APPROVED
By: [signature] Date: 6/6/2003
City of Fort Collins
Engineering Department
8" HBP + 12" ABC ONLY

CTL/THOMPSON, INC.
CONSULTING ENGINEERS

SUBGRADE INVESTIGATION
AND PAVEMENT DESIGN
HARMONY ROAD AT BANK ONE
FORT COLLINS, COLORADO

Prepared For:

Greystar Construction West, LLC
1899 Wynkoop Street
Suite 950
Denver, Colorado 80202

Attention: Mr. Edward "Skip" Washburn

Job No. FC-2715

June 3, 2003

CTL/THOMPSON, INC.
CONSULTING ENGINEERS
375 E. HORSETOOTH RD. ■ THE SHORES OFFICE PARK ■ BLDG. 3, SUITE 100 ■ FT. COLLINS, CO 80525
(970) 206-9455

TABLE OF CONTENTS

SCOPE

This report presents the results of our subgrade investigation and pavement design for a segment of Harmony Road in Fort Collins, Colorado. The included street segment is described below. We believe our report is in general conformance with Chapters 5 and 10 of the *"Larimer County Urban Areas Street Standards"* revised October 1, 2002, as adopted by the City of Fort Collins.

The purpose of our investigation was to determine the type and support characteristics of the subgrade soils at the site and provide pavement design alternatives. The City has reviewed the previously submitted subgrade investigation portion of this report pertaining to the type and support characteristics of the subgrade soils and has released traffic study information. The traffic study information was used to complete the design portion of this report.

Our report includes a description of the subgrade soils encountered in our exploratory borings and laboratory test results, alternative pavement sections, and construction and materials guidelines. The pavement design alternatives presented in this report are based upon laboratory test results, City of Fort Collins design criteria and traffic data, and the American Association of State Highway Transportation Officials (AASHTO) 1993 "*Guide for Design of Pavement Structures*".

FIELD AND LABORATORY INVESTIGATION

The section of Harmony Road that is the subject of this investigation is the eastbound turn lane located north of the Bank One construction site on the southwest corner of Harmony Road and Boardwalk Drive in Fort Collins, Colorado. The turn lane is approximately 500 feet in length and improvements to it are planned as part of the development of the adjacent bank. At the time of our investigation the existing turn lane was surfaced with asphalt pavement. A vicinity map and site plan are shown on Figure 1.

The subgrade soils were investigated by drilling two (2) exploratory borings to depths of 5 and 10 feet at the approximate locations shown on Figure 1. The borings were drilled on May 8, 2003 with a truck-mounted drill rig using 4-inch diameter continuous flight augers. A representative of our firm supervised the drilling and sampling, and logged the subsoils penetrated by the borings. We obtained samples by driving a 2.5-inch O.D. California-type sampler into the subsoils using a 140-pound hammer falling 30 inches, by hydraulically pushing 3-inch O.D. Shelby tubes into the subgrade soils, and by collecting bulk samples from auger cuttings. The samples were returned to our laboratory for visual examination and testing.

Subsurface conditions generally consisted of an approximate 9-inch asphalt pavement section over medium dense to dense aggregate base course overlying clayey to very clayey sand with gravel, occasionally grading to sandy clay. In one area between our two borings and nearer the pavement edge, the contractor excavated a shallow pit and encountered approximately two feet of coarse "pit run" type gravel overlying the sand and clay. The clayey sands and sandy clays were medium dense or stiff to very stiff based on field penetration resistance tests and observations during drilling. Summary logs of the subgrade borings and the results of field penetration resistance tests are presented on Figure 2.

The laboratory test program was designed to evaluate swell/consolidation characteristics, and provide index and support properties of the subgrade soils encountered. Index properties of the soils sampled were used to classify the soils according to the AASHTO and Unified Soil Classification Systems (USCS). A sample of the subgrade soils encountered in our two borings were tested in our laboratory. One sample had a liquid limit of 37 and a plasticity index of 21, and had 66 percent silt and clay-sized particles (passing the No. 200 sieve). The sample was classified as a sandy clay (CL) soil according to the USCS. According to the AASHTO system, the sample classifies as an A-6 soil. The two samples were combined and tested as a single soil group. The composite sample had a liquid limit of 31, a plasticity index of 19 and had 40 percent silt and clay-sized particles. The composite sample also classified as an A-6 soil according to the AASHTO method, but classified as an SC soil according to the USCS system. A Hveem stabilometer test (R-value) (ASTM D 2844, AASHTO T190) that was performed on the composite sample of the subgrade soils indicated an R-value of 22. Because of variability of the sand content of soils encountered in our borings, we recommend a design R-value of 18 be used for pavement thickness design. The design R-value was used to calculate a resilient modulus for the subgrade for pavement section design calculations. Laboratory test results are presented in Appendix A and summarized in Table A-1.

One-dimensional swell/consolidation tests were performed on two (2) samples to characterize the swell potential of the subgrade soils. The samples were loaded to 150 psf in a one-dimensional swell/consolidation apparatus, flooded with water and allowed to swell or consolidate. Both of the samples exhibited swells less than 2 percent (0.2 and 1.0 percent). The test results indicate the subgrade soils have engineering properties that are consistent with low swelling clayey sand and sandy clay soils. We judge the swell potential of subgrade soils tested to be low.

"Larimer County Urban Area Street Standards" adopted by the City of Fort Collins require mitigation of subgrade soils with an average swell potential greater than 2 percent (Chapter 5, Section 5.7.2). Therefore, mitigation of the site soils is not required. However, we believe the engineering properties of the soils encountered indicate they should be uniformly compacted to at least 95 percent of standard Proctor maximum dry density (AASHTO T 99) at a moisture content between 1 percent below and 2 percent above optimum moisture content. Moisture conditioning is discussed below in the "SUBGRADE PREPARATION" section.

