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SUBGRADE INVESTIGATION AND PAVEMENT RECOMMENDATIONS
TURN LANE
BANK OF CHOICE
HARMONY ROAD AND BOARDWALK DRIVE
FORT COLLINS, COLORADO

Prepared For:

BANK OF CHOICE
3780 West 10th Street
Greeley, Colorado 80634

Attention: Mr. Darrell McAllister

Project No. FC04254-135

May 16, 2008

351 Linden Street | Suite 140 | Fort Collins, Colorado 80524
Telephone: 970-206-9455 Fax: 970-206-9441

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SCOPE

This report presents the results of our subsurface investigation and pavement recommendations for the new turn lane on the east side of Boardwalk Drive adjacent to the Bank of Choice property in Fort Collins, Colorado. The purpose of our investigation was to determine the type of subgrade soils, if ground water was present at the site, and to evaluate pavement support characteristics. The report presents geotechnical design criteria for the roadway in general conformance with the Chapters 5 and 10 of the *Larimer County Urban Areas Street Standards (LCUASS)* dated January 2, 2001 (repealed and reenacted April 1, 2007) as adopted by the City of Fort Collins. We reviewed a Geotechnical Engineering Report prepared by Terracon under Project No. 20035149, dated October 13, 2003 that included an estimated R-value of subgrade soils for the parking lot.

This report was prepared from data developed during field exploration, laboratory testing, engineering analysis, and experience with similar conditions. The report includes a description of the subgrade soils found in exploratory borings, laboratory test results, and pavement recommendations. If plans change significantly, we should be contacted to review our investigation. A brief summary of our conclusions is presented below, with more detailed criteria and recommendations contained in the report.

SUMMARY OF CONCLUSIONS

1. Soils encountered in our borings consisted of clayey sand and gravelly sand to depths explored. Ground water was not encountered in the borings. Ground water levels are not expected to affect site development.

2. Our borings indicate the soils and rock are generally considered to exhibit good subgrade support characteristics. However, our tests indicate the subgrade soils have a medium expansion classification and will need to be mitigated for swell.

3. Recommended minimum pavement sections and mitigation methods are presented in the body of the report.

SITE LOCATION AND CONDITIONS

The site is located at the northeast corner of Harmony Road and Boardwalk Drive in south Fort Collins, Colorado. The proposed turn lane begins at the intersection of Whalers Way and Boardwalk Drive and extends southward approximately 450 feet along the east edge of Boardwalk Drive. The site was rough graded with underground utilities and curb and gutter installed prior to our investigation. The site is relatively flat.

PROPOSED CONSTRUCTION

The turn lane is part of the improvements associated with the new Bank of Choice building and pad sites located at the northeast corner of Harmony Road and Boardwalk Drive. We understand the proposed construction includes the construction of the new turn lane.

INVESTIGATION

Subsurface conditions at the site were investigated by drilling two borings along the east edge of the proposed turn lane at approximate spacing of 200 lineal feet. The approximate locations of the borings are shown on Figure 1. Our field representative observed drilling, logged the soils found in the borings and obtained samples. Summary logs of the borings, including results of field penetration resistance tests, are presented on Figure 2.

Samples obtained during drilling were returned to our laboratory and examined by the geologist for this project. Laboratory testing included moisture content, dry density, gradation analysis and Atterberg Limits. Results of laboratory tests are presented in Appendix A and summarized on Table A-I.

SUBSURFACE CONDITIONS

Soil encountered in our borings generally consisted of clayey sand and gravelly sand. Ground water was not encountered in the borings. Graphic logs of the borings are presented on Figure 2.

A sample of clayey sand tested in the laboratory contained 37 percent clay and silt-sized particles (passing the No. 200 sieve), had a liquid limit of 38, and plasticity index of 23. The sample classified as A-6 in accordance with the AASHTO classification method with a group index of 3. Samples of clayey sand tested for swell potential swelled between 2.8 percent and 3.0 percent. Based on the results of laboratory testing and City of Fort Collins requirements, the subgrade soils have a medium expansion classification and swell mitigation will be required for the subgrade soils in the turn lane. No Hveem stabilometer tests for R-value were conducted for this project. We have conservatively estimated an R-value of 7 for our design, which was also estimated by Terracon for site soils.

PAVEMENT DESIGN

The City of Fort Collins requires the use of the AASHTO and CDOT design methods for their roadways. We used DARWin software to develop our pavement thickness calculations with input values provided by LCUASS. An Equivalent Daily Load Application (EDLA) of 175 was provided by City of Fort Collins personnel for the turn lane. We converted the EDLA value to an 18-kip Equivalent Single Axle Load (ESAL) of 1,277,500 for a 20-year design life. We converted the estimated R-value of 7 to a resilient modulus of 3,228. Computer generated printouts of the DARWin calculations are presented in Appendix B.

Our recommended pavement design sections for the turn lane on Boardwalk Drive are presented in Table I below. We understand the City desires to use a pavement section consisting of hot mix asphalt on aggregate base course over fly ash treated subgrade. We recommend treating the existing subgrade with a minimum of 12% fly ash in the upper one foot for expansive soil mitigation purposes. According to the LCUASS, credit for strength gain is not allowed for fly ash treatment in this manner. In order to use fly ash treated subgrade in the pavement section calculations, a mix design must be performed and the soil/fly ash mixture must achieve a minimum 7-day compressive strength of 150 psi. Our scope of work did not include design of a soil/fly ash mixture. If plans change, we are available to perform a soil/fly ash mix design.

We have provided pavement design alternatives including hot mix asphalt (HMA) on aggregate base course (ABC) and portland cement concrete (PCC) pavement, both over fly ash treated subgrade. Our alternatives do not include credit for strength for fly ash treated subgrade. Our pavement thickness alternatives are presented on Table I. Additional discussion regarding advantages and disadvantages of the pavement alternatives and their expected performance is included under PAVEMENT

SELECTION

TABLE I
PAVEMENT THICKNESS ALTERNATIVES

Road	Hot Mix Asphalt (HMA) + Aggregate Base Course (ABC) + Fly Ash Treated Subgrade (FASS)	Portland Cement Concrete (PCC) + Fly Ash Treated Subgrade (FASS)
East Turn Lane at Boardwalk between Harmony Road and Whalers Way	Option A 6.0" HMA + 18.0" ABC + 12.0" FASS Option B 8.0" HMA + 10.0" ABC + 12.0" FASS Option C 9.0" HMA + 6.5" ABC + 12.0" FASS	7.0" + 12.0" FASS

PAVEMENT SELECTION

Hot mix asphalt (HMA) and aggregate base course over a prepared subgrade is expected to perform well in areas with sandy subgrade soils. HMA provides a stiff, stable pavement to withstand heavy loading and will provide a good fatigue resistant pavement. Concrete pavement is also expected to perform well in this area. However, concrete pavement has better performance in freeze-thaw conditions and should require less long-term maintenance than asphalt pavement. If the owner is considering concrete pavement, they should contact the City of Fort Collins to discuss potential future milling and pavement function in this area. In any event, the performance of the pavement structure depends partly on the stability of the subgrade soils.

