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APPROVED

By: RedR Date: 10-20-15

City of Fort Collins
City of Fort Collins
Engineering Department

SUBGRADE INVESTIGATION AND PAVEMENT RECOMMENDATIONS SPRING CREEK FARMS SUBDIVISION FORT COLLINS, COLORADO

Prepared For:

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1043 Eagle Drive
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Project No. FC06432-135

October 20, 2015

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SCOPE

This report presents the results of our subgrade investigation and pavement recommendations for the planned roadway improvements at Spring Creek Farms Subdivision in Fort Collins, Colorado. The purpose of our subgrade investigation was to determine the subsurface conditions and to evaluate pavement support characteristics. The report was conducted 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with the Chapters 5 and 10 of the *Larimer County Urban Areas Street Standards (LCUASS)* dated January 2, 2001 (repealed and reenacted April 1, 2007) as adopted by the City of Fort Collins (City).

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 subsurface conditions found in exploratory borings and laboratory test results. If plans change significantly, we should be contacted to review our investigation and determine if our recommendations still apply. 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 generally consisted of sandy clay with layers of clayey sand. The upper 2 to 4 feet of material in six of the seven borings was considered fill. Groundwater was not encountered in any of the borings during our investigation.

2. The subgrade soils primarily classify as A-6 materials according to AASHTO criteria, with expected subgrade support of fair to poor.

3. Asphaltic concrete and Portland cement concrete are appropriate surface pavements. Recommended pavement thicknesses are presented in this report.

SITE LOCATION AND PROJECT DESCRIPTION

Spring Creek Farms Subdivision is located north of Drake Road, west of Timberline Road in Fort Collins, Colorado (Figure 1). Roadways planned for construction include Adobe Drive, Charles Brockman Drive, Nancy Gray Avenue, and Spring Farm Drive. The site is relatively flat. Adjoining streets are paved with asphaltic concrete.

FIELD AND LABORATORY INVESTIGATION

Our field investigation consisted of drilling seven borings to a depth of approximately 10 feet, logging the subsurface conditions, recording penetration-resistance tests, and acquiring samples of the subgrade materials. The approximate boring locations are shown on Figure 1. The borings were drilled with 4-inch diameter solid-stem augers and a truck-mounted drill. Our field representative directed the field investigation and collected samples. Bulk samples were obtained from the upper 4 feet of each boring. Drive samples were taken at selected intervals in each boring by driving a modified California sampler with blows from a 140-pound hammer falling 30 inches. Borings were backfilled following drilling. Summary logs of the borings, including results of field penetration resistance tests, are presented on Figure 2.

Samples were returned to our laboratory and examined by the geotechnical engineer for the project. Laboratory testing was performed in general accordance with AASHTO and ASTM methods to determine index properties, classification, and subgrade support values for those soil types influencing the pavement design. Laboratory tests and analysis included moisture content, gradation analyses, Atterberg limits, swell-consolidation, and water-soluble sulfate tests. Swell tests were wetted at a confining pressure of 150 psf as specified in *LCUASS*. A Hveem stabilometer test was conducted on a combined sample of

the upper 4 feet of our borings. Results of our laboratory tests are presented in Appendix A and summarized in Table A-I.

SUBSURFACE CONDITIONS

Soils encountered in our borings generally consisted of sandy clay with layers of clayey sand. The upper 2 to 4 feet of material in six of the seven borings was considered fill. Groundwater was not encountered in any of the borings during our investigation.

A Hveem stabilometer test was conducted on a composite sample of material obtained from all three borings. The test indicated an R-value of 17, which we converted to a resilient modulus of 4,467 psi according to AASHTO criteria.

The sandy clay encountered in our borings classified as soft to very stiff based on field penetration test results. Laboratory testing indicated fines contents (percent passing No. 200 sieve) of 76 to 89 percent. Based on gradation and Atterberg limits testing, the pavement subgrade generally classified as A-6 materials. Two samples of the native soil were tested for swell; results indicated low expansive potential (1.0 and 1.1 percent). Further description of the subsurface conditions is presented on our boring logs (Figure 2) and in our laboratory test results (Appendix A).