SUBGRADE PREPARATION

We understand the existing pavement section (asphalt and aggregate base course) will be removed by milling, and expect that any additional cuts and fills within the public right-of-way will be minor. To prepare the final subgrade for paving, subgrade soils should be scarified a minimum of 12 inches deep, moisture conditioned to between 1 percent below and 2 percent above optimum moisture content and compacted to at least 95 percent of standard Proctor maximum dry density (AASHTO T 99). The soils encountered are comparatively weak and will have a tendency to become less stable at moisture contents above the optimum moisture content.

Scarification and recompaction of the upper 12 inches of subgrade soils should occur as close to the time of pavement construction as possible. The acceptable time period between subgrade treatment/preparation and pavement section construction is variable depending on the time of year, weather conditions and other factors. However, the final subgrade surface must be protected from freezing or excessive drying until such time as the pavement section is constructed. Periodic sprinkling of the subgrade surface, covering the subgrade, or other protective measures may be required. Additional guidelines for subgrade preparation are presented in Appendix C.

Stabilization. Maintaining moisture contents near optimum will be critical to avoid excessive deflections, rutting and pumping of the subgrade during subgrade preparation. If moisture and density cannot be sufficiently controlled during subgrade preparation and stabilization is required, chemical stabilization, stabilization by removal and replacement, or stabilization using geotextile fabrics and imported granular materials may be used. Because of the small size and restricted access of this site, we believe removal and replacement or "crowding" coarse aggregate into the subgrade may be a more effective mitigation technique than chemical stabilization.

PAVEMENT DESIGN

The pavement design presented in this report was based on methods in the AASHTO 1993 "*Guide for Design of Pavement Structures*", the "*Larimer County Urban Areas Street Standards*", revised October 1, 2002, as adopted by the City of Fort Collins, and our experience.

Traffic study information was provided by the City of Fort Collins and consisted of a street classification of the subject section as a six-lane arterial with a traffic volume in equivalent daily load applications (EDLA) of 450. For the traffic volume provided, we calculated an 18 kip equivalent single axle load (ESAL) of 3,285,000. We calculated an effective resilient modulus of 4,628 psi based on a design R-value of 18. Additional design parameters are specified in Table 10.1 of the referenced standards, and are shown in our design calculations presented in Appendix B.

Flexible pavement alternatives include asphalt (hot bituminous pavement) over a moisture treated subgrade and asphalt on aggregate base course over a moisture treated subgrade. An equivalent Portland cement concrete pavement is also provided. The pavement section alternatives are summarized in Table A. Thicknesses were calculated from and subject to the design criteria as specified in Table 10-1 of the *"Larimer County Urban Area Street Standards"*.

TABLE A

PAVEMENT DESIGN ALTERNATIVES

Location	Full-Depth Asphalt (HBP) on Moisture Treated Subgrade	Asphalt (HBP) + Aggregate Base Course (ABC) on Moisture Treated Subgrade	Portland Cement Concrete (PCC)
Harmony Road at Bank One (Six-Lane Arterial)	11.0" HBP	8.0" HBP + 12.0" ABC	10.5" PCC

PAVEMENT SELECTION

We have provided three (3) pavement design alternatives for the streets included in this investigation including full-depth asphalt (hot bituminous pavement) on a moisture conditioned subgrade, asphalt over aggregate base course on a moisture conditioned subgrade, and Portland cement concrete on prepared subgrade.

Asphalt concrete provides a stiff, stable pavement to withstand heavy loading and provide a good fatigue-resistant pavement. Asphalt concrete on aggregate base course will likely provide an equivalent fatigue life to that of an equivalent full-depth section. We consider the use of a geotextile fabric, such as Mirafi 500x or equivalent, to separate the subgrade from the aggregate base course as optional. Past experience has shown that such fabrics have been effective in reducing the co-mingling of the aggregate base course and subgrade soils that occurs over time, as well as providing additional reinforcement for the pavement section. Portland cement concrete (PCC) pavement would likely have greater fatigue resistance where the pavement will experience higher stresses due to slower moving and turning traffic. Portland cement concrete for minor pavement features in limited areas, such as crosspans or crosswalks, should be a minimum of 6 inches thick.

SOLUBLE SULFATES

Water soluble sulfate (SO_4) concentrations were measured for a composite sample of the near-surface subgrade soils. The purpose of the tests was to determine the risk of exposure to sulfate attack where Portland cement concrete is used and to assess the risk of increased swelling due to reactions with chemical additives such as lime during chemical stabilization. The concentration measured was 0.004 percent. These results indicate negligible exposure to sulfate attack on concrete (e.g. curb and gutter or pavements), and low risk of increased swelling due to reactions from chemical stabilization according to the American Concrete Institute (ACI). ACI has no special recommendations for concrete with negligible exposure to sulfate attack.

The use of sulfate resistive measures in concrete is most appropriate for foundation elements. Surface flatwork (such as sidewalks, crosspans, curbs and gutters) is usually constructed with a stronger, more durable concrete mix. Air entrainment is also commonly used. These common characteristics yield concrete which probably exhibits moderate resistance to attack. We have very rarely seen instances of sulfate attack on surface flatwork.

For this site we recommend the use of concrete made with Type I or Type II cement with a maximum water to cement ratio of 0.52, and having 5 to 7 percent entrained air for concrete in contact with soils which are likely to stay moist due to surface drainage.

MATERIALS AND CONSTRUCTION

The performance of a pavement system is determined by the quality of the paving materials and construction practices. Material properties and construction practice guidelines are presented in Appendix C. During construction, careful attention should be paid to the following details:

- Maintaining subgrade moisture content as close to optimum moisture content as practical.
- 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.

Moisture treatment of the subgrade will reduce the swell potential of the site soils. However, higher moisture contents will tend to decrease stability of the subgrade for proof rolls. Uniformity of the subgrade and careful monitoring of the subgrade preparation will decrease the likelihood of stability problems during subgrade preparation. Stabilization and swell mitigation are discussed in more detail in the previous sections of this report.

MAINTENANCE

We recommend a preventive maintenance program be developed and followed for all pavement systems to assure the design life can be realized. Choosing to defer maintenance usually results in accelerated deterioration leading to higher future maintenance costs. Recommended maintenance programs for flexible and rigid pavements are outlined in Appendix D.

