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SUBGRADE INVESTIGATION AND PAVEMENT DESIGN BOBCAT RIDGE PROJECT 8429 WEST COUNTY ROAD 32C LARIMER COUNTY, COLORADO

Prepared for:

CITY OF FORT COLLINS
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Attention: Mr. Steve White
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Project No. FC03550-135

September 21, 2005

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SCOPE

This report presents the results of our subgrade investigation and pavement design for the parking lot at the proposed Bobcat Ridge Project located at 8429 West County Road 32C in Larimer County, Colorado. This investigation was to identify the type of subgrade soils under the proposed parking lot and to send design pavement alternatives for paving the parking area.

Our report includes a description of the subgrade soils penetrated by our exploratory borings, laboratory test results, recommended alternative pavement sections and construction and materials guidelines.

SUMMARY OF CONCLUSIONS

1. Our borings penetrated 4 feet to 6 feet of loose to medium dense, clayey sands over nil to 4 feet of hard, slightly cemented sandstone underlain by very hard, cemented sandstone at 6 feet and 8 feet. Ground water was not encountered in the borings.

2. The subgrade soils have excellent subgrade support characteristics.

3. A minimum Portland cement concrete section of 5 inches is recommended for paving the handicapped parking spaces.

SITE CONDITIONS

The Bobcat Ridge Project is a large natural area, owned and operated by the City of Fort Collins. The parking lot addressed in this report is located in the natural area approximately 1 mile southwest of Masonville, Colorado at 8429 West County Road 32C.

The natural area covers 2,600 acres, situated on the steeply sloping eastern side of Green Ridge. A small creek bounds the northeastern side of the property. The Horsetooth Supply Canal crosses the southeast corner of the property and enters an inverted siphon to cross Buffman Canyon. Vegetation consists mainly of low grasses and bushes. Historically the property was used to graze cattle with some irrigated pasture.

The location of the proposed parking lot is currently a intermitant drainage swell that crosses the site from west to east. Corrals and various outbuildings are on the north side of the drainage. The drainage is fenced into several "dry lots" for cattle operations. A few sandstone outcrops were visible along the sides of the drainage, upstream from the proposed parking lot.

PROPOSED CONSTRUCTION

A parking lot will be placed along the north side of the drainage swell. The entrance to the parking lot will be on the north side of the drainage swell right off of County Road 32C. We understand the parking lot will be generally U-shaped and will exit onto the existing access road for the Horsetooth Supply Canal on the south side of the drainage. The swell will be piped under the parking lot on the west side to create a parking area for longer vehicles such as pick-ups with horse trailers. Where the swell is not piped it will be shifted to the south approximately 50 feet to 100 feet. Borrow soils for fill under the parking lot will come from the excavation needed to shift the alignment of the drainage. We understand that the majority of the parking lot and roads will be surfaced with gravel and that the handicapped parking stalls will be surfaced with concrete pavement

INVESTIGATION

Subsoils were investigated by drilling five exploratory borings. Two borings (S-1 and S-2) were drilled to 10 feet in the area of proposed fill, generally in the west portion of the parking area, 1 boring (S-3) was drilled to 5 feet in the area were the parking lot was approximately at the existing grade, and 2 borings were drilled to 5 feet in the proposed borrow area. The boring locations are shown on Figure 1.

The borings were drilled with a truck-mounted drill rig using 6-inch diameter continuous flight augers. Soils were sampled by driving a California sampler with a 140-pound hammer falling 30 inches and by collecting bulk samples from the auger cuttings.

SUBSURFACE

Our borings in the area of proposed fill penetrated 4 feet to 6 feet of medium dense, clayey sands over nil to 4 feet of hard, slightly cemented sandstone over very hard cemented sandstone at 6 feet and 8 feet. Our 5-foot borings penetrated loose to medium dense, clayey sands throughout the depth explored. The clayey sands were slightly moist. Ground water was not encountered in the borings. Summary logs of the borings, including results of field penetration resistance tests, are shown on Figure 2.

