GEOTECHNICAL ENGINEERING REPORT

MIDWEST CAR WASH

291 HWY & THOMPSON DRIVE
LEE’S SUMMIT, MISSOURI

Prepared for:

Kaden Construction Company

Kansas City, Missouri

August 15, 2022

Olsson Project No. 022-04040

olsson

August 15, 2022

Kadean Construction
Attn: Mr. Josh Moore
1821 McGee Street
Kansas City, Missouri 64108

Re: Geotechnical Engineering Report
Midwest Car Wash
291 Hwy and Thompson Drive
Lee's Summit, Missouri
Olsson Project No. 022-04040

Dear Mr. Moore,

Olsson has completed the geotechnical engineering report for the new car wash. The enclosed report summarizes our understanding of the project, presents the findings of the borings and laboratory tests, discusses the observed subsurface conditions, and based on those conditions, provides geotechnical engineering recommendations for the new car wash and associated pavement areas.

We appreciate the opportunity to provide our geotechnical engineering services for this project. If you have any questions or need further assistance, please contact us at your convenience.

Respectfully submitted,
Olsson, Inc.

JAMES M.
LANDRUM
NUMBER
E-28954

8/15/2022

JD Putnam, E.I.
Assistant Engineer

James M. Landrum, PE
Vice President

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1. PROJECT INTRODUCTION

1.1 Geotechnical Scope

This Geotechnical Engineering Report presents the results of the subsurface exploration performed for the Midwest Car Wash project in Lee's Summit, Missouri. We drilled five borings within the proposed building footprint and associated pavements areas. The approximate locations of the borings are shown on the Boring Location Map in Appendix A. The associated Borehole Reports are presented in Appendix B. The purpose of this report is to evaluate the existing subsurface conditions at the site, and based on those conditions, present our opinions and geotechnical engineering recommendations for site preparation, foundation design parameters for the proposed structure, floor slab and pavement subgrades, and estimates of minimum pavement section thicknesses.

1.2 Project Site Information

The project site located at the northeast corner of Missouri 291 and SE Scherer Road in Lee's Summit, Missouri (Figure 1). At the time of our exploration, the project site was grass covered and sloped down from the west and south to the east and north.

Figure 1. Project Site Location

Based on readily available historical aerial images from Google Earth, the site has remained undeveloped since at least 1991. The site appears to have been used for construction staging purposes between 2016 and 2017.

1.3 Project Information

We understand the project consists of a single story, slab-on-grade car wash structure. We anticipate the structure will have column loads less than 60 kips and wall loads less than 5 kips per lineal foot. If the structural loads are greater than those anticipated, ***Olsson*** should be contacted to determine if additional recommendations are necessary. We understand a below grade oil-separator pit will be located at the site.

At the time of this report, a grading plan including the anticipated finished floor elevation was not available; we anticipate that cut and fills will be less than 10 feet. ***Olsson*** should be contacted if greater cuts and fills are planned for the site, so additional recommendations can be provided. A 3-lane canopy kiosk is planned south of the building. Vacuum parking stalls are planned north of the building.

The proposed project site layout is shown in Figure 2.

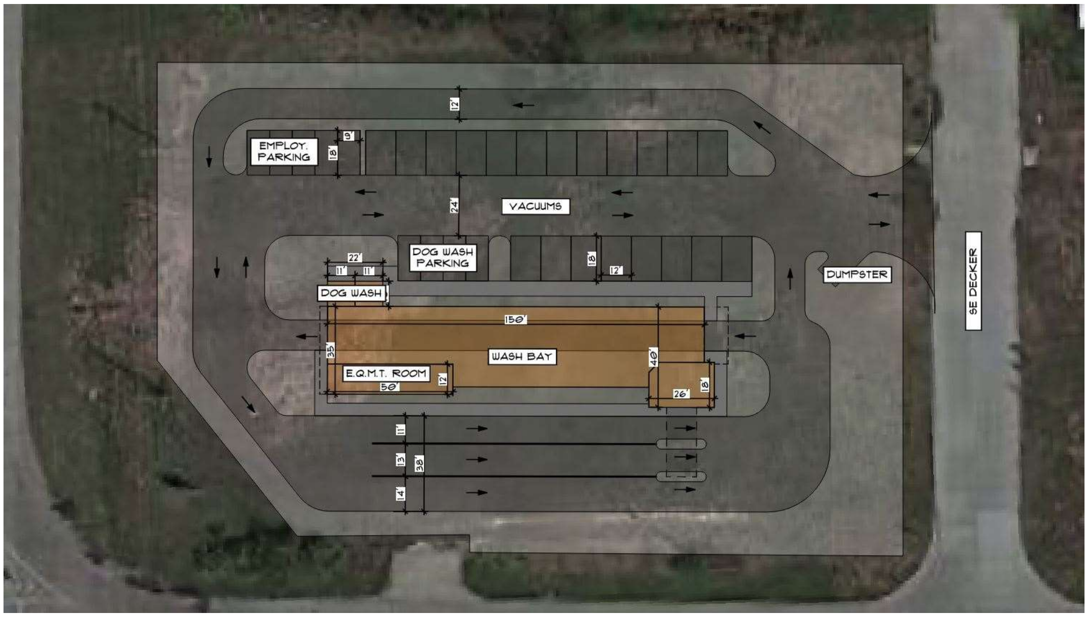


Figure 2. Proposed Site Layout

2. FIELD EXPLORATION AND LABORATORY TESTING

2.1 Field Exploration

The drill crew used truck mounted CME-55 drill rig, equipped with continuous flight augers, to advance five borings at the site. The borings were placed according to the proposed layout shown in Figure 2, the approximate locations are shown in Appendix A. The drill crew located the borings using GPS coordinates and a cell phone app.