LIMITATIONS

The subgrade investigation, conclusions and recommendations included in this report are based upon our field observations, laboratory testing, and design criteria required by the City of Fort Collins and the AASHTO design guide. The report will be amended to include pavement section design recommendations following review and approval by the City of Fort Collins.

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 currently practicing under similar conditions in the locality of the project. No other 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.

COLORADO REGISTERED DAVID CASTELBAUM 36317 PROFESSIONAL ENGINEER

David Castelbaum, PE
Geotechnical Staff Engineer

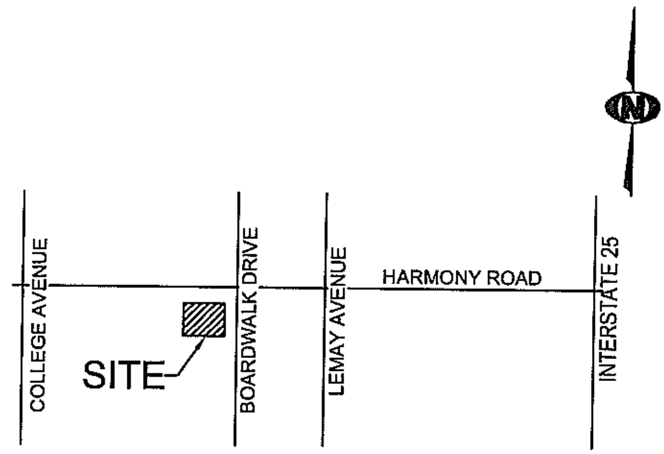
Reviewed by:

COLORADO REGISTERED THOMAS A. CHAPEL 33848 6/3/03 PROFESSIONAL ENGINEER

Thomas A. Chapel, CPG, PE
Associate

DC:TAC:bly
(6 copies sent)

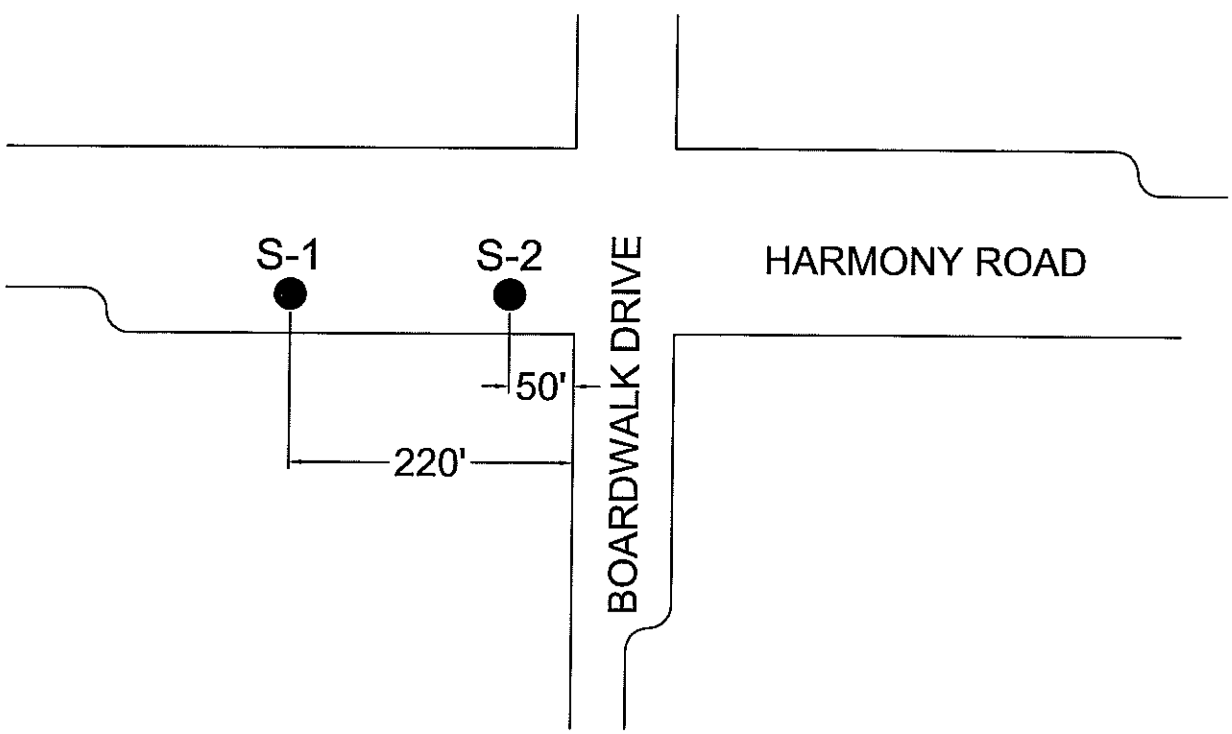
NO SCALE



VICINITY MAP
(FORT COLLINS AREA)
NO SCALE

LEGEND :

S-1 ● INDICATES LOCATION OF SUBGRADE BORING

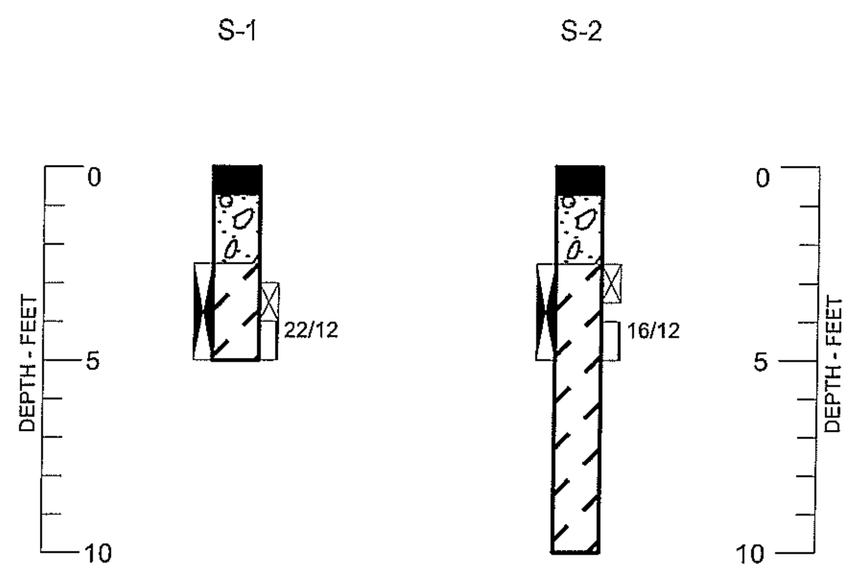


FC-2715 MMH 05/14/03

GREYSTAR CONSTRUCTION WEST, LLC.
HARMONY ROAD AT BANK ONE
JOB NO. FC-2715

Locations of Subgrade Borings

FIGURE 1



LEGEND:

ASPHALT.