PAVEMENT DESIGN

We understand improvements to roadways in Spring Creek Farms are regulated by the City of Fort Collins, which requires the use of the AASHTO and CDOT pavement design methods for their roadways. These design methods require input parameters for traffic projections for a specified design life, roadway

classification, characteristics of the subgrade materials, type and strength characteristics of pavement materials, groundwater conditions, drainage conditions, minimum pavement sections, and statistical data.

Traffic Projections

Traffic projections are expressed as an 18-kip Equivalent Daily Load Application (EDLA) for a single day and as an 18-kip Equivalent Single Axle Load (ESAL) for the design period, which is typically 20 years. For pavement design at this subdivision, the City of Fort Collins has requested an EDLA of 10, corresponding to an ESAL of 73,000 over a 20 year design life.

Pavement Thickness Recommendations

We used DARWin™ software to develop our pavement thickness calculations for flexible pavements with input values provided by the City, *LCUASS*, and our laboratory tests and observations. For our design, we assumed the pavement will be constructed during a single stage. Computer generated printouts of the DARWin™ calculations are presented in Appendix B.

For our design, we assume the pavement will be constructed during a single stage. If multiple-stage construction is desired, we should be consulted to revise our recommendations.

We have provided pavement design alternatives for hot mix asphalt (HMA) on aggregate base course (ABC), and portland cement concrete (PCC) pavement. Our pavement thickness alternatives are presented on Table B. Additional discussion regarding advantages and disadvantages of the pavement alternatives and their expected performance is included under the PAVEMENT SELECTION section of this report.

TABLE B
MINIMUM PAVEMENT THICKNESS RECOMMENDATIONS

Roadways	Hot Mix Asphalt (HMA) + Aggregate Base Course (ABC) + Moisture Treated Subgrade (MTS)	Portland Cement Concrete (PCC))+ Moisture Treated Subgrade (MTS)
Adobe Drive, Charles Brockman Drive, Nancy Gray Avenue, Spring Farm Drive ESAL = 73,000	4½" HMA + 6" ABC+ 12" MTS	7" PCC+ 12" MTS

PAVEMENT SELECTION

Both HMA/ABC composite (flexible) and PCC (rigid) pavements are expected to perform well for the roadways; however, PCC pavement has better performance in freeze-thaw conditions and should require less long-term maintenance than HMA pavement. PCC pavement is also recommended for sections that may experience frequent stopping and turning or heavy point loads.

SUBGRADE AND PAVEMENT MATERIALS AND CONSTRUCTION

The construction materials are assumed to possess sufficient quality as reflected by the strength factors used in our design calculations. Materials and construction requirements outlined in *LCUASS* should be followed.

Swell testing indicated relatively low expansive potential for the subgrade at this subdivision. Conventional moisture treatment and compaction of the subgrade is appropriate for these conditions. To prepare the subgrade for paving

with conventional moisture treatment and compaction, subgrade soils should be scarified a minimum of 12 inches deep, moisture conditioned to within 2 percent of optimum moisture content and compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D 698, AASHTO T99).

Scarification and recompaction 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 excessive drying or wetting until such time as the pavement section is constructed. Maintaining moisture contents near optimum will be critical to avoid excessive deflections, rutting and pumping of the subgrade during subgrade preparation of streets.

Further recommendations for conventional moisture treatment and compaction are presented in Appendix D. Preparation of the subgrade should extend from back-of walk to back-of-walk where feasible.

