In response to a request from Bret Davidson, the Geotechnical Section has conducted an investigation to determine the cause and corrective measures for two slides that have occurred on Route U in Warren County.

**Location and History**

The two slides are located just south of Rodgers Drive on Route U in Warren County. Slide 1 is located near Sta 109+48.0, approximately 300 feet south of Rodgers Road. Slide 1 is approximately 90 feet in width and 22 feet in height. Slide 2 is located near Sta 105+00, approximately 700 feet south of Rodgers Drive, and is approximately 110 feet in width and 15 feet in height.

The slides were discovered by the district on May 24, 2022. It is unknown when the slides began moving. Slide 1 does not show signs of movement at the toe of the slope but settled along the center line and within the northbound lane leading to cracks roughly 1 to 2 inches deep developing. Slide 2 shows signs of previous movement with an older slide being visible just off the side of the road. In addition, there is evidence that the pavement has been repaired before by repaving over where the road has settled with the pavement being 2.5 feet thick in places under the roadway. This likely only induces additional movement of the slide as more asphalt is placed on top. The current slide appears to have developed cracks from the center line to the edge of the northbound lane.

**Existing Conditions**

Our investigation for each slide was completed from the roadway limits due to site constraints. We have extrapolated conditions at the toe of each slide based on materials encountered from our borings in the roadway. Conditions are likely to vary from the assumed stratigraphy and should be verified during the repair of each failed embankment.
The slope height of Slide 1 is approximately 22 feet with the subsurface consisting of roughly 1.5 feet of asphalt and road base underlain by 10 to 15 feet of gravelly lean clay. The gravelly lean clay is divided into a soft to medium stiff saturated layer in the upper 6 to 10 feet. The lower layer is moist and stiff. Beneath the clay layer is a layer of highly weathered dolomite roughly 2.5 to 4 feet thick underlain by a very dry, red, thinly laminated shale.

The slope height of Slide 2 is approximately 15 feet with the subsurface consisting of 1.0 to 2.5 feet of asphalt underlain by 0.8 to 3.7 feet of road base. Beneath the subgrade is 5.5 to 7.5 feet of soft to medium stiff lean and gravelly lean clay followed by 1.0 to 5.0 feet of stiff, reddish brown fat clay believed to be completely weathered shale. Underlying the fat clay is a tannish grey dolomite with thin clay seams.

Though there could be additional reasons not discovered by the field investigation, it is believed that Slide 1 likely occurred due to the over saturation of the upper layer of gravelly lean clay resulting in a loss of shear strength. This combined with the very steep nature of the embankment allowed the layer to begin sliding along the surface of the lower clay layer resulting in the settling and cracking in the pavement. Slide 2 is a result of poorly placed fill that became saturated resulting a loss of shear strength.

**Site Drainage**

On the west side of the roadway, it appears rock is near the surface at both slides. The ditch line appears to be choked in some places with debris consisting of sand, gravel, cobbles, leaves, and tree limbs.

A drainpipe was discovered on the downhill slope between Slide 1 and 2 at roughly Sta. 107+50. The uphill side of the drain could not be found but is believed to daylight somewhere between the slides, in the ditch on the west side of the roadway. Without this drain, drainage is facilitated by the ditch on the west side of the roadway. As stated above the ditch seems to be cluttered with debris and is likely affected by this. We recommend that the drainpipe’s uphill side should be found and cleaned out if it is not damaged. In addition, we recommend that the ditch be cleaned and have a ditch liner placed according to Specification Section 609.6 between stations 104+50 and 110+00. It is also encouraged that regular inspection and cleaning of the ditch be conducted for the length of Route U between Rodgers Drive and Lake Ridge Lane after the project’s completion.

**Recommendations for Slide 1 (Sta 108+50 to 110+00) Reinforced L-Basket Slope Repair (Figure 1)**

Global stability modeling was completed for a slope reconstructed to follow a similar geometry to the existing slope prior to failure. Our initial repair model consisted of a rock wedge with an embankment slope of 1.5:1. However, this system has a very low factor of safety (FOS~1.1) and is not recommended. We then modeled a repair consisting of a reinforced rock wedge fill. This system has a suitable factor of safety for global stability and incorporates a slope facing product and horizontal geogrid reinforcement as outlined below.

Beginning at the edge of the western shoulder, make a temporary benched excavation no steeper than 1.5H:1V. The excavation should be embedded a minimum of 4 feet into shale at the toe of the slope or excavator refusal if shallower. We recommend the shale surface at the base of the repair be excavated such that it’s slope is no steeper than 10 percent in any direction. We also recommend a representative from the geotechnical section be on site during excavation of the toe of the slope to verify these recommendations are valid based upon actual subsurface conditions.