GRAVEL, SANDY, SLIGHTLY SILTY TO SILTY, MEDIUM DENSE TO DENSE, MOIST, BROWN (AGGREGATE BASE COURSE).

SAND, CLAYEY TO VERY CLAYEY WITH GRAVEL, OCCASIONALLY GRADING TO SANDY CLAY, MEDIUM DENSE/STIFF TO VERY STIFF, MOIST TO VERY MOIST, LIGHT BROWN TO DARK BROWN (SC, CL).

DRIVE SAMPLE.THE SYMBOL 22/12 INDICATES THAT 22 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2.5-INCH O.D. SAMPLER 12 INCHES.

BULK SAMPLE TAKEN FROM AUGER CUTTINGS.

SHELBY TUBE SAMPLE.

NOTES:

1. THE BORINGS WERE DRILLED ON MAY 8, 2003 WITH A TRUCK MOUNTED DRILL RIG USING 4-INCH DIAMETER CONTINUOUS FLIGHT POWER AUGERS.

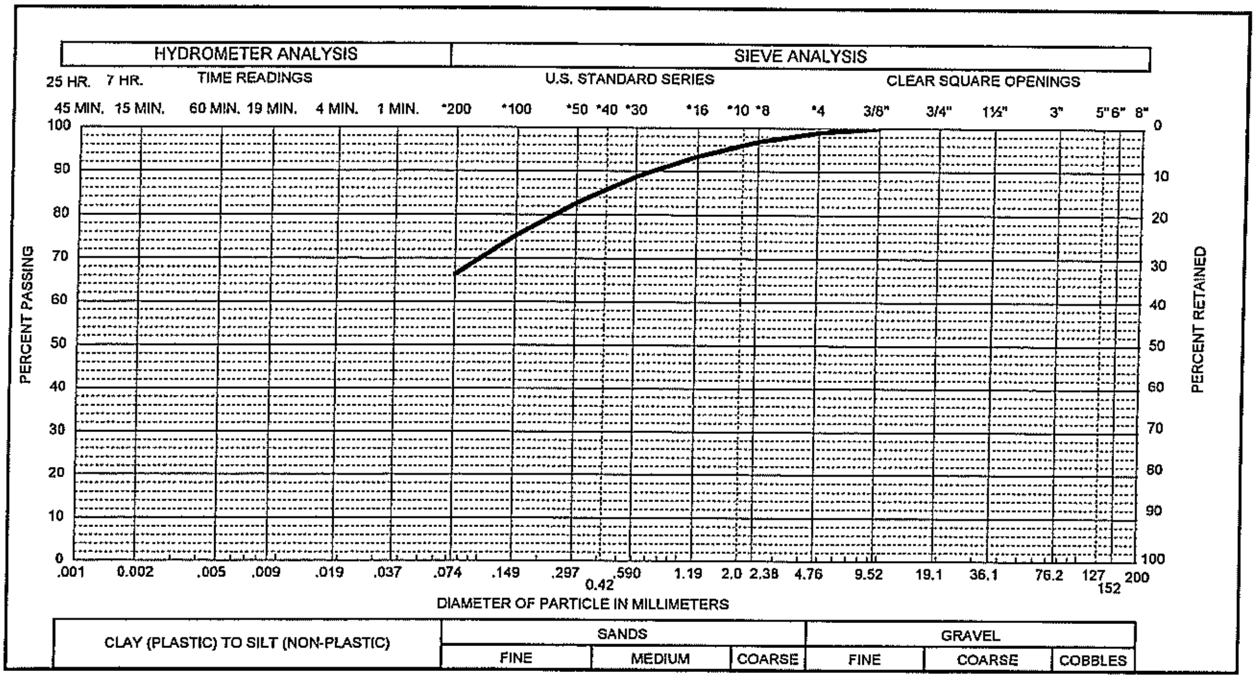
2. BORING LOCATIONS WERE DETERMINED BY A REPRESENTATIVE OF CTL/THOMPSON, INC. BY PACING FROM FEATURES IN THE FIELD AND AS SHOWN ON FIGURE 1.