SUBGRADE AND PAVEMENT MATERIALS

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

Fly Ash Stabilized Subgrade (FASS)

1. The subgrade should be shaped to final line and grade.

2. The fly ash used should meet requirements specified in ASTM C 593 and C 618.

3. Fly ash should be spread with a mechanical spreader from back of curb to back of curb for detached sidewalks or back of walk to back of walk for attached sidewalks.

4. Fly ash and subgrade soils should be mixed, and water added until a homogeneous, uniform mixture is obtained that is within 2 percent of laboratory determined optimum moisture content in accordance with ASTM D 558.

5. The fly ash/soil mixture should be compacted to at least 95% of the mixtures maximum dry density (ASTM D 558) where subsequent sub-base and/or base courses are to be placed.

6. The subgrade should be re-shaped to final line and grade.

7. Mixing, compaction and final shaping should be completed within 2 hours of addition of water to the fly ash/soil mixture.

8. The subgrade should be sealed with a pneumatic-tire roller that is sufficiently light in weight so as to not cause hairline cracking of the subgrade.

9. The City requires a minimum of 2 days curing prior to paving (the surface of the stabilized area should be kept moist during the cure period by periodic, light sprinkling if needed). Strength gains will be slower during cooler weather. The City of Fort Collins requirements specify that traffic is not permitted on the treated subgrade during the curing period.

10. The treated areas will gain greater strength if they are allowed to cure for 1 to 3 days prior to paving. Construction traffic on the treated subgrade prior to pavement section construction should be limited and the subgrade should be protected from freezing or drying at all times until paving.

Aggregate Base Course (ABC)

1. A Class 5 or 6 Colorado Department of Transportation (CDOT) specified ABC should be used. A recycled concrete alternative which meets the Class 5 or 6 designation is also acceptable.

2. Aggregate base course should have a minimum Hveem stabilometer value of 72, or greater. ABC or recycled concrete material must be moisture stable. The change in R-value from 300 psi to 100 psi exudation pressure should be 12 points or less.

3. ABC or recycled concrete should be laid in thin lifts not to exceed 8 inches, moisture treated to near optimum moisture content, and compacted to at least 95 percent of maximum modified Proctor dry density (ASTM D 1557, AASHTO T 180).

4. Placement and compaction of ABC or recycled concrete should be observed and tested by a representative of our firm. Placement should not commence until the underlying subgrade is properly prepared and tested.

Hot Mix Asphalt (HMA)

1. HMA should be composed of a mixture of aggregate, filler, hydrated lime and asphalt cement. Some mixes may require polymer modified asphalt cement, or make use of up to 20 percent reclaimed asphalt pavement. A job mix design is recommended and periodic checks on the job site should be made to verify compliance with specifications.

2. HMA should be relatively impermeable to moisture and should be designed with crushed aggregates that have a minimum of 80 percent of the aggregate retained on the No. 4 sieve with two mechanically fractured faces.

3. Gradations and lifts should be in accordance with Table 10-1 of the LCUASS.

4. Total void content, voids in the mineral aggregate (VMA) and voids filled should be considered in the selection of the optimum asphalt cement content. The optimum asphalt content should be selected at a total air void content of approximately 4 percent. The mixture should have a

minimum VMA of 14 percent and between 65 percent and 80 percent of voids filled.

5. Asphalt cement should meet the requirements of the Superpave Performance Graded (PG) Binders. The minimum performing asphalt cement should be PG 64-22 for use along the Front Range. The use of PG 58-28 or PG 58-22 asphalt cement has been known to cause tenderness in pavements in the Front Range corridor area and should be avoided.

6. Hydrated lime should be added at the rate of 1 percent by dry weight of the aggregate and should be included in the amount passing the No. 200 sieve. Hydrated lime for aggregate pretreatment should conform to the requirements of ASTM C 207, Type N.

7. Paving should only be performed when subgrade temperatures are above 40°F and air temperature is at least 40°F and rising.

8. HMA should not be placed at a temperature lower than 245°F for mixes containing PG 64-22 asphalt, and 290°F for mixes containing polymer-modified asphalt. The breakdown compaction should be completed before the mixture temperature drops 20°F.

9. The maximum compacted lift should be 3.0 inches and joints should be staggered. No joints should be placed within wheel paths.

10. HMA should be compacted to between 92 and 96 percent of Maximum Theoretical Density. The surface shall be sealed with a finish roller prior to the mix cooling to 185°F.

11. Placement and compaction of HMA should be observed and tested by a representative of our firm. Placement should not commence until the subgrade is properly prepared (or stabilized), tested and proof-rolled. Proof rolling should be performed with the heaviest machine available. The proof roller should be selected from machines providing both mass and high contact pressure.

<u>Portland Cement Concrete (PCC)</u>

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. <u>A job mix design is recommended and periodic checks on the job site should be made to verify compliance with specifications</u>.

2. Portland cement should be Type II "low alkali" and should conform to ASTM C 150.

3. Portland cement concrete should not be placed when the subgrade or air temperature is below 40°F.

4. Free water should not be finished into the concrete surface. Atomizing nozzle pressure sprayers for applying finishing compounds are recommended whenever the concrete surface becomes difficult to finish.

5. Curing of the portland cement concrete should be accomplished by the use of a curing compound. The curing compound should be applied in accordance with manufacturer recommendations.

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

7. 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.

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

9. 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.

10. 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.

MAINTENANCE

Routine maintenance, such as sealing and repair of cracks, is necessary to achieve the long-term life of a pavement system. 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, and/or repair. A recommended maintenance program is outlined in Appendix E.