We recommend an 8oz non-woven geotextile (such as US Fabrics US 205NW or Mirafi 180N) be laid down to separate existing soil from the new rock fill. The fabric should be lapped at the edges a minimum of 18-inches. The embankment should be reconstructed with Select Granular Backfill (SGB) in accordance with Specification Section 1010 with a final embankment slope no steeper than 1.5:1. The SGB should be faced with L-Shaped
Welded Wire Frame such as US Fabric’s Welded Wire Facing Unit, or equivalent, see Image 1 below. The final slope will have a stepped finish.

Image 1 - Welded Wire Facing Units, Taken From US Fabrics, www.usfabricsinc.com

This system should incorporate geogrid reinforcement placed horizontally from the back of the new fill to the face of each L-shaped Welded Wire Form. The L-shaped forms should be placed horizontally and be faced with a non-degradable/UV resistant mesh to retain fine materials. For a concept of the design, we anticipate the design will incorporate a polymer mesh facing similar to US Fabric’s Startamesh and geogrid reinforcement similar to US Fabrics SGU 80 or SGU 100.

We recommend using an 8oz non-woven geotextile to separate the existing soil from the new rock fill. The fabric also needs to be lapped at the edges a minimum of 18 inches. We also recommend installing a 4-inch perforated pipe bedded in 1-inch clean rock and wrapped with an 8 oz non-woven geotextile, such as US Fabrics US 205NW or equivalent, at the back of the base of the repair. If the base of the repair dips toward the toe, a perforated pipe bedded in in 1-inch clean rock and wrapped with an 8-oz non-woven geotextile should also be placed along the toe of the repair. The perforated drainage pipe(s) should be connected to solid 4-inch drainage pipes spaced every 50 feet along the repair. The solid pipes should be routed to daylight and drain on a rock flume pad.

Recommendations for Slide 2 (Sta 104+50 to 105+80) Rock Wedge Repair (Figure 2)

Global stability modeling was completed for a slope reconstructed to follow a similar geometry to the existing slope prior to failure. Our repair model consisted of a rock wedge with an embankment slope of 2:1. A suitable factor of safety was achieved and recommendations for constructing the slope are provided below.
Beginning at the edge of the western shoulder, make a temporary benched excavation no steeper than 2H:1V. The excavation should be embedded a minimum of 4 ft into weathered dolomite or excavator refusal, whichever comes first. We recommend the dolomite surface at the base of the repair be excavated such that it is no steeper than 10 percent in any direction. We also recommend a representative from the geotechnical section be on site during excavation of the toe of the slope to verify these recommendations are valid based upon actual subsurface conditions.

It is recommended that a slope no steeper than 2H:1V be constructed utilizing large rock fill meeting the following:

- Predominant top size of 12 inches
- Particle top size should be restricted to 24”. If boulders larger than 24” are delivered to the site, they can be removed from the fill and placed near the toe of the slope.
- Up to about 20% passing 6 inches is permissible.
- Fines should not exceed 10%.

We recommend using an 8oz non-woven geotextile to separate the existing soil from the new rock fill. The fabric also needs to be lapped at the edges a minimum of 18 inches. We also recommend installing a 4-inch perforated pipe bedded in 1-inch clean rock and wrapped with an 8 oz non-woven geotextile, such as US Fabrics US 205NW or equivalent, at the back of the base of the repair. If the base of the repair dips toward the toe, a perforated pipe bedded in in 1-inch clean rock and wrapped with an 8-oz non-woven geotextile should also be placed along the toe of the repair. The perforated drainage pipe(s) should be connected to solid 4-inch drainage pipes spaced every 50 feet along the repair. The solid pipes should be routed to daylight and drain on a rock flume pad.