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

SUMMARY LOGS OF SUBGRADE BORINGS

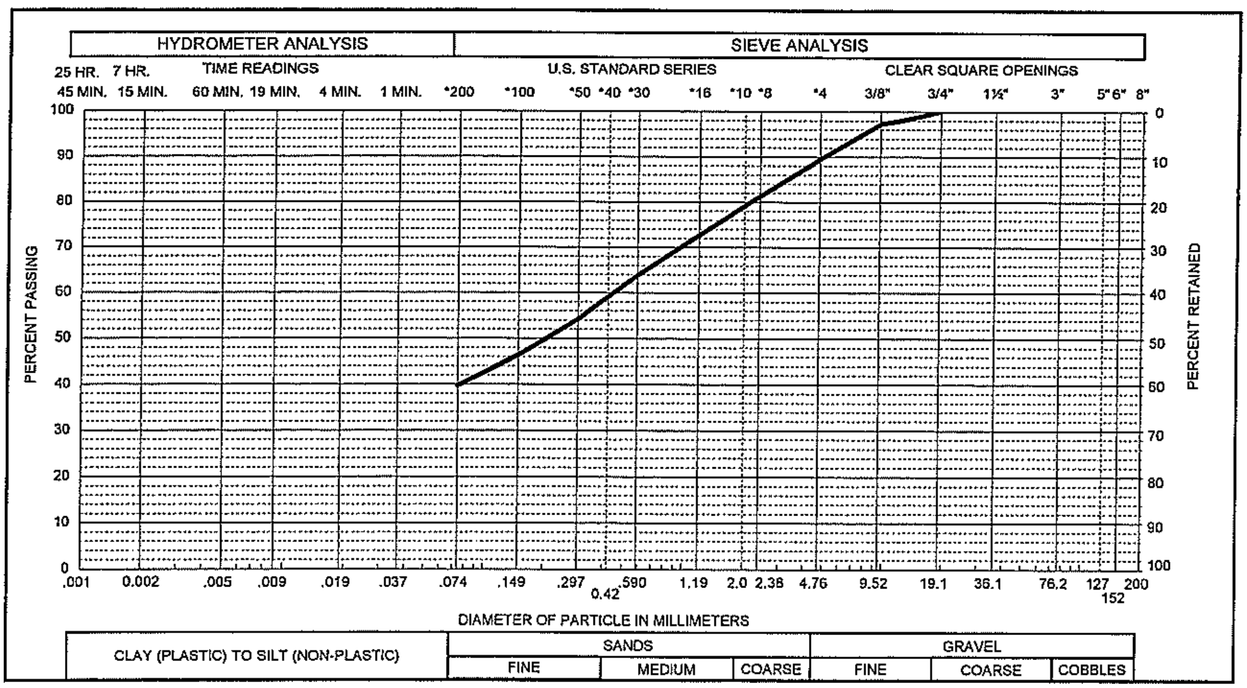
APPENDIX A

LABORATORY TEST RESULTS



Sample of CLAY, SANDY (CL)
From S-1 AT 3 FEET

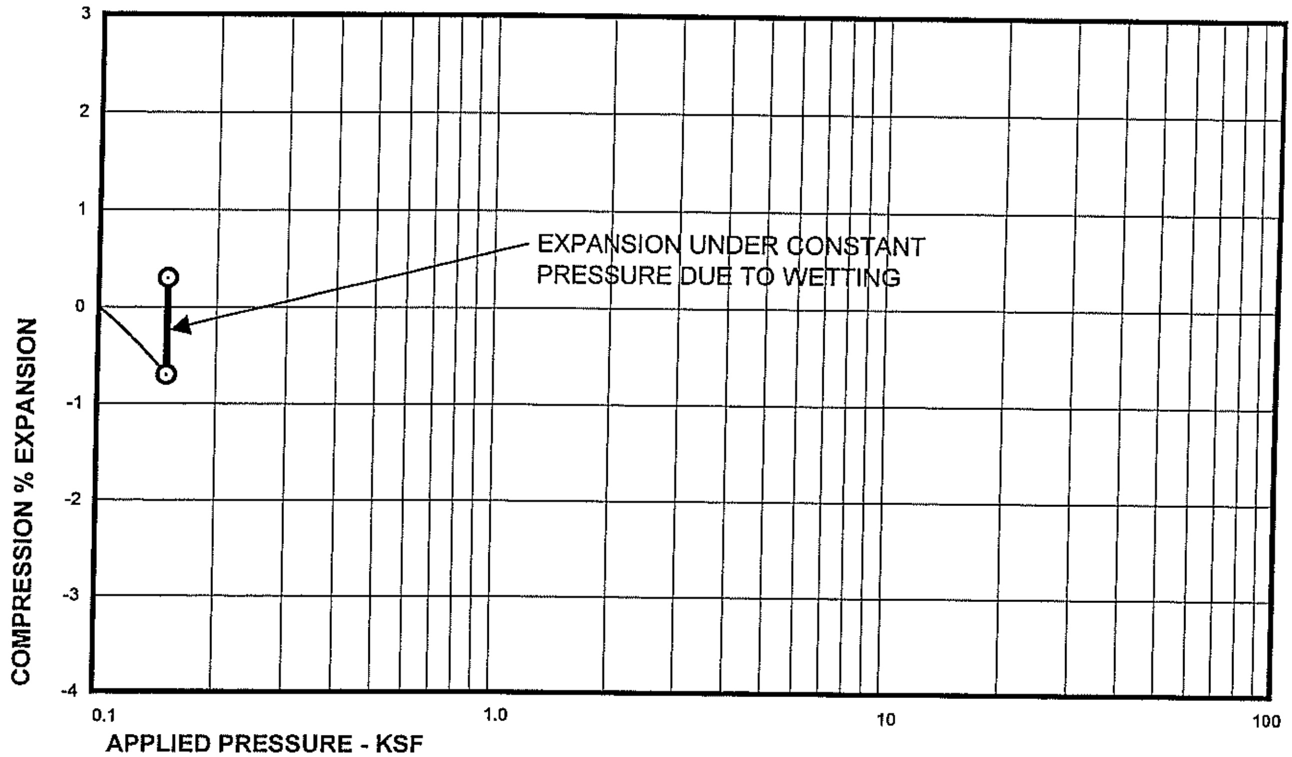
GRAVEL 1 % SAND 33 %
SILT & CLAY 66 % LIQUID LIMIT 37 %
PLASTICITY INDEX 21 %



Sample of SAND, CLAYEY (SC)
From COMPOSITE (S-1 & S-2) AT 2.5 - 5 FEET

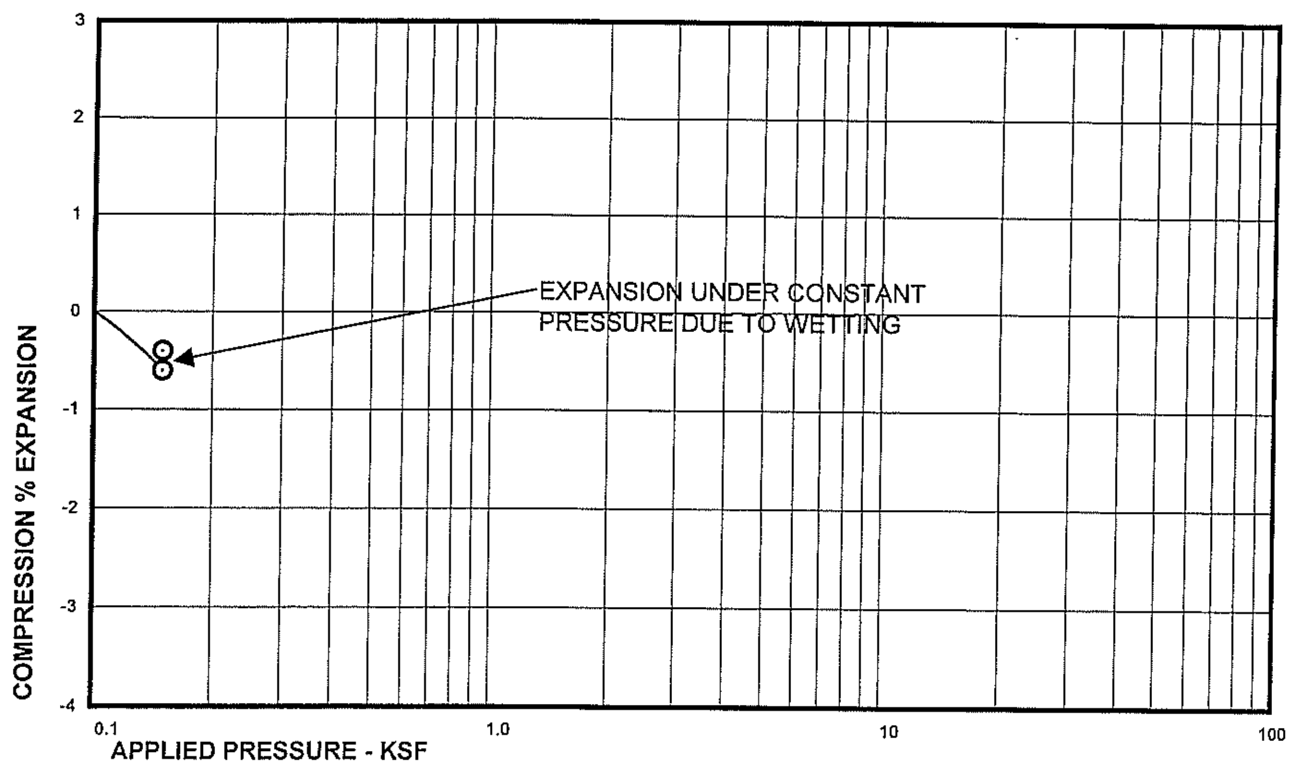
GRAVEL 11 % SAND 49 %
SILT & CLAY 40 % LIQUID LIMIT 31 %
PLASTICITY INDEX 19 %

Gradation Test Results



Sample of CLAY, SANDY (CL)
From S-1 AT 3 FEET

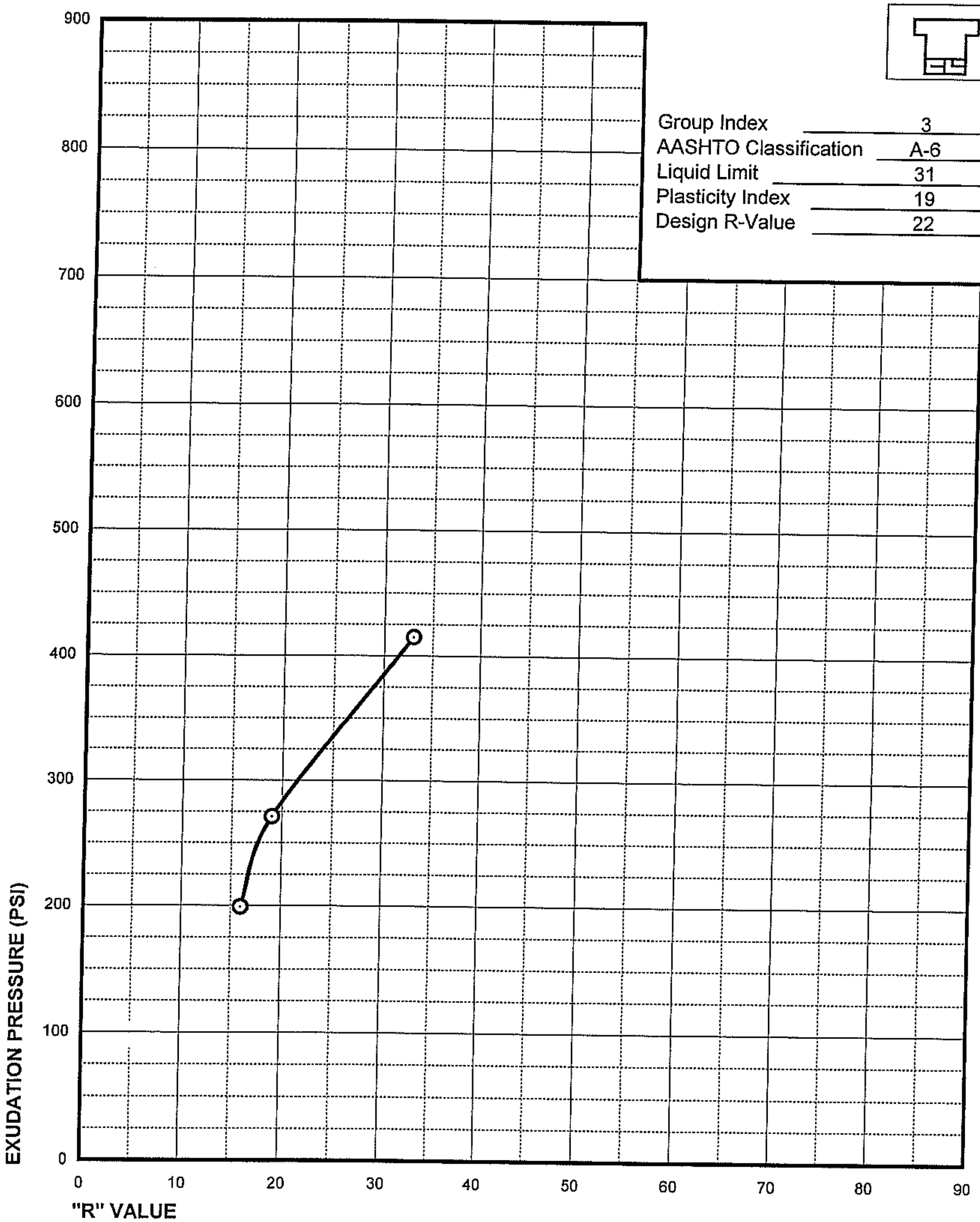
NATURAL DRY UNIT WEIGHT= 104.8 PCF
NATURAL MOISTURE CONTENT= 19.8 %



Sample of CLAY, SANDY (CL)
From S-2 AT 2.5 FEET

NATURAL DRY UNIT WEIGHT= 110.5 PCF
NATURAL MOISTURE CONTENT= 16.7 %

Swell Consolidation Test Results



Group Index	3
AASHTO Classification	A-6
Liquid Limit	31
Plasticity Index	19
Design R-Value	22

Sample of SAND, CLAYEY (CL)
From COMPOSITE (S-1 & S-2) AT 2.5 - 5 FEET

Hveem Stabilometer Test Results

JOB NO. FC-2715

FIGURE A-3

TABLE A-1

SUMMARY OF LABORATORY TEST RESULTS

BORING NUMBER	DEPTH (FEET)	SAMPLE TYPE	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (%)	SWELL TEST DATA		PASSING NO. 200 SIEVE (%)	ATTERBERG LIMITS		GROUP INDEX	CLASSIFICATION		R-VALUE	WATER SOLUBLE SULFATES (%)	DESCRIPTION
					SWELL (%)	APPLIED PRESURE (psf)		LIQUID LIMIT (%)	PLASTICITY INDEX (%)		AASHTO	USCS			
S-1	3	SHELBY	19.8	104.8	1.0	150	66.3	37	21	11	A-6	CL			CLAY, SANDY TO VERY SANDY
S-2	2.5	SHELBY	16.7	110.5	0.2	150									CLAY, SANDY TO VERY SANDY (CL)