Excavation of completed pavement for utility construction or repair can destroy the integrity of the pavement and result in a severe decrease in serviceability. To restore the pavement top original serviceability, careful backfill compaction before repaving is necessary.

SURFACE DRAINAGE

The primary cause of premature pavement deterioration is infiltration of water into the pavement system. This increase in moisture content usually results in the softening of base course and subgrade and eventual failure of the pavement. We recommend that pavements and surrounding ground surface be sloped to cause surface water to run off rapidly and away from pavements. Backs of curbs and gutters should be backfilled with compacted fill and sloped to prevent ponding adjacent to backs of curbs and to paving. The final grading of the subgrade should be carefully controlled so the pavement design cross-section can be maintained. Low spots in the subgrade that can trap water should be eliminated. Seals should be provided within the curb and pavement and in all joints to reduce the possibility of water infiltration.

LIMITATIONS

Our borings were spaced to obtain a reasonably accurate indication of pavement conditions for the proposed construction. The borings are representative of conditions encountered only at the exact boring locations. Variations in the subsoil conditions not indicated by our borings are always possible. A representative of our firm should observe subgrade preparation, subgrade stabilization and pavement construction.

This report was prepared from data developed during our field exploration, laboratory testing, engineering analysis, and experience with similar conditions. The recommendations contained in this report were based upon our understanding of the planned construction. If plans change or differ from the assumptions presented herein, we should be contacted to review our recommendations.

We believe this investigation was conducted with that level of skill and care ordinarily used by geotechnical engineers practicing in this area at this time. No warranty, express or implied, is made. If we can be of further service in discussing the contents of this report or in the analysis of the influence of subsoil conditions on design of the pavements, please call the undersigned.

CTL | THOMPSON, INC. by:

Thomas W. Finley, CPG
Senior Geologist

Reviewed by:

Eric D. Bernhardt, P.E.
Manager of Field Services

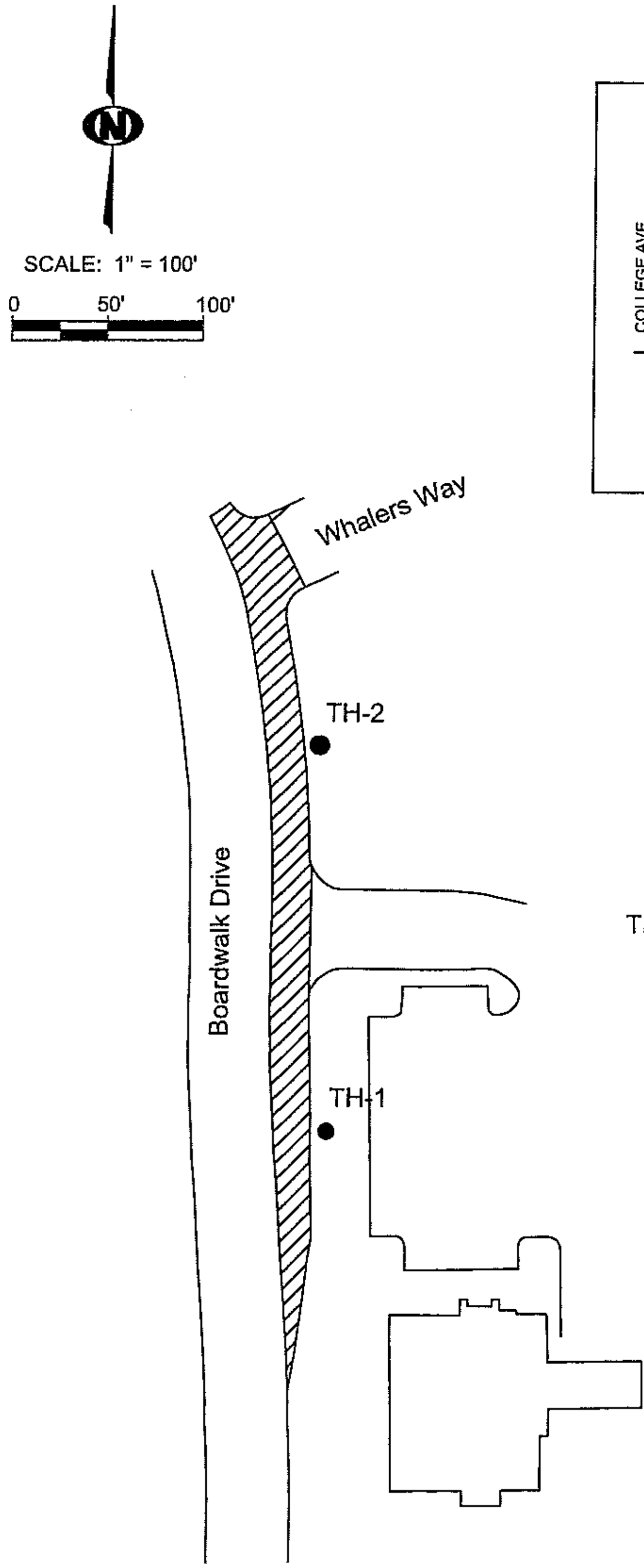
COLORADO LICENSED ... D. BERNHARDT ... PROFESSIONAL ENGINEER

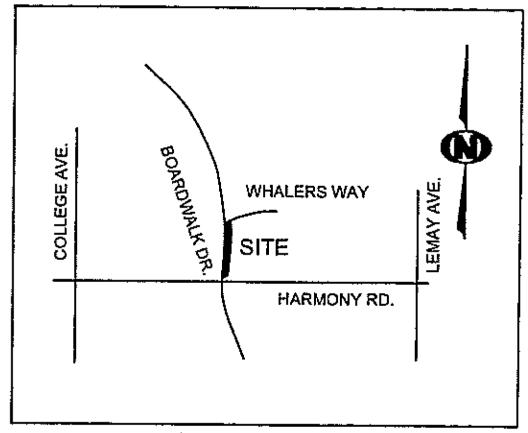
5/20/08

2 copies sent

cc: Roche Constructors, Inc.
Attention: Mr. Neal Swift
361 71st Avenue
P.O. Box 1721
Greeley, Colorado 80634

City of Fort Collins
Engineering Department
Attention: Mr. Rick Richter
281 North College Avenue
PO Box 580
Fort Collins, Colorado 80522-0580