DN/zt
Missouri Department of Transportation  
Construction and Materials

Job No.: S2967  
Design: N Slide  
Bent:  
Station: 109+61.3  
Offset: 6.0 L  
Elevation: 876.4  
Requested Station: 109+59.3  
Requested Offset: 4.0 L  
Requested Elevation: 876.4  
Drill No.: G-9402

Boring No. A1

Field Tests

N = (Em/60)Nm  
N = Corrected N value for standard 60% SPT efficiency; Em - Measured hammer efficiency in percent; Nm - Observed N-value

(1) = Assumed, (2) = Actual

Coordinate System: U.S. State Plane 1983  
Coordinate Zone: Missouri Central  
Coordinate Proj. Factor: 

Coordinate Datum: NAD 83 (CONUS)  
Coordinate Units: U.S. Survey Feet

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Missouri Department of Transportation
Construction and Materials

County: Warren
Route: U

Logged By: Duncan Noack
Operator: Gary Degraffenreid

Date of Work: 07/05/22-07/05/22

Depth to Water: 873.1 ft

Equipment: Acker Soil XLS, Split-Spoon Sampler, Shelby Tube

Job No.: S2967
Design: N Slide

Bent: N Slide

Station: 109+35.6
Offset: 9.5 R

Elevation: 873.1
Requested Station: 
Requested Offset: 
Requested Elevation: 

Drill No.: G-9462
Hammer Efficiency: 81%
Drilling Method: Hollow Stem Auger

---

**Field Tests**

\[ N_{60} = \frac{E_{m}}{60} \]

\[ N_{60} = \text{Corrected N value for standard 60\% SPT efficiency; } E_{m} = \text{Measured hammer efficiency in percent; } N_{m} = \text{Observed N-value} \]

**Index Tests**

\[ MC = \text{Moisture Content} \]
\[ \gamma = \text{Unit Weight} \]
\[ LL = \text{Liquid Limit} \]
\[ PL = \text{Plastic Limit} \]

**Coordinate System:** U.S. State Plane 1983
**Coordinate Zone:** Missouri Central
**Coordinate Proj. Factor:** U.S. State Plane 1983
**Coordinate Datum:** NAD 83 (CONUS)

*Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "log of materials" is limited thereby and by judgement of the operator. THIS INFORMATION IS FOR DESIGN PURPOSES ONLY.*
<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Graphic</th>
<th>Description</th>
<th>Elevation (ft)</th>
<th>Sample Type</th>
<th>REC % (ROD %)</th>
<th>Blow Counts (N&lt;sub&gt;60&lt;/sub&gt;)</th>
<th>Shear Data</th>
<th>Field Tests</th>
<th>Index Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-0.4'</td>
<td>ASPHALT</td>
<td>0.0-0.4' ASPHALT</td>
<td>875</td>
<td></td>
<td></td>
<td>13 4-1-1</td>
<td></td>
<td></td>
<td>MC = 18.1%</td>
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<tr>
<td></td>
<td></td>
<td>0.4-1.4' CRUSHED AGGREGATE BASE</td>
<td>870</td>
<td>50</td>
<td>5-3-5</td>
<td>(3)</td>
<td>PP = 0.75 taf Torvane = 0.50 taf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.8-14.4'</td>
<td>Dolomite, light gray and white, highly weathered</td>
<td>865</td>
<td>100</td>
<td>17-37-37/0.2'</td>
<td>100'</td>
<td>Bottom of borehole at 14.4 feet.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.8-14.4' Dolomite, light gray and white, highly weathered</td>
<td>865</td>
<td>100</td>
<td>27/0.2'</td>
<td>100'</td>
<td></td>
<td>MC = 19.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>17/0.3', 100'</td>
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Missouri Department of Transportation
Construction and Materials

Job No.: S2967
Design: N Slide
County: Warren
Skew: 
Route: U
Logged By: Duncan Noack
Station: 108+97.4
Offset: 5.4 L
Elevation: 868.9
Requested Station: 108+97.4
Requested Offset: 3.9 L
Requested Elevation: 868.9
Drill No.: G-9402

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Graphic</th>
<th>Description</th>
<th>Elevation (ft)</th>
<th>Sample Type</th>
<th>REC % (ROD %)</th>
<th>Bow Counts (N&lt;sub&gt;m&lt;/sub&gt;)</th>
<th>Shear Data</th>
<th>Field Tests</th>
<th>Index Tests</th>
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<tr>
<td>0</td>
<td></td>
<td>0.0-1.3' ASPHALT</td>
<td>865</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.3-2.2' CRUSHED AGGREGATE BASE</td>
<td>865</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.2-4.0' Brown, GRAVELLY LEAN CLAY, soft, moist</td>
<td>865</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.0-6.5' BOULDERS and cobbles</td>
<td>865</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>6.5-9.0' Tan, GRAVELLY LEAN CLAY scattered cobbles, medium stiff, moist</td>
<td>860</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>9.0-12.0' BOULDERS and cobbles</td>
<td>860</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>12.0-14.2' Tan, GRAVELLY LEAN CLAY scattered cobbles, medium stiff, moist</td>
<td>855</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>14.2-18.0' Red, LEAN CLAY, stiff, moist</td>
<td>855</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>15</td>
<td></td>
<td>18.0-20.2' Bedrock, red, likely Shale</td>
<td>850</td>
<td></td>
<td></td>
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<tr>
<td>20</td>
<td></td>
<td>Bottom of borehole at 20.2 feet.</td>
<td>850</td>
<td></td>
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</tr>
</tbody>
</table>

\[ N_m = \left(\frac{E_m}{60}\right)N_m \]
\[ N_{cor} = \text{Corrected N value for standard 60% SPT efficiency; } E_m = \text{Measured hammer efficiency in percent; } N_m = \text{Observed N-value} \]

