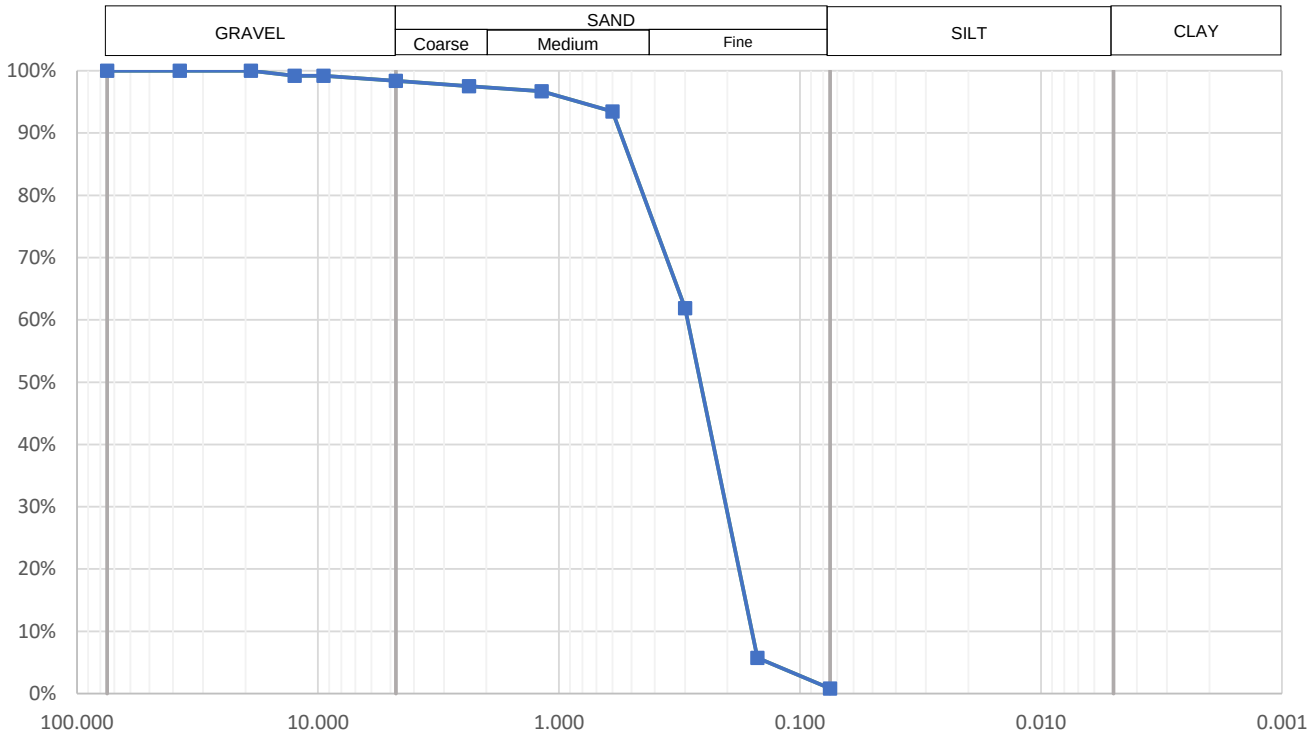
Particle Size Distribution Report

Sample Location	TB-01	Project Name	Mercy Health Arena - Patio
Sample Depth (ft)	4.5	Project Number	2022.0276
Sample ID	MSK_2022032852	Client	Spark43 Architects
		Date	3/30/2022



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0%	0.0%	1.6%	1.1%	22.3%	74.2%	0.0%	0.0%
D85	**D60**	**D50**	**D30**	**D15**	**D10**	**Loss By Wash**	
0.5197	0.2950	0.2682	0.2148	0.1747	0.1614	0.8%	

Sieve	
Particle Size (mm)	% Passing
75.000	100%
37.500	100%
19.000	100%
12.500	99%
9.500	99%
4.750	98%
2.360	98%
1.180	97%
0.600	93%
0.300	62%
0.150	6%
0.075	0.8%

Hydrometer	
Particle Size (mm)	% Passing

Material Description
Fine to Medium SAND (SP)