The drill crew obtained soil samples using thin-walled sampling tubes hydraulically pushed into the soil and split-barreled sampling tubes during the performance of the Standard Penetration Test (SPT). These samples were sealed and returned to our laboratory for testing and classification. The sampling depths and SPT blow counts (N-values) are shown on the appended Borehole Reports in Appendix B.

The drill crew prepared a field log for each boring. These field logs include visual classifications of the materials encountered during the drilling process as well as the drillers' interpretation of the subsurface conditions between the samples.

2.2 Laboratory Testing

At our laboratory, we measured the moisture content of each samples. Dry density and unconfined compressive strength tests were performed on selected tube samples. We also measured the Atterberg limits on two selected samples. Based on the laboratory test results and our observations of the samples, we modified the field logs that were prepared by the drill crew. Results of the laboratory tests are shown on the appended Borehole Reports.

3. SUBSURFACE CONDITIONS

3.1 Subsurface Stratigraphy

The subsurface conditions shown on the borehole reports represent conditions at the specific boring locations at the times they were drilled. Variations may occur between and beyond the borings. The stratification lines shown on the appended Borehole Reports represent the approximate locations of changes in soil and bedrock types. The actual transitions between materials is usually gradual.

Below the surface rootzone layer, the site generally consisted of approximately 3 feet of previously placed clayey fill soils. The fill contained variable amounts of clay, silt, sand, gravel and organics.

Underlaying the fill, native highly plastic (fat) clay soils were encountered. The native fat clays were generally stiff to occasionally firm in consistency. B-5 terminated in the native clays at 5 feet below the existing surface.

At the remaining borings, the native clays extended to depths ranging from 7.5 feet to 11 feet, transitioning into limestone. The native clays exhibited shaley characteristics and contained weathered limestone gravel near the transition zone. The carbide tipped drill bit penetrated approximately 3 to 18 inches into the limestone bedrock before encountering auger refusal at depths of 9 feet to 11 feet.

3.2 Water Level Observations

The drill crew obtained water level readings during drilling and immediately after the completion of drilling operations. The drill crew noted water at borings B-1, B-2 and B-3 at depths ranging from 7 feet and 8.5 feet at these times. The presence and lack of water should not be construed to represent a permanent or stable condition. Variations and uncertainties exist with relatively short-term water level observations in boreholes. Water levels can and should be anticipated to vary between boring locations, as well as time within specific borings. Water typically collects near the interface between different materials, such as soil and bedrock. Groundwater levels can fluctuate with variations in precipitation, site grading, drainage, and adjacent land use. Long term monitoring with piezometers generally provides a more representative reflection of the potential range of groundwater conditions.

4. GEOTECHNICAL CONSIDERATIONS

In our opinion, the new car wash can be supported on a shallow foundation system bearing entirely on native stiff clay soils. Borings B-1 through B-3 and B-5 noted fill to depths of 3 feet. We have not reviewed any records regarding former site grades or fill placement at this site and the fill did not appear suitable for support of the new structure or pavements. We recommend the existing fill material be entirely removed from the building footprint and new pavement areas. The zone of removal should extend laterally at least 5 feet beyond the edges of the proposed building footprint and at least 2 feet from the proposed curblines of new pavements.

Limestone bedrock was encountered at borings B-1 through B-4 at depths of 7 to 11 feet. Excavations that extend into limestone could require hard rock removal techniques.

5. SITE PREPARATION

5.1 General Site Preparation

Site preparation should commence with the stripping of any organic topsoil, as well as and any loose, soft, or otherwise unsuitable materials. These materials should be carefully separated to avoid incorporation of organic materials into new fill sections within the building or pavement areas. Site clearing, grubbing and stripping activities should be performed during dry weather conditions. Operation of heavy equipment on the site during wet conditions could result in excessive rutting and mixing of construction debris with the underlying soils.

Following stripping operations, the on-site fill material should be removed from the site. At the borings, the fill generally extended to depths of 3 feet (+/-). It is possible that the fill could be deeper in other areas of the site. The fill could also contain other materials than noted on the boring logs. In our opinion, the existing fill should be completely removed from within the proposed building footprint and parking lot areas. The zone of removal should extend at least 5 feet beyond the building footprint and 2 feet beyond the pavement curblines.

Upon completion of stripping operations and removal of the existing fill, but prior to any new fill being placed on site, we recommend that the exposed ground surface be proofrolled with a loaded tandem axle dump truck weighting at least 20 tons or similar equipment. Proofrolling operations should be observed by a representative of ***Olsson***. Unstable and unsuitable soils revealed by proofrolling should be removed and replaced with structural fill.

Once proofrolling is complete, the upper 9 inches of exposed subgrade should be scarified, moisture conditioned, and recompacted to a minimum of 95 percent of the materials Standard Proctor maximum dry density (ASTM Specification D-698) at a moisture content between 0 percent and 4 percent above optimum.