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**Missouri Department of Transportation**

**Construction and Materials**

---

**Job No.:** S2967  
**Design:** N Slide  
**Bent:**  
**Station:** 109+5.7  
**Offset:** 9.1 R  
**Elevation:** 869.4  
**Requested Station:**  
**Requested Offset:**  
**Requested Elevation:**  
**Drill No.:** G-9462

---

**Logged By:** Duncan Noack  
**Operator:** Gary Degraffenreid  
**Date of Work:** 07/06/22-07/06/22  
**Location Note:**  
**Equipment:** Acker Soil XLS, Split-Spoon Sampler, Shelby Tube

---

**Description**

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Graphic</th>
<th>Description</th>
<th>Elevation (ft)</th>
<th>Sample Type</th>
<th>REC % (ROD %)</th>
<th>Blow Counts ($N_{60}$)</th>
<th>Shear Data</th>
<th>Field Tests</th>
<th>Index Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>0.0-0.4' ASPHALT</td>
<td>865</td>
<td>27</td>
<td>3-3-1 (5)</td>
<td>PP = 0.50 tsf, Torvane = 0.30 tsf</td>
<td>PP = 0.50 tsf, Torvane = 0.30 tsf</td>
<td>MC = 9.9% $γ_w = 147 \text{pcf}^1$</td>
<td></td>
</tr>
<tr>
<td>0.4-1.4' CRUSHED AGGREGATE BASE</td>
<td></td>
<td>1.4-11.1' Reddish brown, GRAVELLY LEAN CLAY, medium stiff, moist</td>
<td>865</td>
<td>100</td>
<td>4-3-2 (7)</td>
<td>PP = 0.00 tsf</td>
<td>PP = 0.00 tsf</td>
<td>MC = 17.3% $γ_w = 133 \text{pcf}^1$</td>
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</tr>
<tr>
<td>6.1' shelby tube refusal</td>
<td></td>
<td></td>
<td>860</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.1' shelby tube refusal</td>
<td></td>
<td></td>
<td>860</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.1-14.7' Brown, GRAVELLY LEAN CLAY, very stiff, moist to wet</td>
<td></td>
<td></td>
<td>855</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.1' shelby tube refusal</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.7-21.2' Shale, red, thinly laminated, with layers of tan, highly weathered sandstone</td>
<td></td>
<td></td>
<td>850</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Bottom of borehole at 21.2 feet.</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

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**Sample Type:** REC %(RQD %)  
**Blow Counts ($N_{60}$):**  
**Shear Data:**  
**Field Tests:**  
**Index Tests:**

---

**MC = 9.9% $γ_w = 147 \text{pcf}^1$**

---

**Bottom of borehole at 21.2 feet.**

---

**LETTER BOREHOLE - MODOT 20150728.GDT - 9/8/22 08:23 - Z:\SG\GINT\PROJECT FILES\R35G-U SLIDE WARREN COUNTY.GPJ

---

**Coordinate System:** U.S. State Plane 1983  
**Coordinate Zone:** Missouri Central  
**Coordinate Proj. Factor:**  
**Coordinate Datum:** NAD 83 (CONUS)  
**Coordinate Units:** U.S. Survey Feet

---

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---

$N_{60} = (Em/60)N_m$  
$N_{60}$ - Corrected N value for standard 60% SPT efficiency; $Em$ - Measured hammer efficiency in percent; $N_m$ - Observed N-value

---

(1) = Assumed, (2) = Actual
Missouri Department of Transportation
Construction and Materials

Job No.: S2967
Design: S Slide
Bent: 
Station: 105+51.0
Offset: 15.8 L
Elevation: 826.7
Requested Station: 105+50.0
Requested Offset: 8.8 L
Requested Elevation: 826.7
Drill No.: G-9402
Logged By: Duncan Noack
Operator: Kenneth Tuttle
County: Warren
Route: U
Logbook No.: 10142
Distance: 
Site: 
Sample Type: 
Sample Rec.: 
Blow Counts (N_60):
Shear Data:
Field Tests:
Index Tests:

d| Description |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>5</td>
</tr>
</tbody>
</table>

Bottom of borehole at 5.4 feet.