LABORATORY INVESTIGATION

The laboratory investigation for the pavement subgrade soils was designed to provide index properties, swell/consolidation characteristics, and subgrade support values for those soils that influence the pavement design.

Index properties of the soils sampled were measured and the soils were classified according to AASHTO and the Unified Soil Classification System. The soils classified as A-6 and A-2-6 according to the AASHTO classification. The soils classified as clayey sands (SC) according to the Unified Soil Classification System. The samples had group indices ranging from 0 to 2.

The samples tested had liquid limits ranging from 27 percent to 30 percent and plasticity indices from 11 percent to 12 percent. The samples had 35 percent to 44 percent silt and clay-sized particles (passing the No. 200 sieve). Laboratory test results are presented on Figure 3 and summarized in Table I.

SUBGRADE PREPARATION

Subgrade immediately below the pavement section should be scarified a minimum of 12 inches deep, moisture conditioned to between 2 percent below and 2 percent above optimum moisture content and compacted to at least 95 percent of standard maximum dry density (ASTM D 698). Scarification and re-compaction of the upper 12 inches of subgrade soils should occur as close to the time of pavement construction as possible. The final subgrade surface must be protected from freezing and from excessive drying or wetting until such time as the pavement section is constructed.

On-site soils substantially free of trash, debris, organics or other deleterious materials are suitable for use as fill. Imported fill should consist of soils with properties similar or better than the on-site soils. Samples of the proposed fill should be submitted to our office for approval prior to importing to the site. All fill should be placed in 8 inch maximum loose lifts, moisture conditioned to between 2 percent below and 2 percent above optimum moisture content and compacted to at least 95 percent of standard maximum dry density (ASTM D 698). A representative of our firm should observe placement and test compaction of fill.

Proper grading and drainage and maintaining moisture contents near optimum will be critical to avoid excessive deflections, rutting and pumping of the roadway during subgrade preparation. If moisture and density cannot be sufficiently controlled during subgrade preparation and stabilization is required, stabilization by removal and replacement or stabilization using geotextile fabrics and/or imported granular and rock materials may be used. For isolated or small areas requiring stabilization, removal and replacement or "crowding" angular, coarse aggregate into the subgrade may be effective.

SOLUBLE SULFATES

Water-soluble sulfate (SO_4) concentrations were measured in a sample of the near-surface subgrade soils to determine the risk of exposure to sulfate attack where portland cement concrete is used. The soluble sulfate concentration was below the detectable limit. These results indicate Class 0 (formerly "negligible") and Class I (formally "moderate") exposure to sulfate attack on concrete (e.g. curb and gutter or pavements) according to the American Concrete Institute (ACI). According to the Portland Cement Association criteria, Type I cement can be used in concrete exposed to these soils.

PAVEMENT DESIGN

We used the Group Index design method. Based upon our experience we believe that a group index of 0 to 2 is equivalent to an R-value of 30. We have assumed an equivalent daily load application (EDLA) of 5, which corresponds to an equivalent single axle load (ESAL) of 36,500. These values are typical of single-family residential parking or a residential two-lane road. We have further assumed a minimum 28-day compressive strength for the Portland cement concrete of 4000 pounds per square inch (psi).

Using the traffic loading assumed, we calculated a minimum required Portland cement concrete thickness of 5 inches. The pavement should be placed directly upon the prepared subgrade as specified in the above "Subgrade Preparation" section. It is possible that departmental or other regulations might specify a thicker section. We can provide a flexible pavement section design upon request. The pavement section calculation worksheet is included as Appendix A.

If subgrade stabilization due to soft or loose soils is required, overexcavation and replacement with coarse, granular soil such as pit run gravel, use of geotextiles or geogrids, or chemical stabilization such as fly ash typically perform well in soil environments similar to those we encountered at this site.

Chemical stabilization techniques have weather and temperature limitations that should be considered.