S-1 & S-2	2.5 - 5	COMPOSITE					39.7	31	19	3	A-6	SC	22	0.004	SAND, CLAYEY

JOB NO. FC-2715

APPENDIX B

DESIGN CALCULATIONS

AASHTO FLEXIBLE PAVEMENT DESIGN

Project: Harmony Road at Bank One

Location: Southwest Corner of Harmony and Boardwalk

What is the Design ESAL ?	3,285,000	
What is the Serviceability Loss ?	2.0	
What is the Reliability ?	90	
What is the Standard Deviation ?	0.44	
What is the R-value ?	18	
Computed Resilient Modulus =	4,628	psi
If R is not available, Input Resilient Modulus =		psi
DESIGN RESILIENT MODULUS =	4,628	psi
DESIGN STRUCTURAL NUMBER (SN) =	4.75	
Full Depth HBP Thickness on Subgrade is	10.8	inches
What is the HBP Layer Coefficient ?	0.44	
What is the ABC Layer Coefficient ?	0.11	
What is the FASS Layer Coefficient?	0.10	

8.0	**inches HBP over**	11.2	**inches Aggregate Base Course**
8.0	**inches HBP over**	12.3	**inches Fly Ash Stabilized Subgrade**

NOTES: HBP = Hot Bituminous Pavement, ABC = Aggregate Base Course

This table presents design parameters and pavement thickness calculations, and should not be used for construction purposes. Final pavement thicknesses are presented in the report.

AASHTO RIGID PAVEMENT DESIGN

Project: **Harmony Road at Bank One**
Location: **Southwest Corner of Harmony and Boardwalk**

What is the Design ESAL ?	3,285,000	
What is the Reliability ?	90	
What is the Serviceability Loss ?	2.0	
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 ?	18	
Computed Resilient Modulus =	4,628	psi
If R is not available, Input Resilient Modulus =		psi
DESIGN RESILIENT MODULUS =	4,628	psi
Design Slab Thickness is	10.5	inches

APPENDIX C

MATERIAL PROPERTIES AND CONSTRUCTION CHECKLIST

MATERIAL PROPERTIES