N_60 = (Em/60)Nm
N_60 - Corrected N value for standard 60% SPT efficiency; Em - Measured hammer efficiency in percent; Nm - Observed N-value
(1) = Assumed, (2) = Actual

Coordinate System: U.S. State Plane 1983
Coordinate Zone: Missouri Central
Coordinate Proj. Factor: 
Coordinate Datum: NAD 83 (CONUS)
Coordinate Units: U.S. Survey Feet

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "log of materials" is limited thereby and by judgement of the operator. THIS INFORMATION IS FOR DESIGN PURPOSES ONLY.
Missouri Department of Transportation
Construction and Materials

Job No.: S2967
Design: S Slide
Bent: S Slide
Station: 105+46.0
Offset: 14.8 L
Elevation: 826.7
Requested Station: 105+50.0
Requested Offset: 8.8 L
Requested Elevation: 826.7
Drill No.: G-9402

County: Warren
Route: U
Skew: __________________________
Location: _________________________
Logged By: Duncan Noack
Operator: Kenneth Tuttle
Nothing: 1047145.8
Easting: 612668.8
Requested Nothing: 1047152.2
Requested Easting: 612674.1
Equipment: Mobile B-31,

Depth (ft)
0
5
10

Description
0.0-5.1' Brown, LEAN CLAY, soft, moist
5.1-5.3' COBBLES
5.3-6.6' Brown, LEAN CLAY scattered gravel, soft, moist
6.8-6.9' COBBLES
6.9-13.6' Brown, GRAVELLY LEAN CLAY trace cobbles, soft, moist
13.6-14.3' Bedrock, highly weathered, likely Dolomite
14.3-14.7' Bedrock, likely Dolomite

Bottom of borehole at 14.7 feet.

Nc = (Em/60)Nm    Nc - Corrected N value for standard 60% SPT efficiency; Em - Measured hammer efficiency in percent; Nm - Observed N-value
(1) = Assumed, (2) = Actual

Drilling Method: Continuous Flight Auger

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "log of materials" is limited thereby and
by judgement of the operator. THIS INFORMATION IS FOR DESIGN PURPOSES ONLY.
Job No.: S2967
Design: N Slide
County: Warren
Bent: 
Route: U
Station: 109+21.6
Offset: 0.2 L
Elevation: 871.5
Requested Station: 
Requested Offset: 
Requested Elevation: 
Drill No.: G-9462
Operator: Gary Degraffenreid
Hamilton Efficiency: 81%
Drilling Method: Hollow Stem Auger

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Graphic</th>
<th>Description</th>
<th>Elevation (ft)</th>
<th>Sample Type</th>
<th>REC % (RQD %)</th>
<th>Blow Counts (N&lt;sub&gt;60&lt;/sub&gt;)</th>
<th>Shear Data</th>
<th>Field Tests</th>
<th>Index Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-0.3'</td>
<td>ASPHALT</td>
<td>0.3-1.7' CRUSHED AGGREGATE BASE</td>
<td>870</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.7-2.4'</td>
<td>BOULDERS</td>
<td>2.4-8.4' Reddish brown, GRAVELLY LEAN CLAY trace cobbles, medium stiff to stiff, moist</td>
<td>865</td>
<td>33</td>
<td>2-5-4 (12)</td>
<td></td>
<td></td>
<td>PP = 0.50 tfs</td>
<td>Mc = 22.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.4-12.6' Dolomite, light gray and white, highly weathered, with clay 8.4' shely tube refusal</td>
<td>860</td>
<td>33</td>
<td>1-2-2 (5)</td>
<td></td>
<td></td>
<td>PP = 0.50 tfs</td>
<td>Mc = 22.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.6-13.9' Shale, red, thinly laminated, with layers of tan, highly weathered sandstone Bottom of borehole at 13.9 feet.</td>
<td></td>
<td>67</td>
<td>3-11-19 (41)</td>
<td></td>
<td></td>
<td>PP = 0.50 tfs</td>
<td>Mc = 12.2%</td>
</tr>
</tbody>
</table>

N<sub>60</sub> = (Em/60)N<sub>n</sub>  N<sub>60</sub> - Corrected N value for standard 60% SPT efficiency; Em - Measured hammer efficiency in percent; Nm - Observed N-value
(1) = Assumed, (2) = Actual