PAVEMENT MATERIALS

Material properties and construction criteria for the pavement are provided below. These criteria were developed from analysis of the field and laboratory data, our experience and City of Fort Collins requirements. If the materials cannot meet these recommendations, then the pavement design should be reevaluated based upon available materials. All materials and construction requirements of the City of Fort Collins should be followed. All materials planned for construction should be submitted and the applicable laboratory tests performed to verify compliance with the specifications.

Portland Cement Concrete (PCC)

1. Portland cement concrete should have a minimum compressive strength of 4,000 psi at 28 days and a minimum modulus of rupture (flexural strength) of 600 psi. A job mix design is recommended and periodic checks on the job site should be made to verify compliance with specifications.

2. Portland cement should be Type I and should conform to ASTM C 150.

3. In hot weather conditions Portland cement concrete should be placed in accordance with ACI 305R.

4. In cold weather conditions Portland cement concrete should be placed in accordance with ACI 306R.

5. Curing procedures should be implemented, as necessary, to protect the pavement against moisture loss, rapid temperature change, freezing, and mechanical injury.

6. Construction joints, including longitudinal joints and transverse joints, should be formed during construction or sawed after the concrete has begun to set, but prior to uncontrolled cracking.

7. All joints should be properly sealed using a rod back-up and approved epoxy sealant.

8. Traffic should not be allowed on the pavement until it has properly cured and achieved at least 80 percent of the design strength, with saw joints already cut.

9. Placement of Portland cement concrete should be observed and tested by a representative of our firm. Placement should not commence until the subgrade is properly prepared and tested.

CONSTRUCTION DETAILS

The design of a pavement system is as much a function of the quality of the paving materials and construction as the support characteristics of the subgrade. The construction materials are assumed to possess sufficient quality as reflected by the strength coefficients used in the flexible pavement design calculations. These strength coefficients were developed through research and experience to simulate expected material of good quality, as explained herein. During construction careful attention should be paid to the following details:

- Placement and compaction of trench backfill.
- Compaction at curb lines and around manholes and water valves.
- Excavation of completed pavements for utility construction and repair.
- Design slopes of the adjacent ground and pavement to rapidly remove water from the pavement surface.

LIMITATIONS

The pavement and construction recommendations are based upon our field observation and testing, and minimum traffic levels usually assumed for typical single-family residential parking or a two lane residential road and the AASHTO design methods.

The design procedures were formulated to provide sections with adequate structural strength. Routine maintenance, such as sealing and repair of cracks, is necessary to achieve the long-term life of a pavement system. If the design and construction recommendations cannot be followed, or anticipated traffic loads change considerably, we should be contacted to review the recommendations.

We believe the geotechnical services for this project were performed in a manner consistent with that level of care and skill ordinarily used by members of the profession in the locality of the project. No warranty, express or implied, is made. If we can be of further service in discussing the contents of this report, or in the analyses of the proposed pavement systems from a geotechnical point of view, please call.

CTL | THOMPSON, INC.

John J. Boulden, EIT
Staff Engineer

Reviewed by:

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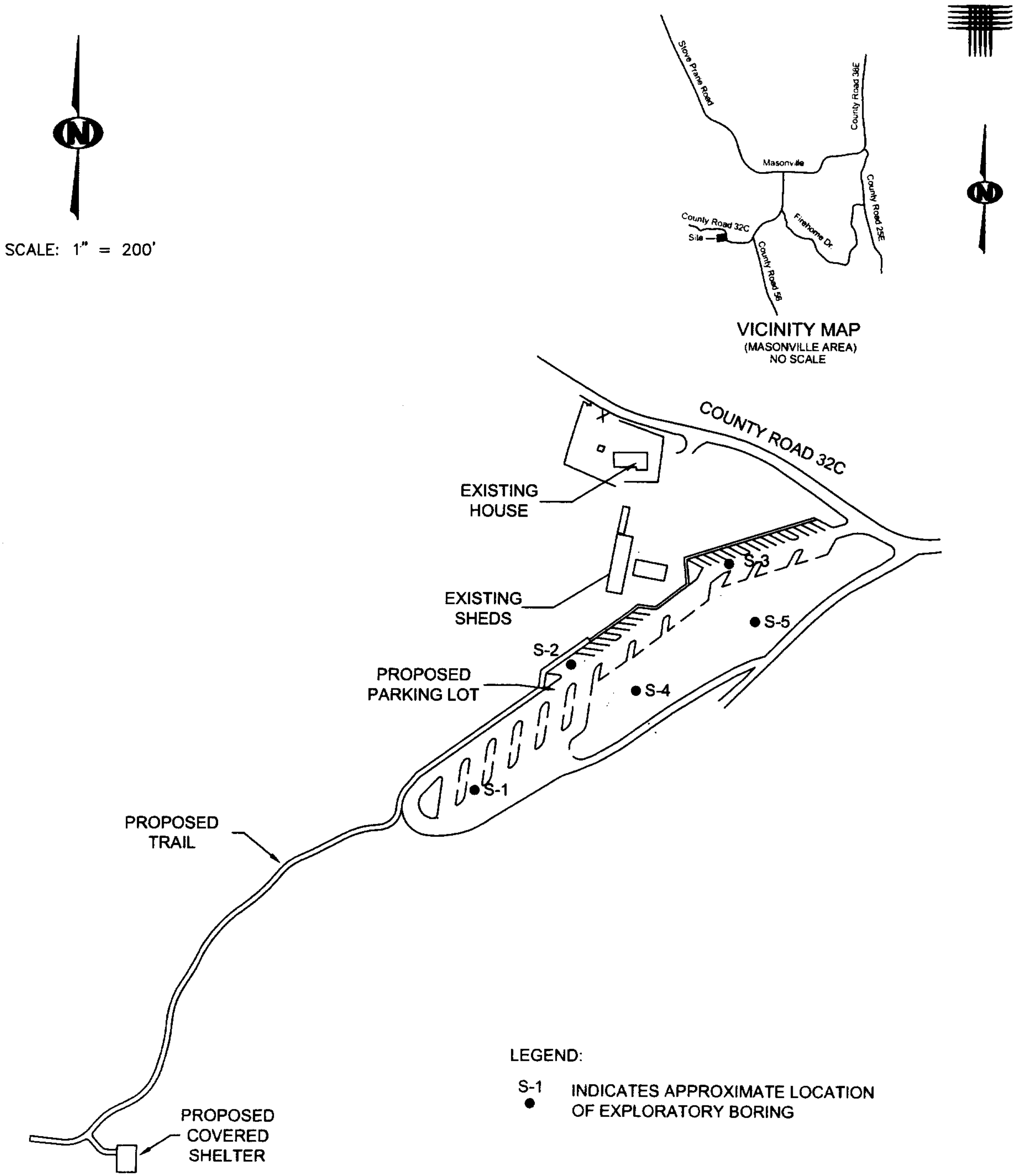
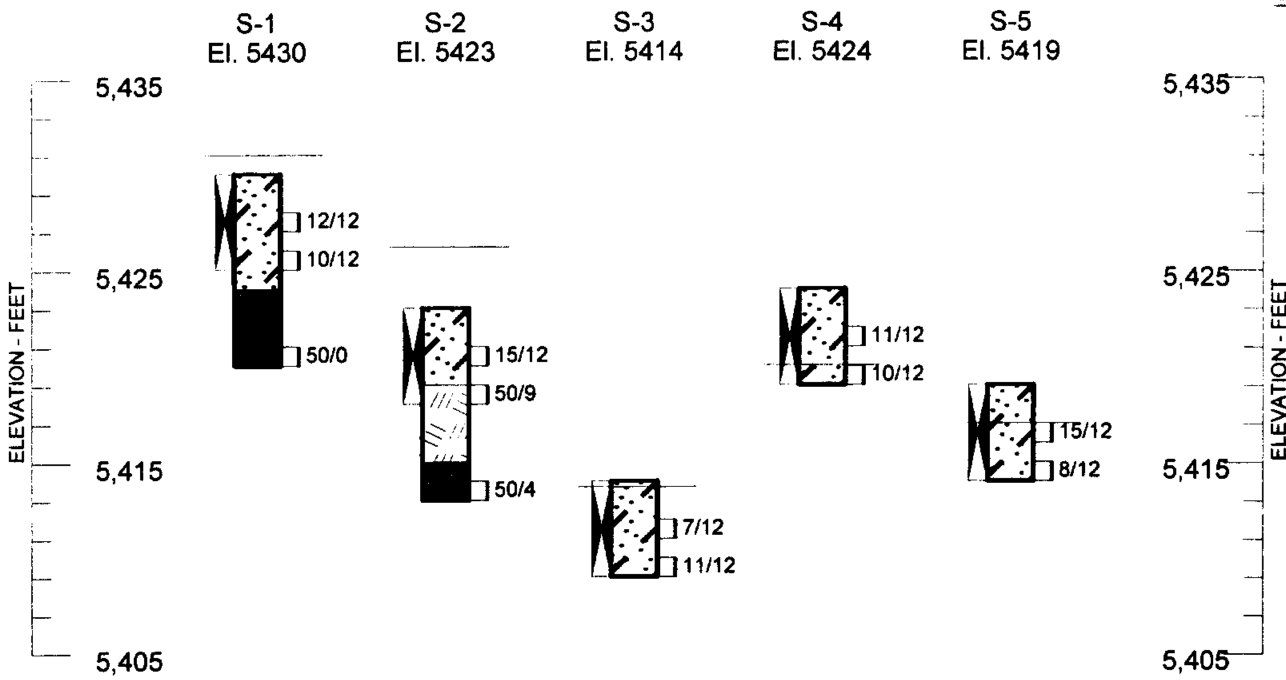