VICINITY MAP
(FORT COLLINS AREA)
NOT TO SCALE

LEGEND

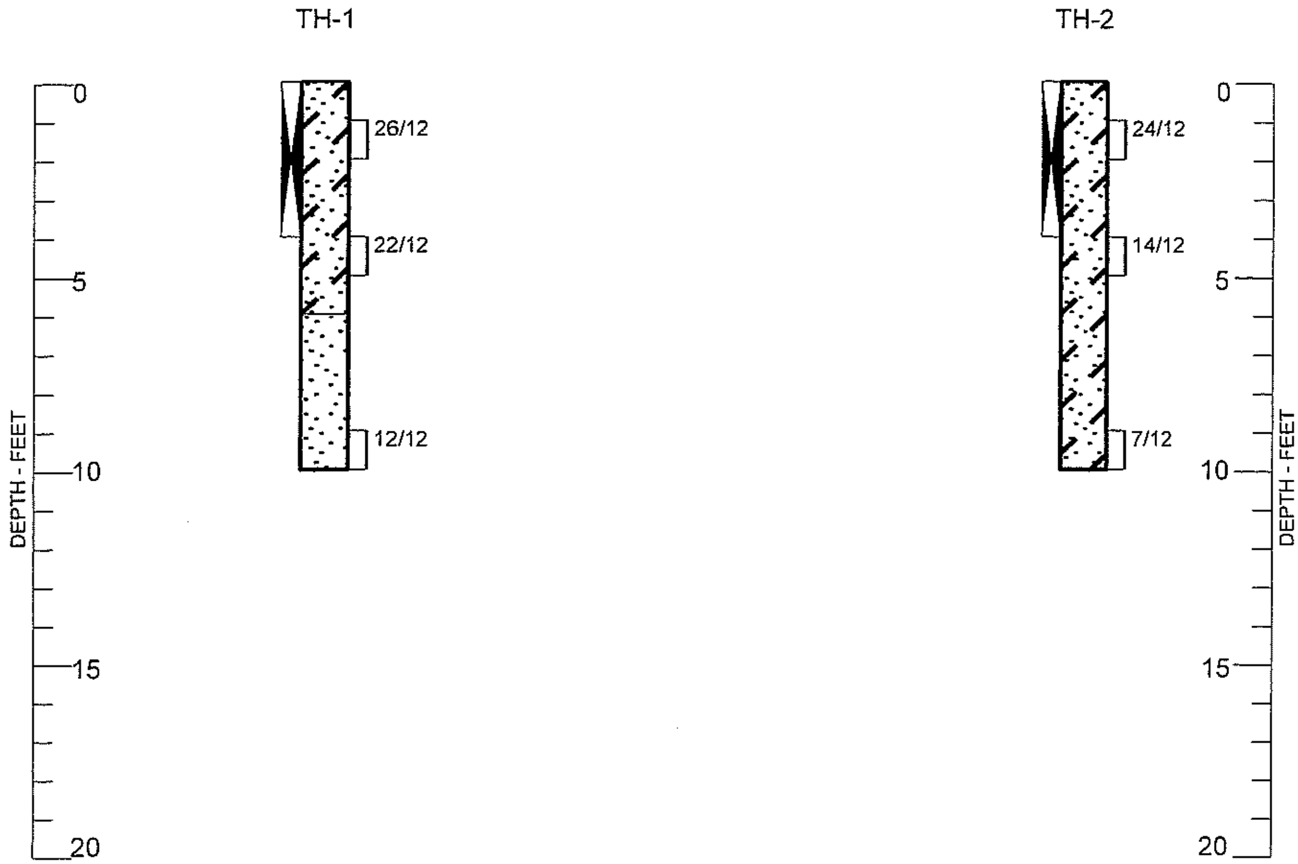
TH-1 ● INDICATES APPROXIMATE LOCATION OF EXPLORATORY BORING

INDICATES APPROXIMATE LOCATION OF PROPOSED IMPROVEMENTS

Locations of Exploratory Borings

BANK OF CHOICE
TURN LANE ON BOARDWALK DRIVE
CTL | T PROJECT NO. FC04254-135

FIGURE 1



LEGEND:

SAND, CLAYEY, MOIST, MEDIUM DENSE, REDDISH BROWN, BROWN (SC)

SAND, GRAVELLY, MOIST, MEDIUM DENSE, REDDISH BROWN (SP)

DRIVE SAMPLE. THE SYMBOL 26/12 INDICATES 26 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.

NOTES:

1. THE BORINGS WERE DRILLED ON MAY 6, 2008, USING 4-INCH DIAMETER CONTINUOUS-FLIGHT AUGERS AND A TRUCK-MOUNTED DRILL RIG.