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "log of materials" is limited thereby and by judgement of the operator. THIS INFORMATION IS FOR DESIGN PURPOSES ONLY.
**Job No.: S2967**

**Design:** S Slide

**County:** Warren

**Skew:**

**Logged By:** Duncan Noack

**Route:** U

**Operator:** Kenneth Tuttle

**Station:** 105+16.6

**Date of Work:** 07/13/22-07/13/22

**Offset:** 14.9 L

**Depth to Water:**

**Elevation:** 822.7

**Requested Station:** 105+16.6

**Depth Hole Open:**

**Requested Offset:** 10.4 L

**Distance Hole Open:**

**Requested Elevation:** 822.7

**Time Change:**

**Equipment:** Mobile B-31,

**Location Note:**

**Drill No.: G-9402**

**Hammer Efficiency:**

**Drilling Method:** Continuous Flight Auger

---

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Graphic</th>
<th>Description</th>
<th>Elevation (ft)</th>
<th>Sample Type</th>
<th>REC % (ROD %)</th>
<th>Blow Counts (N&lt;sub&gt;60&lt;/sub&gt;)</th>
<th>Shear Data</th>
<th>Field Tests</th>
<th>Index Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>0.0-1.3' ASPHALT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>1.3-2.6' CRUSHED AGGREGATE BASE</td>
<td>820</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>2.6-6.8' Brown, LEAN CLAY, soft, moist</td>
<td>815</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>6.8-10.0' Brown, GRAVELLY LEAN CLAY, trace cobbles, moist</td>
<td>810</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10.0-10.6' COBBLES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10.6-14.5' Light brown, FAT CLAY, moist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>14.5-14.9' Bedrock, likely Dolomite, bottom of borehole at 14.9 feet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**N<sub>60</sub> = (Em/60)N<sub>m</sub>**  
*Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "log of materials" is limited thereby and by judgement of the operator. THIS INFORMATION IS FOR DESIGN PURPOSES ONLY.*
## Field Tests

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>REC % (RQD %)</th>
<th>Blow Counts (N&lt;sub&gt;60&lt;/sub&gt;)</th>
<th>Shear Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Shear Data

- **Direct Shear Results**
  - **MC = 20.4%**
  - **sat = 130pcf**
  - **LL = 44**
  - **PL = 22**
  - **MC = 29.4%**
  - **sat = 121pcf**
  - **LL = 51**
  - **PL = 23**
  - **MC = 22.3%**
  - **sat = 128pcf**
  - **LL = 56**
  - **PL = 24**

### Description

- **0.0-2.5' ASPHALT**
- **2.5-4.0' CRUSHED AGGREGATE BASE**
- **4.0-5.5' Brown, GRAVELLY LEAN CLAY trace cobbles, moist**
- **5.5-9.7' Reddish gray mottled, FAT CLAY, moist, trace organics (roots)**
- **9.7-13.2' Brownish gray, LEAN CLAY trace gravel, very stiff, moist**
- **11.5' Shelby tube refusal**
- **13.2-17.4' Dolomite, and, highly weathered to moderately weathered 13.2-17.4' rock bitted**

**Bottom of borehole at 17.4 feet.**
<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Graphic</th>
<th>Description</th>
<th>Elevation (ft)</th>
<th>Sample Type</th>
<th>REC % (RQD %)</th>
<th>Blow Counts (N&lt;sub&gt;60&lt;/sub&gt;)</th>
<th>Shear Data</th>
<th>Field Tests</th>
<th>Index Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0-1.2'</td>
<td></td>
<td>0.0-1.2' ASPHALT</td>
<td>815</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2-3.7'</td>
<td></td>
<td>1.2-3.7' CRUSHED AGGREGATE BASE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.7-6.2'</td>
<td></td>
<td>3.7-6.2' Tan, GRAVELLY LEAN CLAY, soft, moist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.2-12.4'</td>
<td></td>
<td>6.2-12.4' Reddish brown, FAT CLAY, soft, moist</td>
<td>810</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.4-12.7'</td>
<td></td>
<td>12.4-12.7' Bedrock, highly weathered, likely Dolomite</td>
<td>810</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.7-12.8'</td>
<td></td>
<td>12.7-12.8' Bedrock, likely Dolomite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Bottom of borehole at 12.8 feet.