Locations of Exploratory Borings

FC35J-135 JJB 09/06/05

CITY OF FORT COLLINS
BOBCAT RIDGE PROJECT
CTL | T P

FIGURE 1



LEGEND:

SAND, CLAYEY, LOOSE TO MEDIUM DENSE, SLIGHTLY MOIST TO MOIST, DARK BROWN, REDDISH BROWN (SC)

SANDSTONE, MEDIUM HARD, SLIGHTLY CEMENTED, SLIGHTLY MOIST, REDDISH BROWN (BEDROCK)

SANDSTONE, VERY HARD, CEMENTED, SLIGHTLY MOIST, REDDISH BROWN, GRAY (BEDROCK)

DRIVE SAMPLE. THE SYMBOL 12/12 INDICATES 12 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2.5-INCH O.D. SAMPLER 12 INCHES.

BULK SAMPLE FROM AUGER CUTTINGS.

INDICATES FINISHED GROUND SURFACE ELEVATION.

NOTES:

1. THE BORINGS WERE DRILLED ON AUGUST 30, 2005, USING 4-INCH DIAMETER CONTINUOUS-FLIGHT AUGER AND A TRUCK-MOUNTED DRILL RIG.

2. BORING ELEVATIONS ARE APPROXIMATE AND WERE FROM A TOPOGAPHIC PLAN FURNISHED BY THE CLIENT.

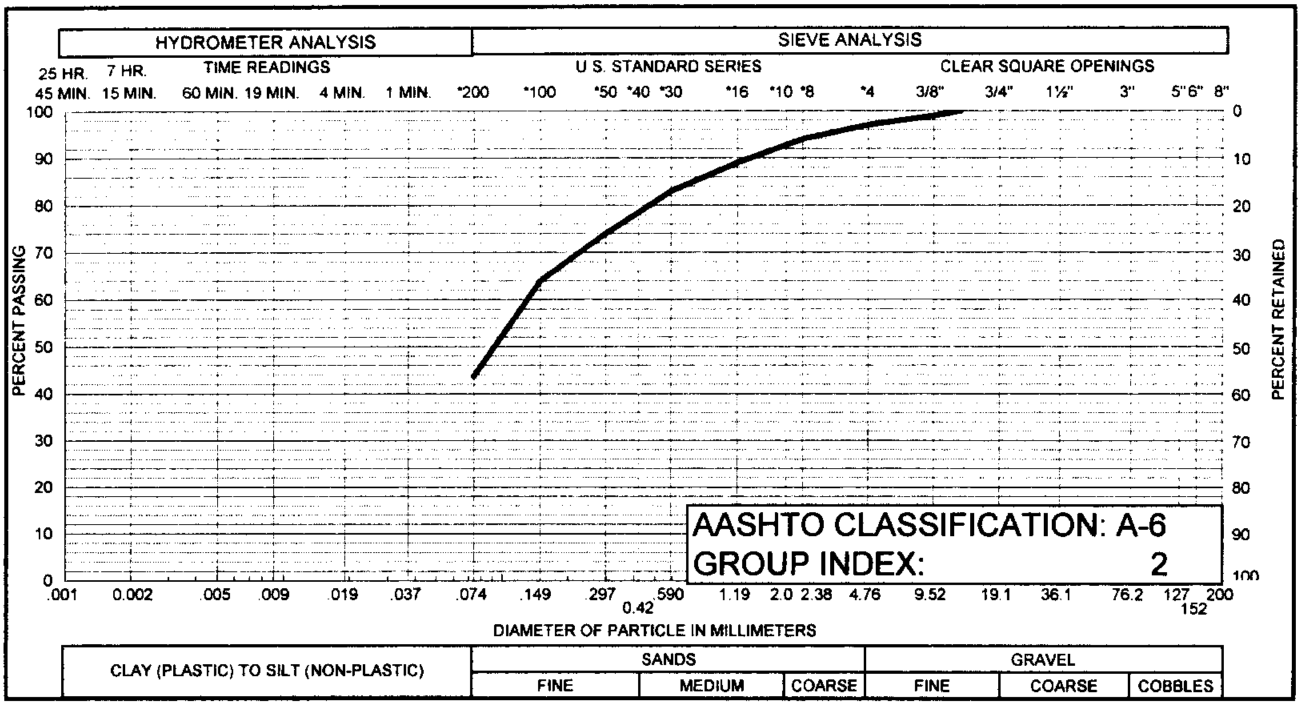
3. THESE LOGS ARE SUBJECT TO THE EXPLANATIONS, LIMITATIONS AND CONCLUSIONS IN THIS REPORT.