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

SUMMARY LOGS OF EXPLORATORY BORINGS

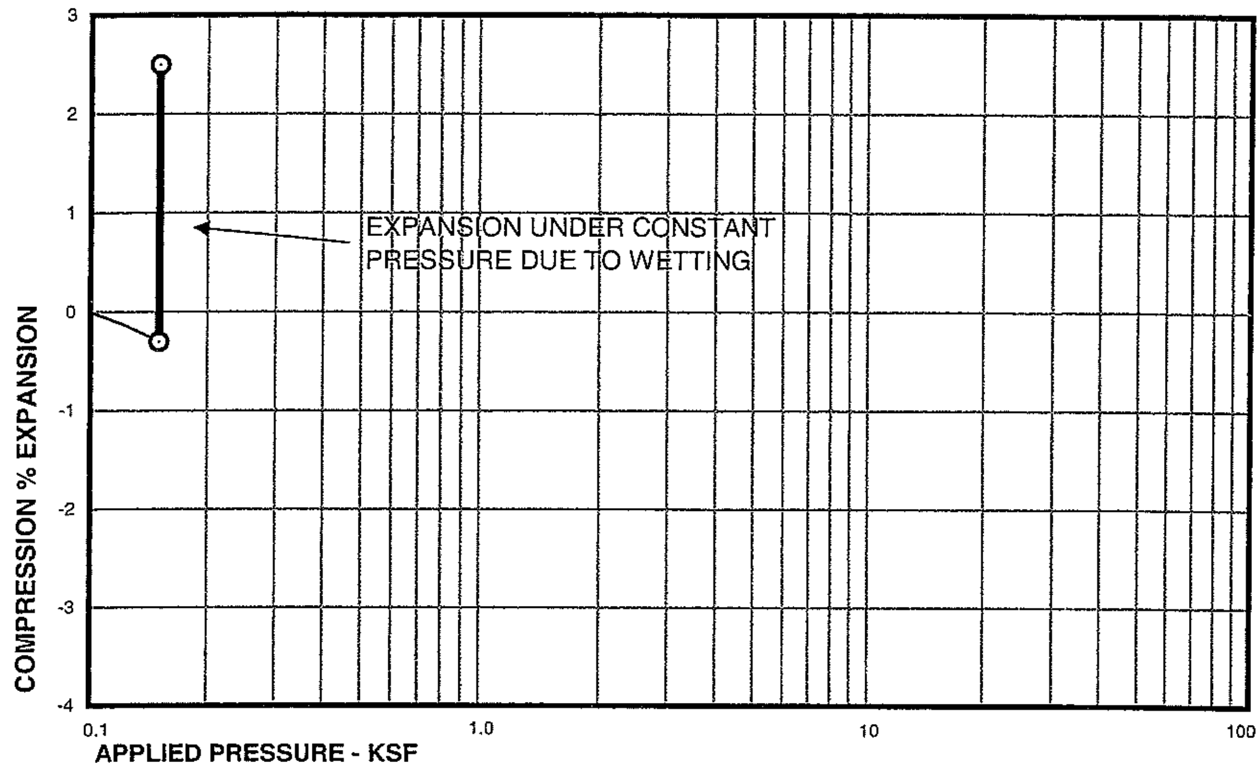
FIGURE 2

BANK OF CHOICE
TURN LANE ON BOARDWALK DRIVE
CTL | T PROJECT NO. FC04254-135

LOGS BY DEPTH WITH LEGEND-LETTER FC04254-135 LOGDATA.GPJ CTLMAIN.GDT 5/13/08

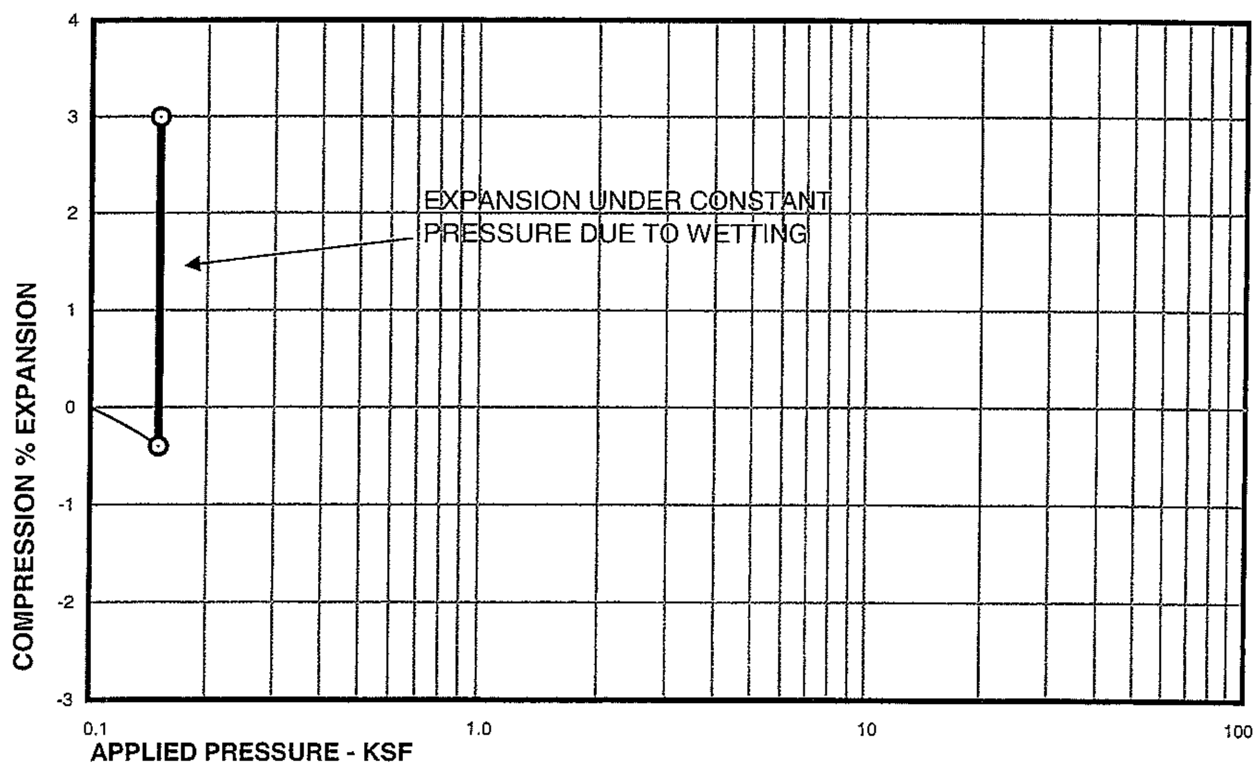
APPENDIX A

RESULTS OF LABORATORY TESTING



Sample of SAND, CLAYEY (SC)
From TH-1 AT 2 FEET

SAMPLE DRY UNIT WEIGHT= 115 PCF
SAMPLE MOISTURE CONTENT= 7.5 %

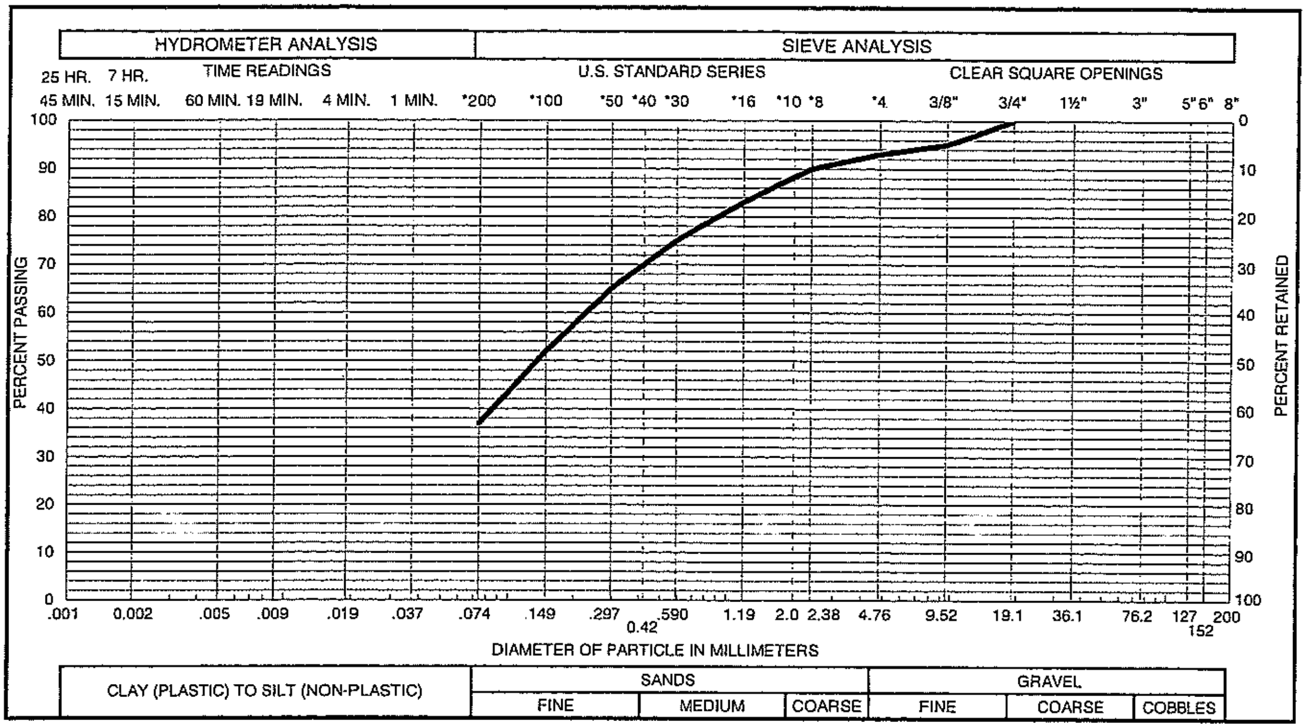


Sample of SAND, CLAYEY (SC)
From TH-2 AT 2 FEET

SAMPLE DRY UNIT WEIGHT= 115 PCF
SAMPLE MOISTURE CONTENT= 9.0 %

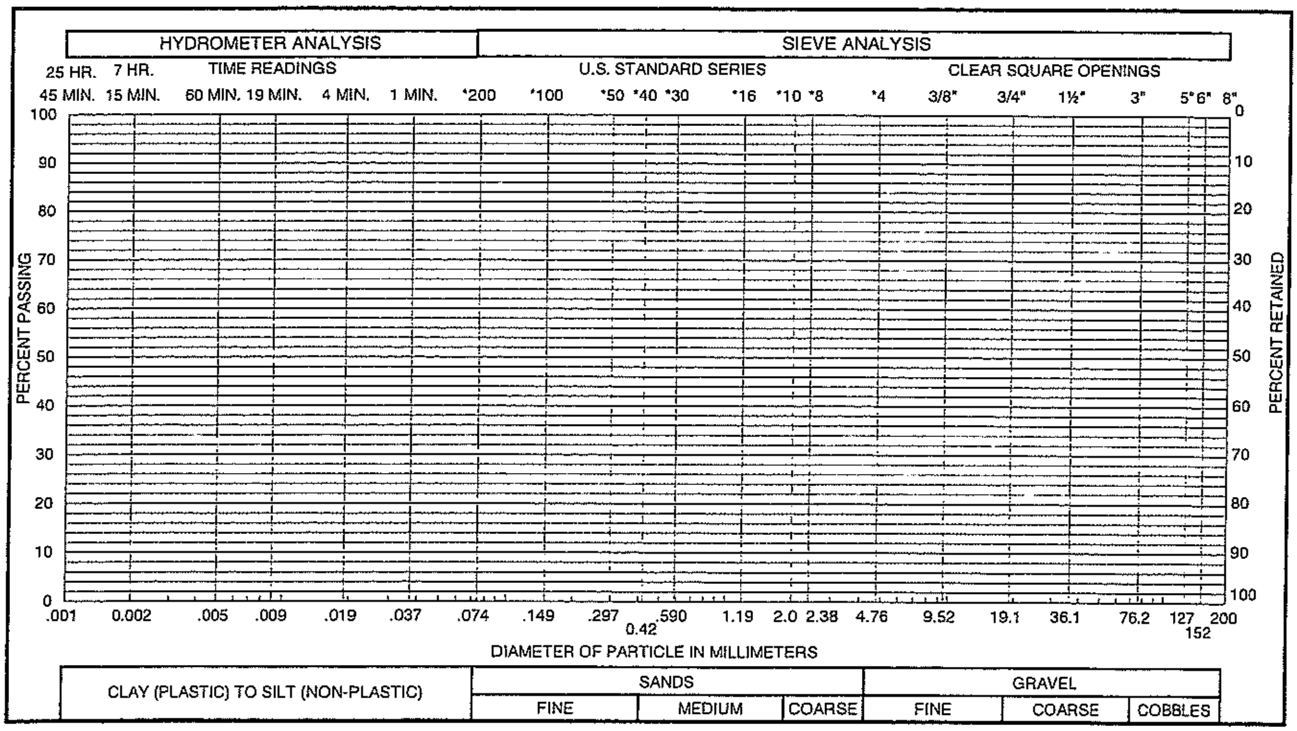
Swell Consolidation Test Results

FIGURE A-1



Sample of SAND, CLAYEY (SC)
From TH - 2 AT 0-4 FEET

GRAVEL 7 % SAND 56 %
SILT & CLAY 37 % LIQUID LIMIT 38 %
PLASTICITY INDEX 23 %



Sample of
From

GRAVEL % SAND %
SILT & CLAY % LIQUID LIMIT %
PLASTICITY INDEX %

BANK OF CHOICE
TURN LANE ON BOARDWALK DRIVE
PROJECT NO. FCO4254-135

Gradation Test Results

FIGURE A-2

TABLE A-I

SUMMARY OF LABORATORY TESTING

TEST HOLE	DEPTH (FEET)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	ATTERBERG LIMITS LIQUID LIMIT (%)	ATTERBERG LIMITS PLASTICITY INDEX (%)	SWELL* (%)	APPLIED PRESSURE (PSF)	PASSING NO. 200 SIEVE (%)	CLASSIFICATION AASHTO	CLASSIFICATION UNIFIED	DESCRIPTION
1	2	7.5	115			2.8	150			SC	SAND, CLAYEY
2	0-4	8.5		38	23			37	A-6(3)	SC	SAND, CLAYEY
2	2	9.0	115			3.0	150			SC	SAND, CLAYEY