WATER-SOLUBLE SULFATES

Concrete that is exposed to sulfate-rich soils can be subject to sulfate attack. If concrete pavements or structures will not be in contact with sulfate-rich soils, by means of an aggregate base course layer or other materials, the risk of sulfate attack should be low. We measured water-soluble sulfate concentrations in two samples from this site; concentrations were measured at 0.03 percent. Water-soluble sulfate concentrations less than 0.1 percent indicate Class 0 exposure to sulfate attack for concrete that is exposed to the soils, according to the American Concrete Institute (ACI). For this level of sulfate concentration, ACI indicates any type of cement can be used for concrete that is exposed to the soils. In our experience, superficial damage may occur to the exposed surfaces of highly permeable concrete, even though sulfate levels are relatively low. To control this risk and to resist freeze-thaw deterioration, the water-to-cementitious

material ratio should not exceed 0.50 for concrete in contact with soils that are likely to stay moist due to surface drainage or high water tables. Concrete should be air entrained.

LIMITATIONS

Our borings were spaced to obtain a reasonably accurate indication of subgrade and/or pavement conditions for the proposed construction. The borings are representative of conditions encountered only at the exact boring locations. Variations in the subsurface 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 geologists and 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:

Brendan P. Moran, EI
Staff Geotechnical Engineer

Spencer Schram, PE
Geotechnical Department Manager

BPM:SAS

(2 Copies)

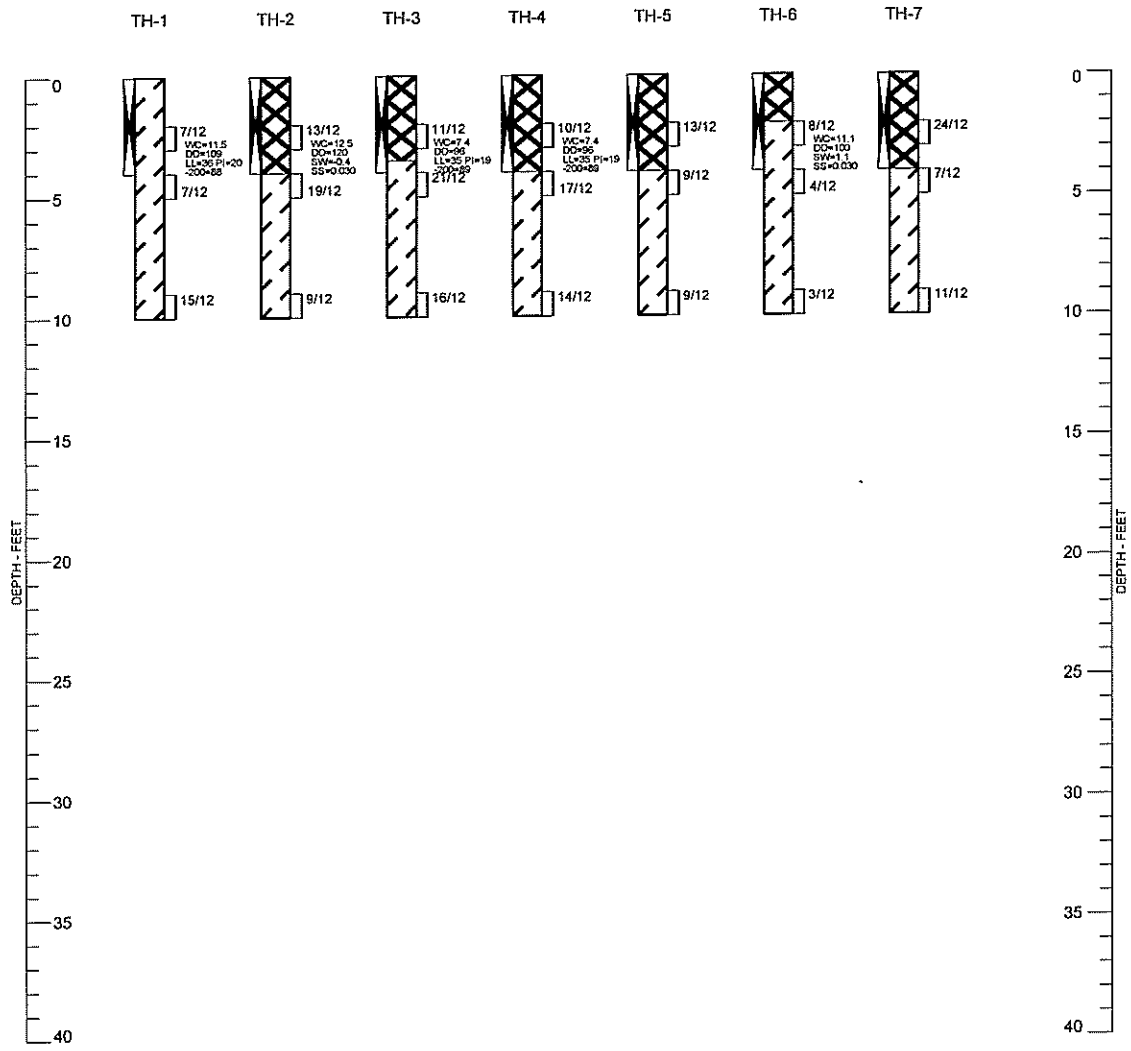
LEGEND:

TH-1 ● INDICATES APPROXIMATE LOCATION OF EXPLORATORY BORING

Locations of Exploratory Borings

FIGURE 1

MIDTOWN HOMES
SPRING CREEK FARMS ROADWAYS
CTL I T PROJECT NO. FC06432-135



LEGEND:

FILL; CLAY, SANDY, MOIST, STIFF TO VERY STIFF, BROWN, DARK BROWN

CLAY, SANDY WITH LAYERS OF SAND, CLAYEY, MOIST, SOFT TO VERY STIFF, BROWN (CL, SC)

DRIVE SAMPLE. THE SYMBOL 7/12 INDICATES 7 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 OCTOBER 1, 2015, 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.

3. WC - INDICATES MOISTURE CONTENT (%).
   DD - INDICATES DRY DENSITY (PCF).
   -200 - INDICATES PASSING NO. 200 SIEVE (%).
   LL - INDICATES LIQUID LIMIT.
   PI - INDICATES PLASTICITY INDEX.
   UC - INDICATES UNCONFINED COMPRESSIVE STRENGTH (psf)
   SS - INDICATES SOLUBLE SULFATE CONTENT (%).
   SW - INDICATES SWELL WHEN WETTED UNDER APPROXIMATE OVERBURDEN PRESSURE (%).