5.2 Structural Fill

All structural fill and backfill should consist of approved materials, free of organic matter (organic content less than 5 percent), and debris. Structural fill should not contain particle sizes larger than 3 inches. Any imported fill should generally exhibit a Liquid Limit less than 55 and a Plasticity Index less than 30. Samples of any proposed imported fill material should be submitted to ***Olsson*** for Laboratory Proctor compaction and classification tests prior to placement at the site. The native on-site soils and, provided all unsuitable material is removed, existing fill appear to be suitable for re-use as structural fill but not for use as low volume change below the floor slabs.

We recommend that structural fill and backfill be compacted in accordance with the criteria provided in Table 1 below. An ***Olsson*** representative should observe the fill placement operations and perform field compaction tests, as required.

Area of Fill Placement	Material	ASTM D-698 Compaction Recommendation	Moisture Content (Percent of Optimum)
Granular Leveling Course 6 inches below floor slabs	ASTM C-33 No.57 Aggregate	65% of Relative Density	As necessary to obtain density
Low Volume Change 18 inches below Granular Leveling Course	LL < 50 PI < 25	95%	0 to +4 percent
	MoDOT Type 5 Baserock*		As necessary to obtain density
Structural Fill Imported	LL < 55 PI < 30	95%	0 to +4 percent
Structural Fill Native On-site soils	Recompacted Native On-Site Soils	95%	0 to +4 percent
Pavement Subgrade On-site soils	Recompacted Native On-Site Soils	95%	0 to +4 percent
Preferred Pavement Subgrade Aggregate Base	MoDOT Type 5 Baserock*	95%	As necessary to obtain density
Preferred Pavement Subgrade Chemical Stabilization	Fly Ash (15%)/ Soil Cement (5%)/ Lime (5%)**	95%	-1 to +3 percent

*Or equivalent
**Percentages based on dry unit weights

Table 1. Fill Placement Compaction Recommendations

Suitable fill materials should be placed in thin loose lifts of 8 inches or less. Within small excavations, such as in utility trenches, around manholes, or behind retaining walls, the use of vibrating plat compactors, jumping jack compactors or walk behind sheepsfoot compactors may be used to facilitate compaction in these areas. Loose lifts thicknesses of 4 inches or less are recommended where small compaction equipment is used.

The moisture content for suitable borrow soils at the time of compaction should generally be maintained between the ranges specified above. More stringent moisture limits may be necessary with certain soils and some adjustments to moistures contents may be necessary to achieve compaction in accordance with project specifications.

5.3 Drainage and Groundwater Conditions

Water should not be allowed to collect at the ground surfaces near foundations, floor slabs, or areas of new pavement, either during or after construction. Provisions should be made to quickly remove accumulating seepage water or storm water runoff from excavations. Undercut or excavated areas should be sloped toward one corner to allow rainwater or surface runoff to be quickly collected and gravity drained or pumped from construction areas. Subgrade soils that are exposed to precipitation or runoff should be evaluated by ***Olsson*** prior to the placement of new fill, reinforcing steel, or concrete, to determine if corrective action is required.

To minimize concerns related to improper or inadequate drainage away from foundation bearing subgrades or from cohesive backfill materials used in utility or foundation trenches, we recommend the following:

- Site grading should provide for efficient drainage of rainfall or surface runoff away from new structures and pavement.
- Roof run-off should be collected and transferred directly to the storm sewer system or directed to a location with positive and rapid drainage away from new structures and pavements.
- External hose connections in unpaved areas should incorporate splash blocks to prevent accidental flooding of foundation bearing or backfill soils. External hose connections should have cut-off valves inside the building to prevent accidental or unauthorized use.

6. STRUCTURES

6.1 Shallow Foundations

Based on the subsurface conditions encountered at the borings, we anticipate that foundations for the individual structures will bear on stiff native fat clay soils and/or properly placed structural fill. For shallow foundations bearing on such soils, a maximum net allowable soil bearing pressure of 2,500 pounds per square foot (psf) can be used for design. The net allowable soil bearing pressure refers to the bearing pressure at foundation level in excess of surrounding overburden pressure.

Exterior footings should bear at a minimum depth of 3 feet below the adjacent final ground surface to provide for frost protection. Footings should have a minimum foundation width of 18 inches for continues footings and 30 inches for isolated column footings. Earth formed trench footings should have a minimum width of 12 inches.

Lightly loaded interior partition walls (applying less than 0.75 kips per lineal foot (klf)) may be supported directly on the slab-on-grade floor. Depending on the floor slab design and the specific wall loads, it may be necessary to increase the floor slab reinforcement or provide a thickened slab cross-section below interior walls. For interior walls with loads greater than 0.75 klf, we recommend a footing be installed, independent of the floor slab, to properly distribute the loads to the underlying soils.

The borings encountered isolated areas of softer clay soils (e.g. boring B-4 at a depth of 3 to 8 feet). Similar softer soils could be encountered at planned bearing elevation for the footings. ***Olsson*** should be retained to review the bearing soils at the time of construction. If the subgrade soils are not capable of supporting the design bearing pressure, the footings should be extended to suitable bearing material. The footings could bear at this lower level or on a lean concrete that extends to the suitable bearing material. Alternatively, the overexcavation could be backfilled with structural fill to the design bearing elevation. If using structural fill, the zone of excavation should extend at least 8 inches for every foot of overexcavation depth laterally beyond the edges of the footing. The structural fill should be placed and compacted as recommended in this report.