Remarks

Technician	bfritz
Checked	mvanweelden
Approved	mvanweelden

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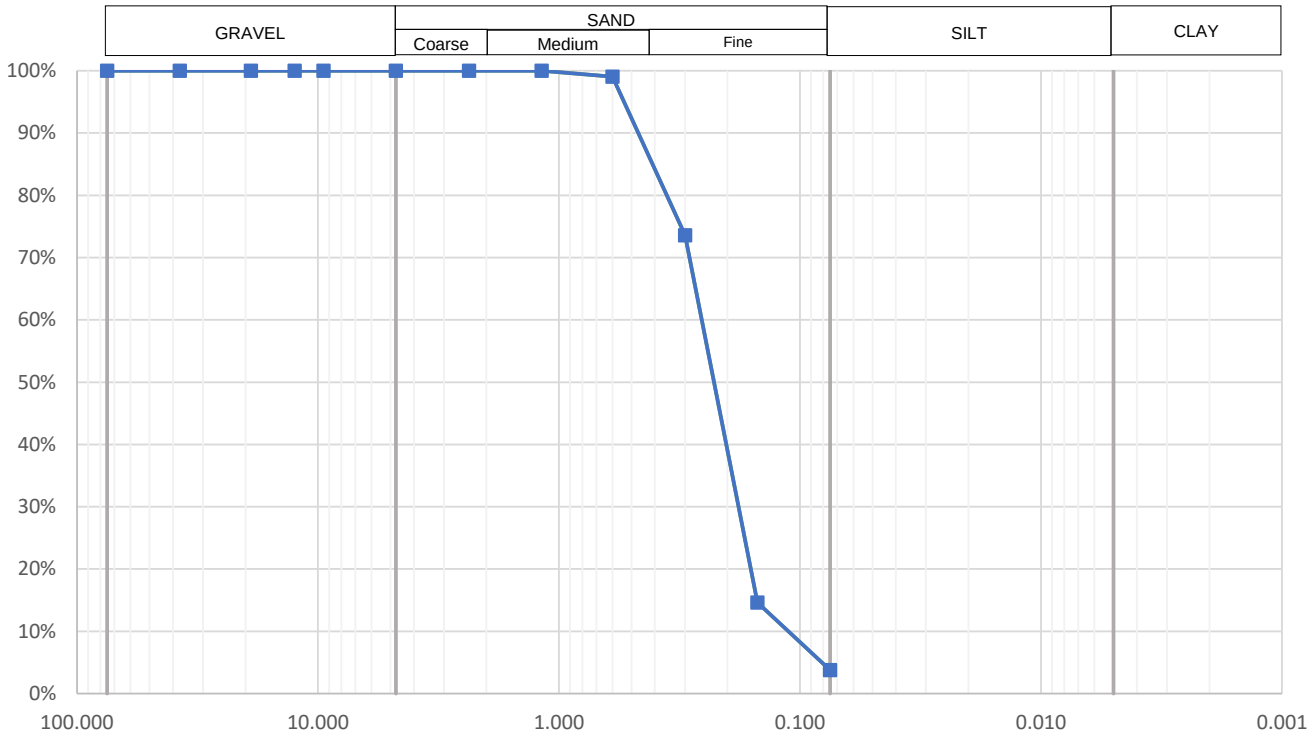
Particle Size Distribution Report

Sample Location	TB-01	Project Name	Mercy Health Arena - Patio
Sample Depth (ft)	14.5	Project Number	2022.0276
Sample ID	MSK_2022032854	Client	Spark43 Architects
		Date	3/30/2022



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0%	0.0%	0.0%	0.0%	15.8%	80.4%	0.0%	0.0%
D85	**D60**	**D50**	**D30**	**D15**	**D10**	**Loss By Wash**	
0.4344	0.2654	0.2400	0.1891	0.1510	0.1180	3.3%	

Sieve	
Particle Size (mm)	% Passing
75.000	100%
37.500	100%
19.000	100%
12.500	100%
9.500	100%
4.750	100%
2.360	100%
1.180	100%
0.600	99%
0.300	74%
0.150	15%
0.075	3.8%

Hydrometer	
Particle Size (mm)	% Passing

Material Description
Fine to Medium SAND (SP)

Remarks

Technician	bfritz
Checked	mvanweelden
Approved	mvanweelden

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General Information for Method of Field Investigation

The soil investigation was performed in accordance with the American Society of Testing and Materials method ASTM D 1586, which is the "Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils". Samples of compressible clays or organic soils are obtained in accordance with ASTM D 1587, which is the "Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes." Rock may be cored in conjunction with the above methods as specified in ASTM D 2113 which is the "Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation."

Field Testing

Standard Penetration Tests (SPT) in accordance with ASTM D 1586 were generally performed at depths of 2.0', 4.5', 7.0', 9.5' and 5.0' intervals thereafter.

Laboratory Testing

Samples obtained from the Standard Penetration Test, ASTM D 1586 or thin walled tube method, ASTM D 1587, were tested in the laboratory for the moisture content and density and/or particle size, where applicable. When soils sampled possessed sufficient cohesive properties, it was tested for its compressive strength in the unconfined state.

Natural Percent Moisture content (N.P.M.) of the soil is the percentage by weight of water contained in the soil sample compared to the dry weight of the solids of which the soil is composed. The NPM of select samples is determined in accordance with ASTM D 2216.