ASPHALTIC CONCRETE

- Design assumes a strength coefficient of 0.44 for Grading S and Grading SG.
- Asphalt concrete should be relatively impermeable to moisture and should be designed with 100% crushed aggregates that have a minimum of 80% of the aggregate retained on the No. 4 sieve with two mechanically fractured faces.
- Gradations that approach the maximum density line (within 5% between the No. 4 and 40 sieve) should be avoided.
- A gradation with a nominal maximum size of 3/4" developed on the fine side of the maximum density line should be used.
- Total void content, Void in the Mineral Aggregate (VMA) and voids filled shall be considered in the selection of the optimum asphalt cement content. The optimum asphalt content shall be selected at a total air void content of 4%. The mixture shall have a minimum VMA of 14% and voids filled that range from 65 to 80%.
- Polymer modification can change the rheology and viscosity to improve pavement performance and should be considered for the upper 3 inches of collector and arterial streets.
- Residential streets should be fog sealed approximately 1 year after the placement of asphalt pavement at 0.1 to 0.15 gallons per square yard.
- A job mix formula and periodic checks on the job site shall be made to verify compliance with the specifications.

CHEMICALLY STABILIZED SUBGRADE

- Design assumes a minimum 7-day 100^0 F Compressive strength of 160 psi.
- For planning purposes, 12% Class C fly ash may be assumed to give the desired strengths and soil stabilization.
- A design should be performed using the subgrade soils and chemical source designated by the contractor.