After foundation subgrades have been observed and evaluated by an ***Olsson*** representative, concrete should be placed as soon as possible to avoid subjecting the exposed soil to drying, wetting, or freezing conditions. If the foundation subgrade soils are subjected to such conditions, ***Olsson*** should be contacted to reevaluate the foundation bearing materials.

In our opinion, foundations supported on stiff native clay soils or properly placed and compacted structural fill could experience post-construction and differential settlements on the order of 1 inch and ½ inch, respectively.

6.2 Floor Slab Subgrade Preparation

Our laboratory tests indicate that the on-site soils have a moderate risk for subgrade volume change with fluctuating moisture contents. To reduce this risk, we recommend the placement of a 24-inch zone of low volume change (LVC) material beneath the base of all floor slabs.

The upper 6 inches of the zone should consist of a well graded, free draining, granular material (e.g. ASTM C-33 No. 57 aggregate). The free draining material should be compacted to 65 percent of the material's relative density and moisture conditioned to a level that is necessary to obtain the required density. Underlaying the granular drainage layer, 18 inches of additional LVC material should be installed. The additional material should consist of cohesive soils exhibiting a Liquid Limit less than 50 and a Plasticity Index less than 25, or a well graded granular material such as MoDOT Type 5 baserock, or equivalent. The additional 18 inches of LVC material should be compacted and moisture conditioned to the levels recommended in Table 1 of this report.

Upon completion of grading operations in the building area, care should be taken to maintain the recommended subgrade moisture content and density prior to construction of the floor slab. If the subgrade should become saturated, desiccated, frozen, disturbed, or altered by construction activity, the subgrade should be restored to the conditions recommended in Table 1 of this report.

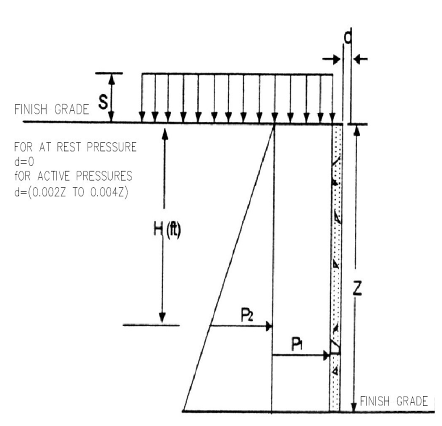
The procedures recommended above may not eliminate all future subgrade volume change and resultant floor slab movement. However, the procedures outlined should significantly reduce the potential for future subgrade volume change. Common construction practice is to tie the slab-on-grade into the foundation elements to limit the impact of differential movement at doorways and windows. Depending on the location of construction joints in the slab, the rigidity of the slab and foundation connection, and the magnitude of actual movement that occurs, some minor cracking within the floor slab could occur and should be expected.

6.3 Lateral Earth Pressures

The following soil parameters are provided for use in designing the walls of a below grade oil-separator pit. The parameters are based on the understanding that the retained soils used during construction will be similar in composition to the on-site soils encountered during this exploration. To ensure similarity, we recommend confirmation testing be performed during construction by ***Olsson***.

The "at-rest" condition assumes no wall rotation. Walls that are unrestrained at the top and are free to rotate slightly, such as Cast-in-Place concrete cantilever walls, may be designed for “active” earth pressure conditions. The "passive" earth pressure condition should be used to evaluate the resistance of soil to lateral loads. Table 2 presents recommended values of earth pressure coefficients based on our experience with soils in the area. Equivalent fluid densities are frequently used for the calculation of lateral earth pressures for the “at-rest” and “active” conditions and are therefore provided in Table 2.

Legend of Symbols	
Z	Wall Height (ft)
H	Depth Below Surface (ft)
D	Wall Displacement (ft)
S	Surcharge Load (psf)
P_1	Surcharge Pressure (psf)
P_2	Earth Load (psf)
K	Earth Pressure Coefficient
G	Equivalent Fluid Density (pcf)
Pressure Calculations	
Surcharge Pressure	P_1 (psf) = K * S
Earth Load	P_2 (psf) = G (pcf) * H (ft)



Earth Pressure Coefficient (K)			**Equivalent Fluid Density (G)**	
			Drained, pcf	**Undrained, pcf**
Active (K_a)	Cohesive	0.39	45	85
	Granular*	0.31	35	-
At-Rest (K_o)	Cohesive	0.56	65	95
	Granular*	0.47	55	-
Passive (K_p)	Cohesive	2.56	305	210
	Granular*	3.25	390	-

*Granular backfill should be permanently drained

Table 2. Lateral Earth Pressure Parameters

The following assumptions were made:

- For active earth pressure, the wall must rotate about its' base, with top lateral movements of 0.002*Z to 0.004*Z, where "Z" is the wall height.
- The equivalent fluid densities in Table 2 do not include the effects of surcharge loading.
- The equivalent fluid densities in Table 2 assume a level backslope. If a backslope is included, ***Olsson*** should be contacted to update the earth pressure coefficient and associated equivalent fluid density.
- The wall must move horizontally to mobilize passive resistance.
- Surcharges are uniform, where "S" is surcharge pressure, in psf.
- In-situ backfill has a maximum weight of 120 pcf.
- Horizontal backfill is compacted to 95% of standard Proctor maximum dry density.
- Heavy equipment and other concentrated load components are not included.
- No hydrostatic pressure acting on wall. Assumes a drained condition.
- No safety factor is included.
- Passive pressure in the frost zone or moisture fluctuation zone should be ignored.