SUMMARY LOGS OF EXPLORATORY BORINGS

FIGURE 2

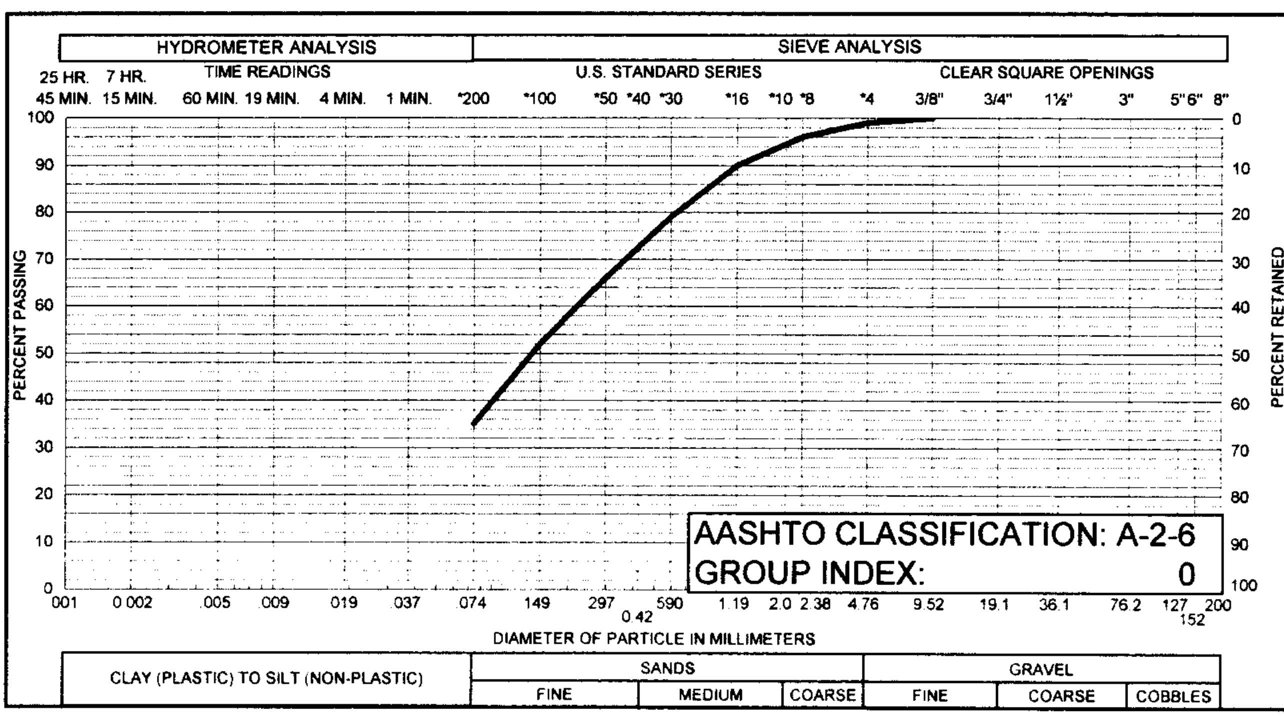
CITY OF FORT COLLINS
BOBCAT RIDGE PROJECT
CTL | T PROJECT NO. FC03550-135

LOGS BY ELEVATION WITH LEGEND-LETTER FC035250-135-DATA.GPJ CTLMAIN.GDT 9/7/05



Sample of SAND, CLAYEY (SC)
From S-2 FROM 0 TO 5 FEET

GRAVEL 3 % SAND 53 %
SILT & CLAY 44 % LIQUID LIMIT 27 %
PLASTICITY INDEX 11 %



Sample of SAND, CLAYEY (SC)
From S-4 FROM 0 TO 5 FEET

GRAVEL 1 % SAND 64 %
SILT & CLAY 35 % LIQUID LIMIT 30 %
PLASTICITY INDEX 12 %

Gradation Test Results

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FIGURE 3

TABLE 1

BORING	DEPTH (FEET)	NATURAL MOISTURE (%)	NATURAL DRY DENSITY (PCF)	ATTERBERG LIMITS LIQUID LIMIT (%)	ATTERBERG LIMITS PLASTICITY INDEX (%)	PASSING NO. 200 SIEVE (%)	SOIL TYPE
S-2	0-5	4.1		27	11	44	SAND, CLAYEY (SC)
S-3	4	15.5	109				SAND, CLAYEY (SC)
S-4	0-5	8.0		30	12	35	SAND, CLAYEY (SC)

APPENDIX A
RIGID PAVEMENT
DESIGN CALCULATION

AASHTO RIGID PAVEMENT DESIGN

Project: FC03550-135
Location: BOBCAT RIDGE

What is the Design ESAL ?	36,500	
What is the Reliability ?	85	
What is the Serviceability Loss ?	2.2	
What is the Concrete Elastic Modulus ?	3,400,000	psi
What is the Concrete Modulus of Rupture ?	600	psi
What is the Drainage Factor ?	1.0	
What is the Standard Deviation ?	0.34	
What is the Load Transfer Coefficient ?	4.2	
What is the R-value ?	30	
Computed Resilient Modulus =	6,852	psi
If R is not available, Input Resilient Modulus =		psi
DESIGN RESILIENT MODULUS =	6,852	psi
Design Slab Thickness is	5.0	inches