AGGREGATE BASE COURSE

- Design assumes a minimum Hveem Stabilometer value (R-value) of 77.
- Class 5 or 6 Colorado Department of Transportation (CDOT) specified aggregate base course is recommended.
- Aggregate base must be moisture stable. The change in R-value from 300 psi to 100 psi exudation pressure must be 12 points or less.

If the construction materials cannot meet these recommendations, then the pavement design should be evaluated based upon available materials. Materials and placement methods should conform to the requirements of the City of Fort Collins. All material planned for construction should be submitted and the applicable laboratory tests performed to verify compliance with the specifications.

CONSTRUCTION CHECKLIST

The construction procedures 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-1 to A-5)

- Soils shall be moisture treated between 2% below to 2% above 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 to between 1% below to 2% 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. CTL/Thompson should be present to observe the proof roll test.
- Subgrade that is pumping or deforming shall be scarified, moisture conditioned, and tested.
- If limited areas of very soft or wet subgrade are found, the material shall be subexcavated and replaced with approved on-site or import material, moisture conditioned, compacted and tested.
- If extensive soft, wet, or unstable subgrade are found, stabilization should be considered.

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 whether the subgrade substantially meets the specifications.
- CTL/Thompson should be present for proof roll operations.

AGGREGATE BASE COURSE

- CDOT Class 5 or 6 Aggregate base course shall be laid in thin, loose lifts, moisture treated to within 2% of optimum moisture content, and compacted to at least 95% of maximum standard Proctor dry density (ASTM D 698, AASHTO T 99).

CURB AND GUTTER

- Curb and gutter shall be backfilled and the backfill 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 Fort Collins 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 at least ½ hour prior to paving.

ASPHALTIC CONCRETE

- Asphalt concrete shall be hot plant-mixed material compacted to between 92 and 96% of maximum theoretical density.
- Paving should only be performed when subgrade temperatures are high enough to allow proper compaction of the lift. General guidelines are often for subgrade temperatures above 40° F and air temperatures at least 40° F and rising.
- The temperature at laydown time shall be determined according to the temperature-viscosity relationship of the asphalt cement. Experience indicates that the laydown temperature shall be at least 275° F for AC-10 asphalt cement.
- The maximum compacted lift should be 3.0 inches for CDOT Grading "S" type materials and joints shall be staggered. No joints shall be placed within wheel paths.
- Surface shall be sealed with a finish roller prior to the mix cooling to 175° F.

PORTLAND CEMENT CONCRETE

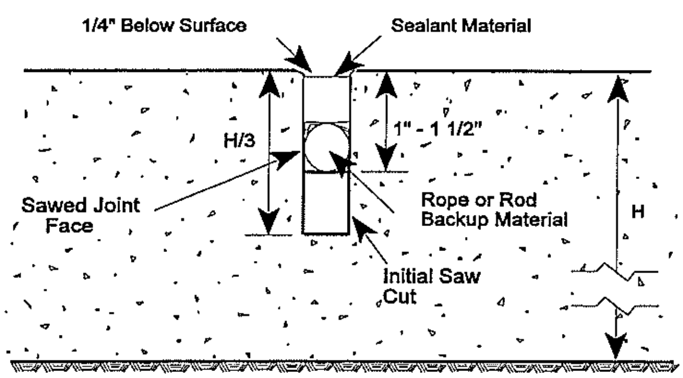
- Concrete shall not be placed on subgrade colder than 40° F nor when air temperatures are less than 40° F.
- Concrete shall have a minimum flexural strength of 600 psi and a minimum compressive strength of 4,000 psi.
- Test shall be conducted at 28 days.

CURING PROCEDURES

- Curing procedures shall protect the concrete against moisture loss, rapid temperature change, freezing, and mechanical injury for at least 3 days after placement.
- Traffic shall not be allowed on the pavement for at least one week.
- A white, liquid membrane curing compound, applied at the rate recommended by the manufacturer, shall be sprayed within 24 hours of placement. The minimum application rate is one gallon per 150 square feet.

CONSTRUCTION JOINTS

- Construction joints, including longitudinal joints and transverse joints, shall be formed during construction or shall be sawed after the concrete has begun to set, but prior to uncontrolled cracking. Transverse joints shall be sawed within 24 hours of placement while longitudinal joints shall be sawed within 48 hours.
- All joints shall be properly sealed to rod back-up at depths shown in joint detail.



The subgrade preparation and the placement and compaction of all pavement material shall be observed and tested by CTL/Thompson. Compaction criteria shall be met prior to the placement of the next paving lift. The additional requirements of the City of Fort Collins shall apply.

APPENDIX D

GUIDELINE MAINTENANCE RECOMMENDATIONS

MAINTENANCE RECOMMENDATIONS FOR FLEXIBLE PAVEMENTS

The primary cause for deterioration of low traffic volume pavements is oxidative aging resulting in brittle pavements. Tire loads from traffic are necessary to "work" or knead the asphalt concrete to keep it flexible and rejuvenated. Preventive maintenance treatments will typically preserve the original or existing pavement by providing a protective seal or rejuvenating the asphalt binder to extend pavement life.

The primary cause for deterioration of high traffic volume pavements is loss of integrity of the asphalt concrete and subgrade failure. High volumes also 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 shall be performed each spring or fall.
   b. Reports documenting the progress of distress shall be kept current to provide information on effective times to apply preventive maintenance treatments.
   c. Crack sealing shall be performed annually as new cracks appear.

2. 3 to 5 Year Preventive Maintenance

   a. The owner should budget for a preventive treatment at approximate intervals of 3 to 5 years to reduce oxidative embrittlement problems.
   b. Typical preventive maintenance treatments include chip seals, fog seals, slurry seals and crack sealing.

3. 5 to 10 Year Corrective Maintenance

   a. Corrective maintenance may be necessary, as dictated by the pavement condition, to correct rutting, cracking and structurally failed areas.
   b. Corrective maintenance may include full depth patching, milling and overlays.
   c. In order for the pavement to provide a 20 year service life, at least one major corrective overlay can be expected.

MAINTENANCE 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 shall 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 shall 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.