Backfill placed against structures should consist of granular soils or low plasticity cohesive soils. For the granular values to be valid, the granular backfill must extend out from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively. To calculate the resistance to sliding, an ultimate coefficient of friction value of 0.30 should be used where the footing bears on soil and 0.65 where the footing bears on limestone bedrock.

To intercept infiltrating surface water behind the wall, we recommend a perimeter drain be installed at the foundation level. The drain line invert should be below the finished subgrade elevation for the interior floor. The drain line should be sloped to provide positive gravity drainage and should be surrounded by free-draining granular material graded to prevent the intrusion of fines, or an alternative free-draining granular material encapsulated with suitable filter fabric. A minimum 2-foot-wide section of free-draining granular fill should be used for backfilling above the drain line and adjacent to the wall and should extend to within 2 feet of final grade. The granular backfill should be capped with compacted cohesive fill to minimize infiltration of surface water into the drain system.

6.4 Site Seismic Classification

For this project site, the soil conditions encountered are consistent with the definition of Site Class “C” (Very Dense Soil and Soft Rock profile) as defined in ASCE 07.

7. PAVEMENTS

We understand that a 3-lane entrance drive will be located south of the proposed structure. Parking spaces and drive lanes are planned to be located to the north side of the building.

As discussed in the site preparation of the report, the on-site fill material should be removed from beneath new pavement areas, extending at least 2 feet beyond the edge of the curblines. The resulting overexcavation should be backfilled with structural fill as needed to obtain the desired site grades.

We recommend that the prepared subgrade extend a minimum of 2-feet outside the pavements, where feasible. ***Olsson*** should be present during subgrade preparation to observe, document, and test compaction of the materials at the time of placement. As recommended for all prepared soil subgrades, heavy, repetitive construction traffic should be controlled, especially during periods of wet weather, to minimize disturbance. The final prepared subgrade should be proof rolled with a loaded dump truck or similar rubber-tired equipment with a total weight of at least 20-tons, immediately prior to placement of new pavements. Proofrolling operations should be observed and documented by ***Olsson***. Unstable or unsuitable soils revealed by proofrolling should be reworked to provide a stable subgrade or removed and replaced with structural fill.

Construction scheduling often involves grading and paving by separate contractors and can involve a time lapse between the end of grading operations and the commencement of paving operations. Disturbance, desiccation, or wetting of the subgrade soils between grading and paving operations can result in the deterioration of the previously completed subgrade. If soft and/or wet areas are identified during subgrade preparation or if the subgrade soils have been exposed to adverse weather conditions, frost, excessive construction traffic, standing water, or similar conditions, ***Olsson*** should be consulted to determine if corrective action is necessary.

It is important that the pavement subgrade support be relatively uniform, with no abrupt changes in the degree of support. Non-uniform pavement support can occur as a result of varying soil moisture contents or soil types, or where improperly placed utility backfill has been placed across or through areas to be paved. Improper subgrade preparation such as inadequate vegetation removal, failure to identify soft or unstable areas by proofrolling, and inadequate or improper compaction can also produce non-uniform subgrade support.

According to the City of Lee’s Summit, Missouri Unified Development Ordinance (*Section 8.620 Table 8-5 Parking Lot Paving*), the minimum pavement sections for parking areas and drives consists of 6 inches of portland cement concrete over a 4 inch thick granular base course or, alternatively, a minimum of 1.5 inches of Asphalt Concrete Surface Course over 4 inches of Asphaltic Concrete Base Course supported on a subgrade consisting of either 6 inches of granular base course with a geogrid or 6 inches of granular base course with 6 inches of stabilized subgrade. In fire lanes and truck access areas, the Asphaltic Base course increases from 4 inches to 5 inches. The city also allows for alternative designs that are equal to or greater than city standards. Table 3 summarizes our recommended alternate minimum pavement section thicknesses for portland cement concrete (PCC), full depth asphaltic concrete (AC), and AC with a granular base. Routine maintenance of the pavement will be required, consisting of periodic seal coats and possible one intermediate mill, in addition to regular crack maintenance.

Parking Areas	Drive Paths	Heavy Vehicle Areas (Dumpster Pads)
Full Depth PCC: 6" PCC 4" Clean Rock Base 9" Prepared Compacted Subgrade*** Full Depth AC: 2" AC Surface 4" AC Base 9" Chemically Stabilized Subgrade* AC w/ Granular Base 2" AC Surface 4" AC Base 9" Compacted MoDOT Type 5 Baserock**	Full Depth PCC: 6" PCC 4" Clean Rock Base 9" Prepared Compacted Subgrade*** Full Depth AC: 2" AC Surface 6" AC Base 9" Chemically Stabilized Subgrade* AC w/ Granular Base 2" AC Surface 6" AC Base 9" Compacted MoDOT Type 5 Baserock**	Full Depth PCC: 8" PCC 4" Clean Rock Base 9" Prepared Compacted Subgrade***

*Cohesive soils chemically stabilized with 15% Class "C" Fly Ash, 5% soil cement, or 5% lime
**Or equivalent
***Cohesive soils compacted to 95% of maximum dry density at a moisture content between 0 to +4 percent of optimum

Table 3. Minimum Pavement Section Thicknesses

In our opinion, PCC pavements should be considered for the new car wash. The clean rock base for the PCC pavements should be uniform and pavement subgrade should be graded to provide positive drainage of the granular base section. The granular section should be graded to adjacent storm sewer inlets and provisions should be made to provide drainage from the granular section into the storm sewers. Drainage of the granular base is particularly important where two different sections of pavements (such as AC and PCC) abut, so that water does not pond beneath the pavements and saturate the subgrade soils. We further recommend that the length of concrete sections be such that no heavy truck wheels are allowed to rest on asphaltic concrete sections during loading/unloading operations.