APPENDIX B

CONSTRUCTION CHECKLIST

CONSTRUCTION CHECKLIST

The construction procedure of the pavement system is as important as the quality of the materials. Inadequate compaction of the subgrade is often the reason for early pavement failure, resulting in pavement instability, rutting, cracking, settlement and heave. We recommend the proposed pavement be constructed in the following manner.

PREPARATION

Subgrade Preparation

- Subgrade shall be stripped of organic matter, scarified, moisture treated, and compacted.
- Utility trenches and all subsequently placed fill shall also be compacted and tested prior to paving.
- Final grading of the subgrade should be carefully controlled so the design cross-slope is maintained and low spots in the subgrade that could trap water are eliminated.

Granular Soils (A-2-4 and A-4)

- Soils shall be moisture treated to within 2% of optimum moisture content.
- Soils shall be compacted to at least 95% of maximum standard Proctor dry density (ASTM D 698, AASHTO T 99).

Cohesive Soils (A-6 to A-7-6)

- Soils shall be moisture treated between optimum and 3% above optimum moisture content.
- Soils shall be compacted to at least 95% of maximum standard Proctor dry density (ASTM D 698, AASHTO T 99).

Proof Testing

- After final subgrade elevation has been reached and the subgrade compacted, the area shall be proof-rolled with a pneumatic-tired vehicle loaded to at least 18 kips per axle.
- Subgrade that is pumping or deforming shall be scarified, moisture conditioned, and tested.
- If areas of very soft or wet subgrade are found, the material shall be sub-excavated and replaced with approved on-site or import material, moisture conditioned, compacted and tested.

Construction Observation

- Where soft, yielding subgrade is encountered, the excavation shall be inspected by a representative of CTL | Thompson, Inc.
- CTL | Thompson shall be notified and tests taken to confirm the subgrade meets the specifications.

CURB AND GUTTER

- Curb and gutter shall be backfilled and compacted to reduce the potential of heave or settlement that would cause water to pond adjacent to the pavement.
- Compaction shall be in accordance with Section 203.11 of the State of Colorado Standard Specifications for Road and Bridge Construction and the City of Longmont specifications.
- An asphalt cement tack coat should be applied to the curb, subgrade and all joints at a rate of not more than 0.10 gallon per square yard. The tack should be applied at a temperature between 80° F and 130° F and allowed to cure for ½ hour prior to paving.

APPENDIX C

GUIDELINE MAINTENANCE RECOMMENDATIONS

MAINTENANCE RECOMMENDATIONS FOR RIGID PAVEMENTS

High traffic volumes create pavement rutting and smooth, polished surfaces. Preventive maintenance treatments will typically preserve the original or existing pavement by providing a protective seal and improving skid resistance through a new wearing course.

1. Annual Preventive Maintenance

   a. Visual pavement evaluations should be performed each spring or fall.
   b. Reports documenting the progress of distress should be kept current to provide information of effective times to apply preventive maintenance.
   c. Crack sealing should be performed annually as new cracks appear.

2. 4 to 8 Year Preventive Maintenance

   a. The owner should budget for a preventive treatment at approximate intervals of 4 to 8 years to reduce joint deterioration.
   b. Typical preventive maintenance for rigid pavements include patching, crack sealing and joint cleaning and sealing.
   c. Where joint sealants are missing or distressed, resealing is mandatory.

3. 15 to 20 Year Corrective Maintenance

   a. Corrective maintenance for rigid pavements includes patching and slab replacement to correct subgrade failures, edge damage and material failure.
   b. Asphalt concrete overlays may be required at 15 to 20 year intervals to improve the structural capacity of the pavement.

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