Natural Density (N.D.) of soil as reported on the appended boring logs is the natural wet density of the soils expressed in pounds per cubic foot.

The unconfined compressive strength of cohesive soils is determined in the laboratory on "undisturbed" select samples in accordance with ASTM D 2166. This test determines the maximum load required at a specified rate to deform the cohesive soil specimen length twenty (20%) percent. The primary purpose of the unconfined compression test is to obtain approximate quantitative values of the compressive strength of soils possessing sufficient coherence to permit testing in the unconfined state. The shear strength of the cohesive soil can be calculated from the results of the unconfined compressive strength test.

Color

When the color of the soils is uniform throughout, the color recorded will be such as brown, gray, and black and may be modified by adjectives such as light and dark. If the soils predominant color is shaded by secondary color, the secondary color precedes the primary color, such as gray-brown, or yellow-brown. If two major and distinct colors are swirled throughout the soil, the colors will be modified by the term mottled; such as mottled brown and gray.

Water Observations

Depth of water recorded in the test boring is measured from the ground surface to the water surface. Initial depth indicates water level during boring, completing depth indicates water level immediately after boring, and depth after "X" number of hours indicates water level after allowing the groundwater rise or fall over a period of time. Water observations in pervious soils are considered reliable groundwater levels for accurate groundwater measurements at the time the test borings were performed unless records are made over several days' time. Factors such as weather, soils porosity, etc., will cause the groundwater level to fluctuate for both pervious and impervious soils.

SOILS & STRUCTURES

Sample Type

If not otherwise indicated, the sample is a split-barrel liner sample ASTM D 1586.

"S.T.' – Shelby tube sample, ASTM D 1587
"A" – disturbed augered sample
"C" – rock core sampled ASTM D 2113
N.P.M. – Natural Percent Moisture of in-situ soils sample
N.D. – Natural Density of in-situ soils sample in pcf.
S.S. – Shear Strength of cohesive soils samples as determined by the Unconfined Compression tests in ksf.

Classification Data – Laboratory data to assist in classification of soils and classification of soils characteristics; i.e., plastic limit or liquid limit

Test Boring Logs

Particle Size	**Visual**
Boulders	Larger than 12" (300 mm)
Cobbles	12" to 3" (300 to 75 mm)
Gravel - Coarse	3" to ¾ " (75 to 19 mm)
Gravel – Fine	19.0 to 4.75 mm
Sand- Coarse	4.75 to 2.0 mm
Sand - Medium	2.0 to 0.425 mm
Sand - Fine	0.425 to 0.075 mm
Silt	0.075 to 0.002 mm
Clay	0.002 mm and smaller

Soils Components

Major Component	**Minor Component**
Gravel	Trace (1 - 10%)
Sand	Some (11 - 35%)
Silt/Clay	And (36 - 50%)

Condition of Soil Relative to Compactness

Granular Material	**"N" Value**
Loose	0 - 4
Slightly Compact	5 - 7
Compact	8 - 20
Very Compact	21 - 50
Extremely Compact	51 and above

Cohesive Material	**"N" Value**
Soft	0 - 4
Firm	5 - 7
Stiff	8 - 20
Very Stiff	21 - 50
Extremely Stiff	51 and above

"N" values in clay soils are not to be used as a measure of shear strength. However, they may be used as a general indication of strength.

SOILS & STRUCTURES

Unified Soil Classification System Chart

Major Divisions			Letter Symbol	Typical Descriptions
Coarse Grained Soils More than 50% of material is larger than No. 200 sieve size	Gravel – Gravelly Soils more than 50% of coarse fraction retained on No. 4 sieve	Clean gravels (little or no fines)	GW	Well-Graded gravels, gravel-sand mixtures, little or no fines
			GP	Poorly-Graded gravels, gravel-sand mixtures, little or no fines
		Gravel with Fines (appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures
			GC	Clayey gravels, gravel-sand-clay mixtures
	Sand and Sandy Soils More than 50% of coarse fraction passing No. 4 sieve	Clean Sand (little or no fines)	SW	Well-Graded sands, gravelly sands, little or no fines
			SP	Poorly-Graded sands, gravelly sands, little or no fines
		Sand with Fines (appreciable amount of fines)	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
Fine Grained Soils More than 50% of material is smaller than No. 200 sieve size	Silts and Clays Liquid limit less than 50		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
			CL	Inorganic clays or low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			OL	Organic silts and organic silty clays or low plasticity
	Silts and Clays Liquid limit greater than 50		MH	Inorganic silts, micaceous or diatomaceous fine sand or silty soils
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays or medium to high plasticity, organic silts
	Highly organic soils		PT	Peat, humus, swamp soils with high organic contents

For Laboratory Classification of Fine Grained Soil
Plasticity Chart