MIDTOWN HOMES
SPRING CREEK FARMS ROADWAYS
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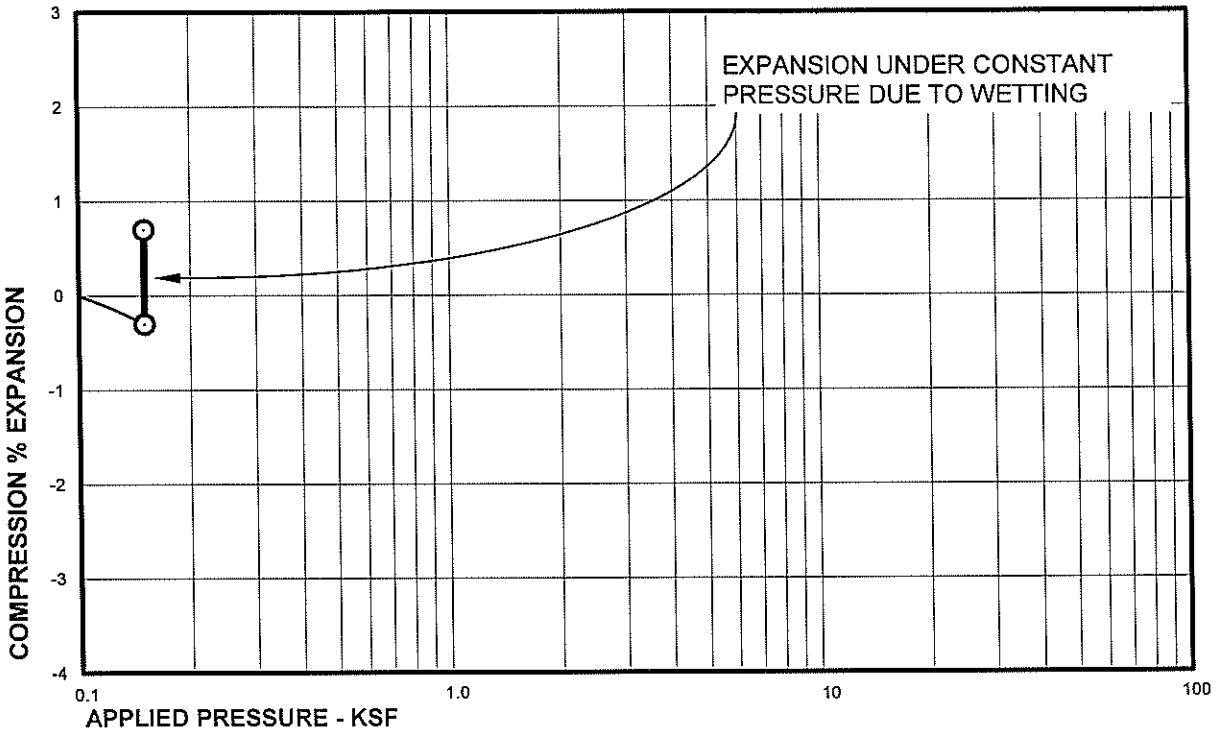
Summary Logs of Exploratory Borings