N<sub>60</sub> = (Em/60)Nm  
N<sub>60</sub> - Corrected N value for standard 60% SPT efficiency; Em - Measured hammer efficiency in percent; Nm - Observed N-value

(1) = Assumed, (2) = Actual

Coordinate System: U.S. State Plane 1983  
Coordinate Zone: Missouri Central  
Coordinate Proj. Factor: U.S. Survey Feet

Coordinate Datum: NAD 83 (CONUS)  
Coordinate Units: U.S. Survey Feet

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "log of materials" is limited thereby and by judgement of the operator. THIS INFORMATION IS FOR DESIGN PURPOSES ONLY.
<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Description</th>
<th>Elevation (ft)</th>
<th>Sample Type</th>
<th>REC % (ROD %)</th>
<th>Blow Counts (N&lt;sub&gt;60&lt;/sub&gt;)</th>
<th>Shear Data</th>
<th>Field Tests</th>
<th>Index Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0-2.5' ASPHALT</td>
<td>815</td>
<td></td>
<td></td>
<td>40 (1-3-2)</td>
<td>PP = 0.50 tsf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>2.5-3.5' CRUSHED AGGREGATE BASE</td>
<td>810</td>
<td></td>
<td></td>
<td>1-3-2 (7)</td>
<td>PP = 0.50 tsf</td>
<td>MC = 24.8%</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>3.5-8.8' Reddish brown mottled gray, GRAVELLY LEAN CLAY trace cobbles, medium stiff, moist 4.7-5.5' boulder</td>
<td>805</td>
<td></td>
<td></td>
<td>46 3-9-20/0.3', 10/0'</td>
<td>PP = 1.25 tsf</td>
<td>UCS = 2.50 ksf, MC = 26.4%, Y&lt;sub&gt;max&lt;/sub&gt; = 118.9 pcf</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>9.8-13.2' Reddish brown mottled gray, FAT CLAY trace fine gravel, hard, moist, trace organics (roots) 13.2-16.2' Dolomite, tannish gray and, highly weathered to moderately weathered, with thin clay seams 13.2-16.2' rock bitted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Direct Shear Results</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Bottom of borehole at 16.2 feet.
**Missouri Department of Transportation**

**Construction and Materials**

**Job No.:** S2967  
**Design:** S Slide  
**County:** Warren  
**Bent:**  
**Station:** 105+50.5  
**Offset:** 3.4 R  
**Elevation:** 826.4  
**Requested Station:**  
**Requested Offset:**  
**Requested Elevation:**  
**Drill No.:** G-9462

**Logged By:** Duncan Noack  
**Operator:** Gary Degraffenreid  
**Date of Work:** 07/06/22-07/06/22  
**Depth to Water:**  
**Depth Hole Open:**  
**Equipment:** Acker Soil XLS, Split-Spoon Sampler, Shelby Tube

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Description</th>
<th>Sample Type</th>
<th>Blow Counts (N&lt;sub&gt;60&lt;/sub&gt;)</th>
<th>Shear Data</th>
<th>Field Tests</th>
<th>Index Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1.7'</td>
<td>ASPHALT</td>
<td></td>
<td>0-1-1 (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.7-2.5'</td>
<td>CRUSHED AGGREGATE BASE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5-10.8'</td>
<td>Reddish brown mottled gray, LEAN CLAY scattered fine gravel, trace cobbles,</td>
<td>40</td>
<td>2-5-6 (15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.7-5.0'</td>
<td>soft to stiff, moist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.8-11.9'</td>
<td>Gray and reddish brown, FAT CLAY trace gravel, hard, moist, trace organics</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.9-13.9'</td>
<td>Dolomite, tannish grey and, highly weathered to moderately weathered, with thin clay seams</td>
<td>100</td>
<td>200.4', 100'</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bottom of borehole at 13.9 feet.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Qu Test Results**
- UCS = 4.66 ksf  
- MC = 23%  
- γ<sub>max</sub> = 126.9pcf

**Technical Details**

- **Hammer Efficiency:** 81%  
- **Drilling Method:** Hollow Stem Auger

**N<sub>60</sub> =** (Em/60)Nm  
**N<sub>60</sub> - Corrected N value for standard 60% SPT efficiency; Em - Measured hammer efficiency in percent; Nm - Observed N-value

(1) = Assumed, (2) = Actual

**Coordinate System:** U.S. State Plane 1983  
**Coordinate Zone:** Missouri Central  
**Coordinate Proj. Factor:**  
**Coordinate Datum:** NAD 83 (CONUS)  
**Coordinate Units:** U.S. Survey Feet