The performance of the pavements will be dependent upon a number of factors, including subgrade conditions at the time of paving, rainwater runoff, and traffic. Rainwater runoff should not be allowed to seep below pavements from adjacent areas. Pavements should be sloped approximately ¼ inch per foot to provide for rapid surface drainage.

Proper drainage below the pavement section helps prevent softening of the subgrade and has a significant impact on pavement performance and pavement life. Therefore, we recommend that a granular blanket drain be constructed at all storm sewer inlets within the pavement areas. The blanket drain should consist of clean, crushed rock extending a minimum of 6 inches below pavement subgrade level. The blanket drains should extend radially a minimum of 8 feet from each of the storm sewer inlets. The grade within the blanket drain should be sloped toward the storm sewer inlet, and weep holes should be drilled through the inlet to provide drainage of the granular section into the inlet. Placement of a geotextile filter fabric across the weepholes could be considered to prevent loss of aggregate through the weep holes.

Construction traffic on the pavements has not been considered in the above noted typical sections. If construction scheduling dictates that the pavements will be subjected to traffic by construction equipment, increasing the pavement thickness should be considered to include the effects of additional traffic loading. Construction traffic should not be allowed on partially completed pavements as the pavements will not have adequate structural capacity and could be damaged.

8. CONCLUSIONS AND LIMITATIONS

8.1 Construction Observation and Testing

We recommend that all earthwork during construction be monitored by a representative of ***Olsson,*** including site preparation, placement of all structural fill and trench backfill, and pavement subgrades. The purpose of these services would be to provide ***Olsson*** the opportunity to observe the soil conditions encountered during construction, evaluate the applicability of the recommendations presented in this report to the soil conditions encountered, and recommend appropriate changes in design or construction procedures if conditions differ from those described herein.

8.2 Limitations

The conclusions and recommendations presented in this report are based on the information available regarding the proposed construction, the results obtained from our borings, laboratory testing program, and our experience with similar projects. The borings represent a very small statistical sampling of subsurface soils and it is possible that conditions may be encountered during construction that are substantially different from those indicated by the borings. In these instances, adjustments to design and construction may be necessary.

This geotechnical report is based on the site plan and our understanding of the project's information as provided to ***Olsson***. Changes in the location or design of new structures could significantly affect the conclusions and recommendations presented in this geotechnical report. ***Olsson*** should be contacted in the event of such changes to determine if the recommendations of this report remain appropriate for the revised site design.

This report was prepared under the direction and supervision of a Professional Engineer registered in the State of Missouri with the firm of **Olsson, Inc.** The conclusions and recommendations contained herein are based on generally accepted, professional, geotechnical engineering practices at the time of this report, within this geographic area. No warranty, express or implied, is intended or made. This report has been prepared for the exclusive use of **Kaden Construction Company** and their authorized representatives for the specific application to the proposed project described herein.

APPENDIX A

Boring Location Map

Scale: n.t.s.
Project No. 022-04040
Approved by: JDP
Date: 6/30/2022

Boring Location Map

Midwest Car Wash
Lee's Summit, Missouri

APPENDIX B

Borehole Reports Symbols Reports and Nomenclature

SYMBOLS AND NOMENCLATURE

DRILLING NOTES

DRILLING AND SAMPLING SYMBOLS

SS: Split-Spoon Sample (1.375” ID, 2.0” OD)
U: Thin-Walled Tube Sample (3.0” OD)
CS: Continuous Sample
BS: Bulk Sample
MC: Modified California Sampler
GB: Grab Sample
SPT: Standard Penetration Test Blows per 6.0”

HSA: Hollow Stem Auger
CFA: Continuous Flight Auger
HA: Hand Auger
CPT: Cone Penetration Test
WB: Wash Bore
FT: Fish Tail Bit
RB: Rock Bit
PP: Pocket Penetrometer

NE: Not Encountered
NP: Not Performed
NA: Not Applicable
% Rec: Percent of Recovery
WD: While Drilling
IAD: Immediately After Drilling
AD: After Drilling
CI: Cave In

DRILLING PROCEDURES

Soil samples designated as “U” samples on the boring logs were obtained in using Thin-Walled Tube Sampling techniques. Soil samples designated as “SS” samples were obtained during Penetration Test using a Split-Spoon Barrel sampler. The standard penetration resistance ‘N’ value is the number of blows of a 140 pound hammer falling 30 inches to drive the Split-Spoon sampler one foot. Soil samples designated as “MC” were obtained in using Thick-Walled, Ring-Lined, Split-Barrel Drive sampling techniques. Recovered samples were sealed in containers, labeled, and protected for transportation to the laboratory for testing.

WATER LEVEL MEASUREMENTS

Water levels indicated on the boring logs are levels measured in the borings at the times indicated. In relatively high permeable materials, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels is not possible with only short-term observations.

SOIL PROPERTIES & DESCRIPTIONS

Descriptions of the soils encountered in the soil test borings were prepared using Visual-Manual Procedures for Descriptions and Identification of Soils.