FIGURE 2

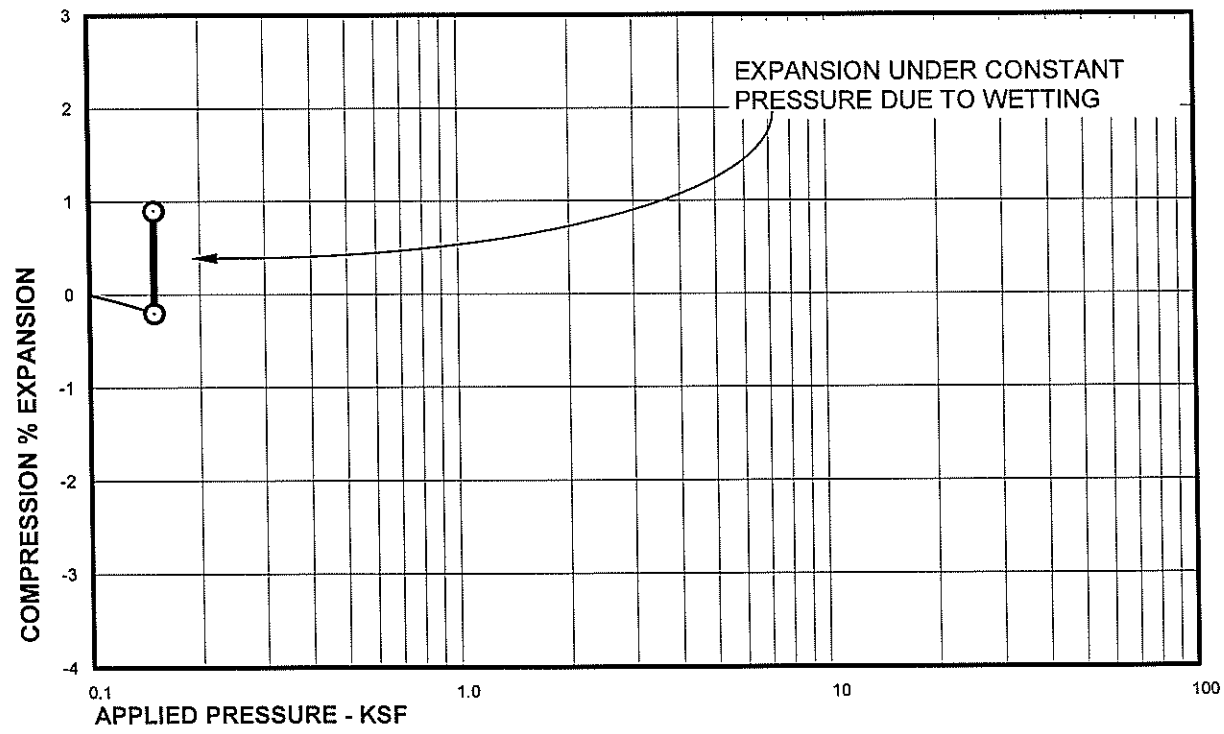
APPENDIX A

RESULTS OF LABORATORY TESTING



Sample of FILL, CLAY, SANDY (CL)
From TH - 2 AT 2 FEET

DRY UNIT WEIGHT= 120 PCF
MOISTURE CONTENT= 12.5 %



Sample of CLAY, SANDY (CL)
From TH - 6 AT 2 FEET

DRY UNIT WEIGHT= 100 PCF
MOISTURE CONTENT= 11.1 %

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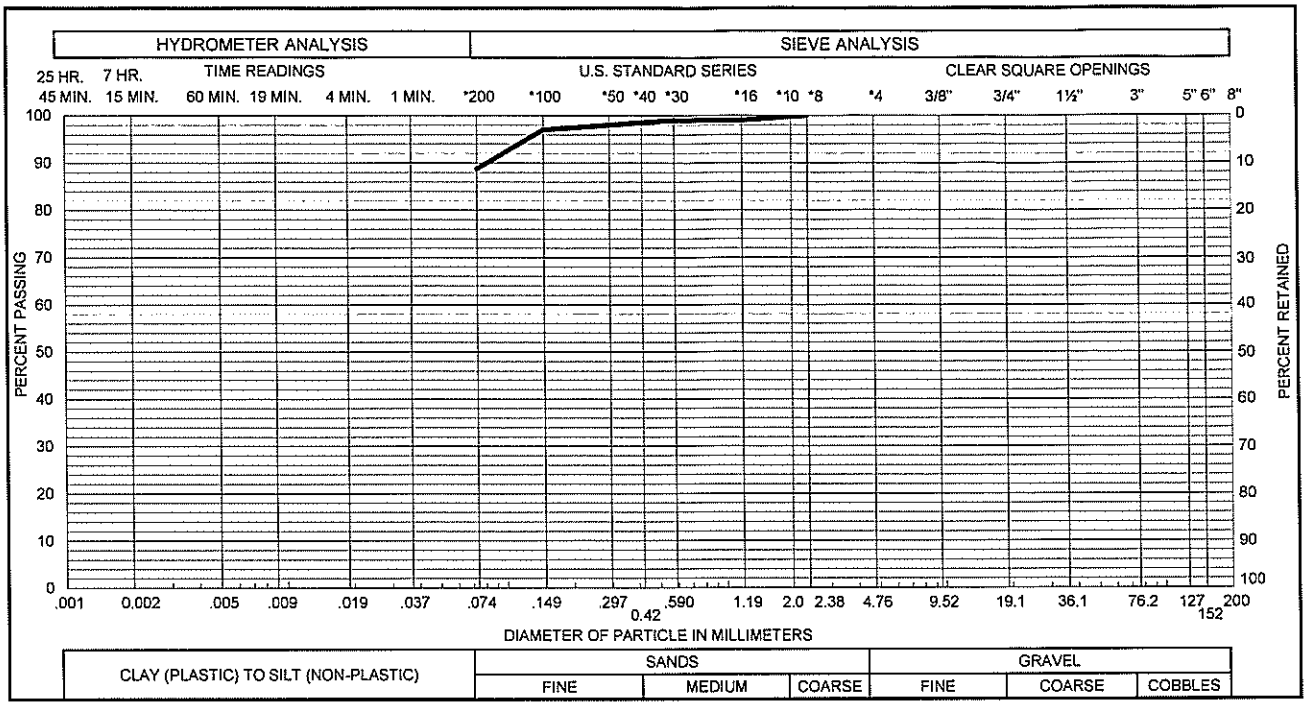
Swell Consolidation