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## Field Tests

<table>
<thead>
<tr>
<th>Elevation (ft)</th>
<th>Sample Type</th>
<th>Sample Rec. (RQD %)</th>
<th>Blow Counts (N&lt;sub&gt;60&lt;/sub&gt;)</th>
<th>Shear Data</th>
<th>Field Tests</th>
<th>Index Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0-1.0'</td>
<td>ASPHALT</td>
<td>820</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0-4.7'</td>
<td>CRUSHED AGGREGATE BASE, very dry and dusty</td>
<td>815</td>
<td>67</td>
<td>6-2-4 (8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.7-5.0'</td>
<td>COBBLES</td>
<td>815</td>
<td>87</td>
<td>6-4-5 (12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0-8.0'</td>
<td>Reddish gray, LEAN CLAY with fine gravel, medium stiff to stiff, moist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.0'</td>
<td>boring terminated due to mechanical issues</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Bottom of borehole at 8.0 feet.**

---

**Note:**

- **N<sub>60</sub>** = (Em/60)Nm
- **N<sub>60</sub>** - Corrected N value for standard 60% SPT efficiency; Em - Measured hammer efficiency in percent; Nm - Observed N-value
- (1) = Assumed, (2) = Actual

**Coordinate System:** U.S. State Plane 1983  
**Coordinate Zone:** Missouri Central  
**Coordinate Proj. Factor:**  
**Coordinate Datum:** NAD 83 (CONUS)  
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LITHOLOGIC SYMBOLS
(Unified Soil Classification System)

- Asphalt
- Boulders and cobbles
- USCS High Plasticity Clay
- USCS High Plasticity Gravelly Clay
- USCS Low Plasticity Clay
- USCS Low Plasticity Gravelly Clay
- Dolomite
- USCS Poorly-graded Gravel
- Highly Weathered Dolomite
- Shale

SAMPLER SYMBOLS

- Split-Spoon Sampler
- Shelby Tube

WELL CONSTRUCTION SYMBOLS

ABBREVIATIONS

- LL - LIQUID LIMIT (%)
- PI - PLASTIC INDEX (%)
- W - MOISTURE CONTENT (%)
- DD - DRY DENSITY (PCF)
- NP - NON PLASTIC
- -200 - PERCENT PASSING NO. 200 SIEVE
- PP - POCKET PENETROMETER (TSF)
- Qu - UNCONFINED COMPRESSIVE STRENGTH (PSF)
- TV - TORVANE
- PID - PHOTOIONIZATION DETECTOR
- UC - UNCONFINED COMPRESSION
- ppm - PARTS PER MILLION
- Water Level at Time of Drilling
- Water Level at End of Drilling
- Water Level after Drilling
R35G
Rte U, South of Rodgers Dr
Warren County

Legend

Auger Boring
Sample Boring

Google Earth
R35G
Slide 1 (North)
Rte U, South of Rodgers Dr
Warren County

Legend
- Auger Boring
- Sample Boring
R35G
Slide 2 (South)
Rte U, South of Rodgers Dr
Warren County
### Table 1

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Moist Wt (pcf)</th>
<th>Sat Wt (pcf)</th>
<th>c (psf)</th>
<th>(deg)</th>
<th>(ratio)</th>
<th>Piez Surf (psf)</th>
<th>Soil Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Asphalt and Subgrade</td>
<td>110.0</td>
<td>110.0</td>
<td>100.0</td>
<td>33.0</td>
<td>0.000</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Soft Gravelly Clays</td>
<td>120.0</td>
<td>125.0</td>
<td>140.0</td>
<td>27.0</td>
<td>0.000</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Stiff Gravelly Clays</td>
<td>120.0</td>
<td>125.0</td>
<td>160.0</td>
<td>28.0</td>
<td>0.000</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Highly Weathered Dolomite</td>
<td>122.0</td>
<td>127.0</td>
<td>56.0</td>
<td>27.0</td>
<td>0.000</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Shale</td>
<td>125.0</td>
<td>130.0</td>
<td>2000.0</td>
<td>33.0</td>
<td>0.000</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Select Granular Backfill</td>
<td>135.0</td>
<td>140.0</td>
<td>0.0</td>
<td>35.0</td>
<td>0.000</td>
<td>0.0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Figure 1

Layers of uniaxial geogrid placed at 18" intervals to support the L-Shaped Welded Wide Frame facing.

1.5:1 slope faced with L-Shaped Welded Wire Frame.

Perforated pipe wrapped in geotextile.

1.5:1 benched slope with nonwoven geotextile fabric between soil and rock fill.

Approximate bedrock surface.

Non-perforated pipe leading to rock flume.