PARTICLE SIZE

Boulders	12 in. +	Coarse Sand	4.75mm-2.0mm	Silt	0.075mm-0.005mm
Cobbles	12 in.-3 in.	Medium Sand	2.0mm-0.425mm	Clay	<0.005mm
Gravel	3 in.-4.75mm	Fine Sand	0.425mm-0.075mm		

COHESIVE SOILS

Consistency	Unconfined Compressive Strength (Qu) (tsf)
Very Soft	<0.25
Soft	0.25 – 0.5
Firm	0.5 – 1.0
Stiff	1.0 – 2.0
Very Stiff	2.0 – 4.0
Hard	> 4.0

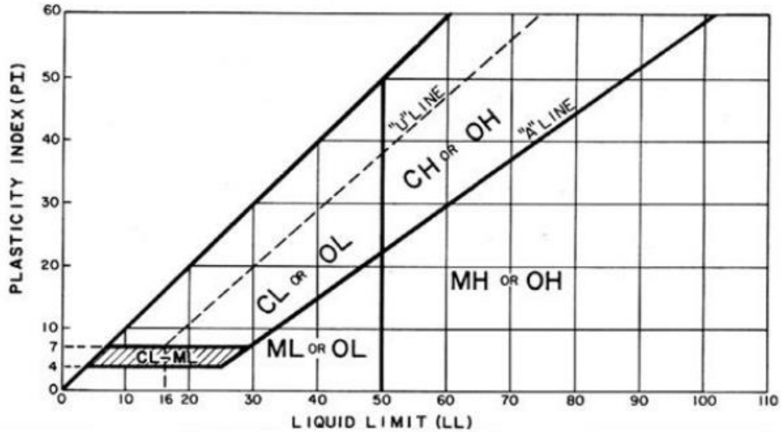
COHESIONLESS SOILS

Relative Density	‘N’ Value
Very Loose	0 – 3
Loose	4 – 9
Medium Dense	10 – 29
Dense	30 – 49
Very Dense	≥ 50

COMPONENT %

Description	Percent (%)
Trace	<5
Few	5 - 10
Little	15 - 25
Some	30 - 45
Mostly	50 - 100

PLASTICITY CHART



ROCK QUALITY DESIGNATION (RQD)

Description	RQD (%)
Very Poor	0 – 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 – 100

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BOREHOLE REPORT NO. B-1

Sheet 1 of 1

PROJECT NAME **MIdwest Car Wash - Lee's Summit**	CLIENT **Kaden Construction**
PROJECT NUMBER **022-04040**	LOCATION **Lee's Summit, Missouri**

■ Shelby Tube

ELEVATION (ft)	MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	SAMPLE TYPE NUMBER	CLASSIFICATION (USCS)	BLOWS/6" N-VALUE	UNC. STR. (tsf)	MOISTURE (%)	DRY DENSITY (pcf)	LL/PI (%)	ADDITIONAL DATA/ REMARKS
	ROOT ZONE ***0.5'***		0								
	FILL *Brown with dark brown clay, sandy, silt, trace organics and gravel* ***3.0'***			■ U 1				14.1			
	FAT CLAY *Stiff, olive brown with light reddish brown and gray, silty, moist*		5	■ U 2			1.0	28.4	96.2		
	8.0' ▼ *Stiff, light reddish brown with gray, silty, moist, trace gravel* ***9.0'***			■ U 3				22.5	106.6		
	LIMESTONE *Variably weathered* ***10.5'***		10								

REFUSAL AT 10.5 FEET

WATER LEVEL OBSERVATIONS	
WD	▽ Not Performed
IAD	▼ 8.5 ft
AD	▼ Not Performed

OLSSON, INC.
1700 E. 123RD STREET
OLATHE, KANSAS 66061

STARTED:	7/26/22	FINISHED:	7/26/22
DRILL CO.:	KCTE	DRILL RIG:	CME 55
DRILLER:	B. HICKS	LOGGED BY:	P. MAYAYA
METHOD: CONTINUOUS FLIGHT AUGER			

olsson

BOREHOLE REPORT NO. B-2

Sheet 1 of 1

PROJECT NAME **MIdwest Car Wash - Lee's Summit**	CLIENT **Kaden Construction**
PROJECT NUMBER **022-04040**	LOCATION **Lee's Summit, Missouri**

■ Shelby Tube ☒ Split Spoon

ELEVATION (ft)	MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	SAMPLE TYPE NUMBER	CLASSIFICATION (USCS)	BLOWS/6" N-VALUE	UNC. STR. (tsf)	MOISTURE (%)	DRY DENSITY (pcf)	LL/PI (%)	ADDITIONAL DATA/ REMARKS
	ROOT ZONE **0.5'**		0								
	FILL *Dark brown with brown clay, sandy, silt, trace gravel and organics* **3.0'**	☒		■ U 1				13.4		51/32	
	FAT CLAY *Stiff, olive brown with reddish brown and gray, silty, moist* ▼ **7.5'**	▨	5	■ U 2			1.4	28.6	95.1		
	WEATHERED LIMESTONE **8.0'**										
	LIMESTONE **9.0'**			SS 3		50/1"		32.0			