APPENDIX B

DESIGN CALCULATIONS

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

IT Administrator

Flexible Structural Design Module

EAST TURN LANE AT BOARDWALK DRIVE BETWEEN HARMONY ROAD AND WHALERS WAY

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	1,277,500
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	90 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,228 psi
Stage Construction	1
Calculated Design Structural Number	4.66 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.44	1	6	24	2.64
2	ABC	0.11	1.05	18	24	2.08
Total	-	-	-	24.00	-	4.72

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

IT Administrator

Flexible Structural Design Module

EAST TURN LANE AT BOARDWALK DRIVE BETWEEN HARMONY ROAD AND WHALERS WAY

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	1,277,500
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	90 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,228 psi
Stage Construction	1
Calculated Design Structural Number	4.66 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.44	1	8	24	3.52
2	ABC	0.11	1.05	10	24	1.16
Total	-	-	-	18.00	-	4.68

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

IT Administrator

Flexible Structural Design Module

EAST TURN LANE AT BOARDWALK DRIVE BETWEEN HARMONY ROAD AND WHALERS WAY

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	1,277,500
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	90 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,228 psi
Stage Construction	1
Calculated Design Structural Number	4.66 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.44	1	9	24	3.96
2	ABC	0.11	1.05	6.5	24	0.75
Total	-	-	-	15.50	-	4.71

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

IT Administrator

Rigid Structural Design Module

EAST TURN LANE AT BOARDWALK DRIVE BETWEEN HARMONY ROAD AND WHALERS WAY

Rigid Structural Design

Pavement Type	JRCP
18-kip ESALs Over Initial Performance Period	1,277,500
Initial Serviceability	4.5
Terminal Serviceability	2.5
28-day Mean PCC Modulus of Rupture	600 psi
28-day Mean Elastic Modulus of Slab	3,300,000 psi
Mean Effective k-value	127 psi/in
Reliability Level	90 %
Overall Standard Deviation	0.34
Load Transfer Coefficient, J	2.8
Overall Drainage Coefficient, Cd	1
Calculated Design Thickness	6.84 in

APPENDIX C

SAMPLE SITE GRADING SPECIFICATIONS

SAMPLE SITE GRADING SPECIFICATIONS

1. DESCRIPTION

This item shall consist of the excavation, transportation, placement, and compaction of materials from locations indicated on the plans, or staked by the Engineer, as necessary to achieve building site elevations.

2. GENERAL

The Soils Engineer shall be the Owner's representative. The Soils Engineer shall approve fill materials, method of placement, moisture contents, and percent compaction, and shall give written approval of the completed fill.

3. CLEARING JOB SITE

The Contractor shall remove all trees, brush, and rubbish before excavation or fill placement is begun. The Contractor shall dispose of the cleared material to provide the Owner with a clean, neat appearing job site. Cleared material shall not be placed in areas to receive fill or where the material will support structures of any kind.

4. SCARIFYING AREA TO BE FILLED

All topsoil and vegetable matter shall be removed from the ground surface upon which fill is to be placed. The surface shall then be plowed or scarified to a depth of 8 inches until the surface is free from ruts, hummocks or other uneven features, which would prevent uniform compaction by the equipment to be used.

5. COMPACTING AREA TO BE FILLED

After the foundation for the fill has been cleared and scarified, it shall be disked or bladed until it is free from large clods, brought to the proper moisture content and compacted to not less than 95 percent of maximum density as determined in accordance with ASTM D 698.

6. FILL MATERIALS

On-site materials classifying as SC and SP are acceptable. Fill soils shall be free from organic matter, debris, or other deleterious substances, and shall not contain rocks or lumps having a diameter greater than three (3) inches. Fill materials shall be obtained from onsite and other approved sources.

7. MOISTURE CONTENT

Fill materials shall be moisture treated. Sand soils can be moistened to within 2 percent optimum moisture content. Sufficient laboratory compaction tests shall be made to determine the optimum moisture content for the various soils encountered in borrow areas.

The Contractor may be required to add moisture to the excavation materials in the borrow area if, in the opinion of the Soils Engineer, it is not possible to obtain uniform moisture content by adding water on the fill surface. The Contractor may be required to rake or disk the fill soils to provide uniform moisture content through the soils.

The application of water to embankment materials shall be made with any type of watering equipment approved by the Soils Engineer, which will give the desired results. Water jets from the spreader shall not be directed at the embankment with such force that fill materials are washed out.

Should too much water be added to any part of the fill, such that the material is too wet to permit the desired compaction from being obtained, rolling, and all work on that section of the fill shall be delayed unit the material has been allowed to uniformly dry to the required moisture content. The Contractor will be permitted to rework wet material in an approved manner to hasten its drying.

8. COMPACTION OF FILL AREAS

Selected fill material shall be placed and mixed in evenly spread layers. After each fill layer has been placed, it shall be uniformly compacted to not less than the specified percentage of maximum density. Fill materials shall be placed such that the thickness of loose material does not exceed 8 inches and the compacted lift thickness does not exceed 6 inches.

Compaction, as specified above, shall be obtained by the use of sheepsfoot rollers, multiple-wheel pneumatic-tired rollers, or other equipment approved by the Engineer. Compaction shall be accomplished while the fill material is at the specified moisture content. Compaction of each layer shall be continuous over the entire area. Compaction equipment shall make sufficient trips to insure that the required density is obtained.

9. COMPACTION OF SLOPES

Fill slopes shall be compacted by means of sheepsfoot rollers or other suitable equipment. Compaction operations shall be continued until slopes are stable, but not too dense for planting, and there is no appreciable amount of loose soil on the slopes. Compaction of slopes may be done progressively in increments of three to five feet (3' to 5') in height or after the fill is brought to its total height. Permanent fill slopes shall not exceed 3:1 (horizontal to vertical).

10. DENSITY TESTS

Field density tests shall be made by the Soils Engineer at locations and depths of his choosing. Where sheepsfoot rollers are used, the soil may be disturbed to a depth of several inches. Density tests shall be taken in compacted material below the disturbed surface. When density tests indicate that the density or moisture content of any layer of fill or portion thereof is below that required, the particular layer or portion shall be reworked until the required density or moisture content has been achieved.