REFUSAL AT 9.0 FEET

WATER LEVEL OBSERVATIONS	
WD	▽ Not Performed
IAD	▼ 7.0 ft
AD	▼ Not Performed

OLSSON, INC.
1700 E. 123RD STREET
OLATHE, KANSAS 66061

STARTED:	7/26/22	FINISHED:	7/26/22
DRILL CO.:	KCTE	DRILL RIG:	CME 55
DRILLER:	B. HICKS	LOGGED BY:	P. MAYAYA
METHOD: CONTINUOUS FLIGHT AUGER			

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BOREHOLE REPORT NO. B-3

Sheet 1 of 1

PROJECT NAME **MIdwest Car Wash - Lee's Summit**	CLIENT **Kaden Construction**
PROJECT NUMBER **022-04040**	LOCATION **Lee's Summit, Missouri**

■ Shelby Tube ☒ Split Spoon

ELEVATION (ft)	MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	SAMPLE TYPE NUMBER	CLASSIFICATION (USCS)	BLOWS/6" N-VALUE	UNC. STR. (tsf)	MOISTURE (%)	DRY DENSITY (pcf)	LL/PI (%)	ADDITIONAL DATA/ REMARKS
	ROOT ZONE **0.5'**		0								
	FILL *Dark brown with brown clay, sandy, silty, moist, trace organics and gravel* **3.0'**			U 1				22.6	97.7		
	FAT CLAY *Stiff, olive brown with reddish brown and gray, silty, moist*			U 2				27.5	98.8		
			5								
	▼ **8.0'** **8.2'**										
	Olive brown with reddish brown and gray, silty, shaley, moist, trace weathered limestone **9.0'** ***LIMESTONE***			SS 3		50/2"		26.2			

REFUSAL AT 9.0 FEET

WATER LEVEL OBSERVATIONS	
WD	▽ Not Performed
IAD	▼ 8.0 ft
AD	▼ Not Performed

OLSSON, INC.
1700 E. 123RD STREET
OLATHE, KANSAS 66061

STARTED:	7/26/22	FINISHED:	7/26/22
DRILL CO.:	KCTE	DRILL RIG:	CME 55
DRILLER:	B. HICKS	LOGGED BY:	P. MAYAYA

METHOD: CONTINUOUS FLIGHT AUGER

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BOREHOLE REPORT NO. B-4

Sheet 1 of 1

PROJECT NAME **MIdwest Car Wash - Lee's Summit**	CLIENT **Kaden Construction**
PROJECT NUMBER **022-04040**	LOCATION **Lee's Summit, Missouri**

■ Shelby Tube

ELEVATION (ft)	MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	SAMPLE TYPE NUMBER	CLASSIFICATION (USCS)	BLOWS/6" N-VALUE	UNC. STR. (tsf)	MOISTURE (%)	DRY DENSITY (pcf)	LL/PI (%)	ADDITIONAL DATA/ REMARKS
	ROOT ZONE ***0.5'***		0								
	FAT CLAY *Very stiff, very dark brown, silty, moist, trace organics*	▨		■ U 1			2.6	20.3	101.2	50/33	
	3.0'										
	Firm, dark gray with brown, silty, moist	▨		■ U 2			0.9	29.8	92.8		
			5								
	8.0'										
	Stiff, olive gray with reddish brown, silty, shaley, moist	▨		■ U 3			1.9	24.8	102.6		
			10								
	11.0'										
	LIMESTONE ***11.3'***										

REFUSAL AT 11.3 FEET

WATER LEVEL OBSERVATIONS	
WD	▽ Not Encountered
IAD	▼ Not Encountered
AD	▼ Not Encountered

OLSSON, INC.
1700 E. 123RD STREET
OLATHE, KANSAS 66061

STARTED:	7/26/22	FINISHED:	7/26/22
DRILL CO.:	KCTE	DRILL RIG:	CME 55
DRILLER:	B. HICKS	LOGGED BY:	P. MAYAYA

METHOD: CONTINUOUS FLIGHT AUGER

BOREHOLE REPORT NO. B-5

Sheet 1 of 1

PROJECT NAME
MIdwest Car Wash - Lee's Summit

CLIENT
Kaden Construction

PROJECT NUMBER
022-04040

LOCATION
Lee's Summit, Missouri

■ Shelby Tube

ELEVATION (ft)	MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	SAMPLE TYPE NUMBER	CLASSIFICATION (USCS)	BLOWS/6" N-VALUE	UNC. STR. (tsf)	MOISTURE (%)	DRY DENSITY (pcf)	LL/PI (%)	ADDITIONAL DATA/ REMARKS
	ROOT ZONE ***0.5'***		0								
	FILL *Brown with dark brown clay, sandy, gravel, silt, trace organics* ***3.0'***			■ U 1				16.2			
	FAT CLAY *Stiff, olive brown with reddish brown and gray, silty, moist* ***5.0'***		5	■ U 2			1.4	25.5	97.7		

BASE OF BORING AT 5.0 FEET

WATER LEVEL OBSERVATIONS	
WD	▽ Not Encountered
IAD	▼ Not Encountered
AD	▼ Not Encountered

OLSSON, INC.
1700 E. 123RD STREET
OLATHE, KANSAS 66061

STARTED:	7/26/22	FINISHED:	7/26/22
DRILL CO.:	KCTE	DRILL RIG:	CME 55
DRILLER:	B. HICKS	LOGGED BY:	P. MAYAYA

METHOD: CONTINUOUS FLIGHT AUGER

MIDWEST CAR WASH

Lee's Summit, Missouri - 2022

August, 2022

Olsson Project No. 022-04040