11. COMPLETED PRELIMINARY GRADES

All areas, both cut and fill, shall be finished to a level surface and shall meet the following limits of construction:

A. Overlot cut or fill areas shall be within plus or minus 2/10 of one foot.

B. Street grading shall be within plus or minus 1/10 of one foot.

The civil engineer, or duly authorized representative, shall check all cut and fill areas to observe that the work is in accordance with the above limits.

12. SUPERVISION AND CONSTRUCTION STAKING

Observation by the Soils Engineer shall be continuous during the placement of fill and compaction operations so that he can declare that the fill was placed in general conformance with specifications. All site visits necessary to test the placement of fill and observe compaction operations will be at the expense of the Owner. All construction staking will be provided by the Civil Engineer or his duly authorized representative. Initial and final grading staking shall be at the expense of the owner. The replacement of grade stakes through construction shall be at the expense of the contractor.

13. SEASONAL LIMITS

No fill material shall be placed, spread or rolled while it is frozen, thawing, or during unfavorable weather conditions. When work is interrupted by heavy precipitation, fill operations shall not be resumed until the Soils Engineer indicates that the moisture content and density of previously placed materials are as specified.

14. NOTICE REGARDING START OF GRADING

The contractor shall submit notification to the Soils Engineer and Owner advising them of the start of grading operations at least three (3) days in advance of the starting date. Notification shall also be submitted at least 3 days in advance of any resumption dates when grading operations have been stopped for any reason other than adverse weather conditions.

15. REPORTING OF FIELD DENSITY TESTS

Density tests made by the Soils Engineer, as specified under "Density Tests" above, shall be submitted progressively to the Owner. Dry density, moisture content, of each test taken, and percentage compaction shall be reported for each test taken.

16. DECLARATION REGARDING COMPLETED FILL

The Soils Engineer shall provide a written declaration stating that the site was filled with acceptable materials, or was placed in general accordance with the specifications.

APPENDIX D

PAVEMENT CONSTRUCTION RECOMMENDATIONS

FLEXIBLE PAVEMENT CONSTRUCTION RECOMMENDATIONS

Experience has shown that construction methods can have a significant effect on the life and serviceability of a pavement system. We recommend that the proposed pavement be constructed in the following manner:

1. The subgrade should be stripped of organic matter, scarified, moisture treated and compacted. The compacted subgrade should extend at least 3 feet beyond the edge of the pavement where no edge support, such as curb and gutter, are to be constructed. Soils should be moisture treated to optimum to 2 percent above optimum moisture content and compacted to at least 95 percent of maximum standard Proctor dry density (ASTM D 698, AASHTO T 99). Additional discussions for site-specific subgrade preparation are presented in the body of this report.

2. Utility trenches and all subsequently placed fill should be properly compacted and tested prior to paving. As a minimum, fill should be compacted to 95 percent of maximum standard Proctor dry density.

3. After final subgrade elevation has been reached and the subgrade compacted, the area should be proof-rolled with a heavy pneumatic-tired vehicle (i.e. a loaded ten-wheel dump truck). Subgrade that is pumping or deforming excessively should be scarified, moisture conditioned and compacted.

4. If areas of soft or wet subgrade are encountered, the material should be sub excavated and replaced with properly compacted structural backfill. Where extensively soft, yielding subgrade is encountered; we recommend a representative of our office observe the excavation.

5. Aggregate base course should be laid in thin, loose lifts, moisture treated to near optimum moisture content and compacted to at least 95 percent of maximum modified Proctor dry density (ASTM D 1557, AASHTO T 180). Aggregate base course should be used for the shoulders of the roadways should be compacted to these specifications.

6. Hot mix asphalt (HMA) should be hot plant-mixed material compacted to at least 92 to 96 percent of maximum theoretical density (ASTM D2041). The temperature at laydown time should be near 235 degrees F. The maximum compacted lift should be 3.0 inches, or as determined for the HMA grading by the regulatory agency. Joints should be staggered.

7. The subgrade preparation and the placement and compaction of all pavement material should be observed and tested. Compaction criteria should be met prior to the placement of the next paving lift. The additional requirements of the local regulatory agency and the Colorado Department of Transportation Specifications should apply.

RIGID PAVEMENT CONSTRUCTION RECOMMENDATIONS

Rigid pavement sections are not as sensitive to subgrade support characteristics as flexible pavement. Due to the strength of the concrete, wheel loads from traffic are distributed over a large area and the resulting subgrade stresses are relatively low. The critical factors affecting the performance of a rigid pavement are the strength and quality of the concrete, and the uniformity of the subgrade. We recommend subgrade preparation and construction of the rigid pavement section be completed in accordance with the following recommendations:

1. Natural soils should be stripped of organic matter, scarified, moisture treated, and compacted. We recommend the top one-foot of the subgrade be moisture treated to between optimum and 2 percent above optimum moisture content. Soils should be compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D 698, AASHTO T 99). Moisture treatment and compaction recommendations also apply where additional fill is necessary. Additional discussions for site-specific subgrade preparation are presented in the body of this report.

2. The resulting subgrade should be checked for uniformity and all soft or yielding materials should be replaced prior to paving. Concrete should not be placed on soft, spongy, frozen, or otherwise unsuitable subgrade.

3. The subgrade should be kept moist prior to paving.

4. Curing procedures should protect the concrete against moisture loss, rapid temperature change, freezing, and mechanical injury for at least 3 days after placement. Traffic should not be allowed on the pavement for at least one week.

5. A white, liquid membrane-curing compound, applied at the rate of 1 gallon per 150 square feet, should be used.

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

7. Construction control and observation should be carried out during the subgrade preparation and paving procedures. Concrete should be carefully monitored for quality control. The additional requirements of the local regulatory agency and Colorado Department of Transportation Specifications should apply.

8. Aggregate base course, compacted to the specifications presented under *Flexible Pavement Construction Recommendations* of this report, should be placed along the shoulders of the pavement where no edge support, such as curb and gutter, are constructed.

9. The design section is based upon a 20-year design life for the specified serviceability. Experience in the area indicates virtually no maintenance or overlays are necessary for the design period. To avoid problems associated with scaling and to continue the strength gain, we recommend deicing salts not be used for the first year after placement.

APPENDIX E

MAINTENANCE PROGRAM

MAINTENANCE RECOMMENDATIONS FOR FLEXIBLE PAVEMENTS

A primary cause for deterioration of 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.

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 on effective times to apply preventive maintenance treatments.
    c. Crack sealing should 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 should be expected.

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 includes 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.