FIGURE A-1



Sample of FILL, CLAY, SANDY (CL)
From TH - 4 AT 2 FEET

GRAVEL	0 %	SAND	11 %
SILT & CLAY	89 %	LIQUID LIMIT	35 %
PLASTICITY INDEX			19 %

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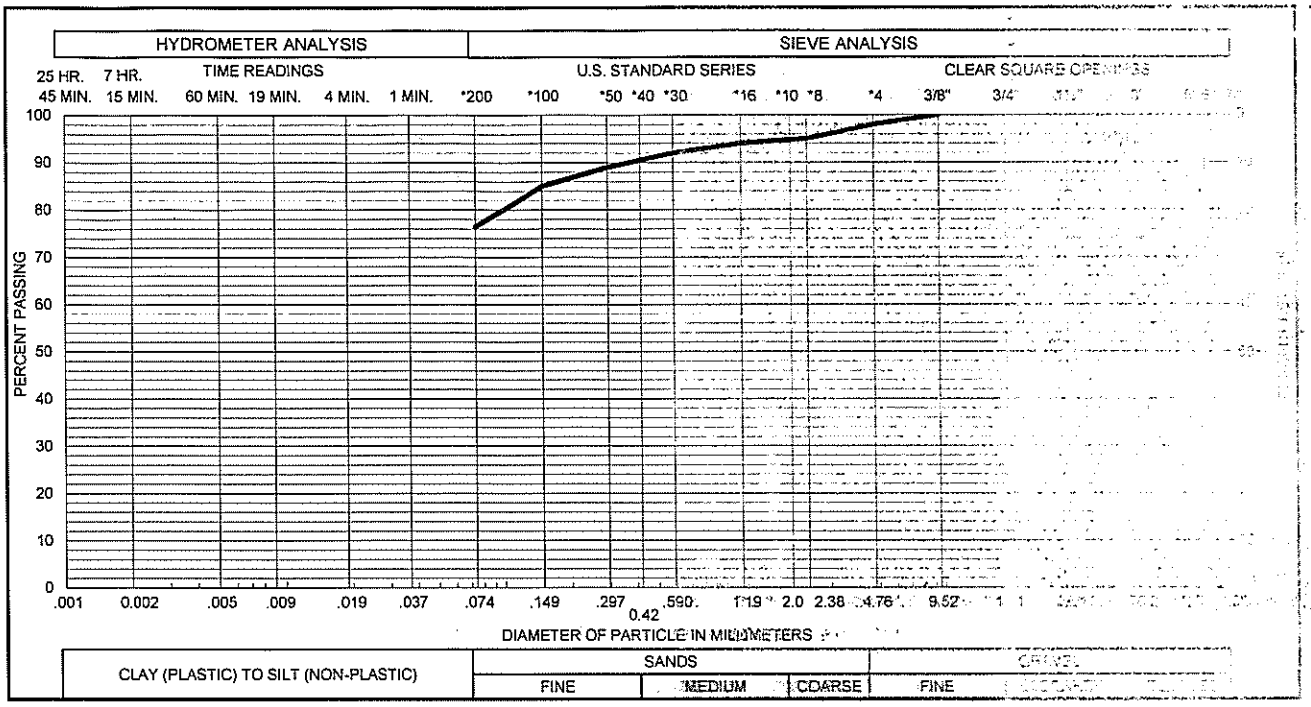
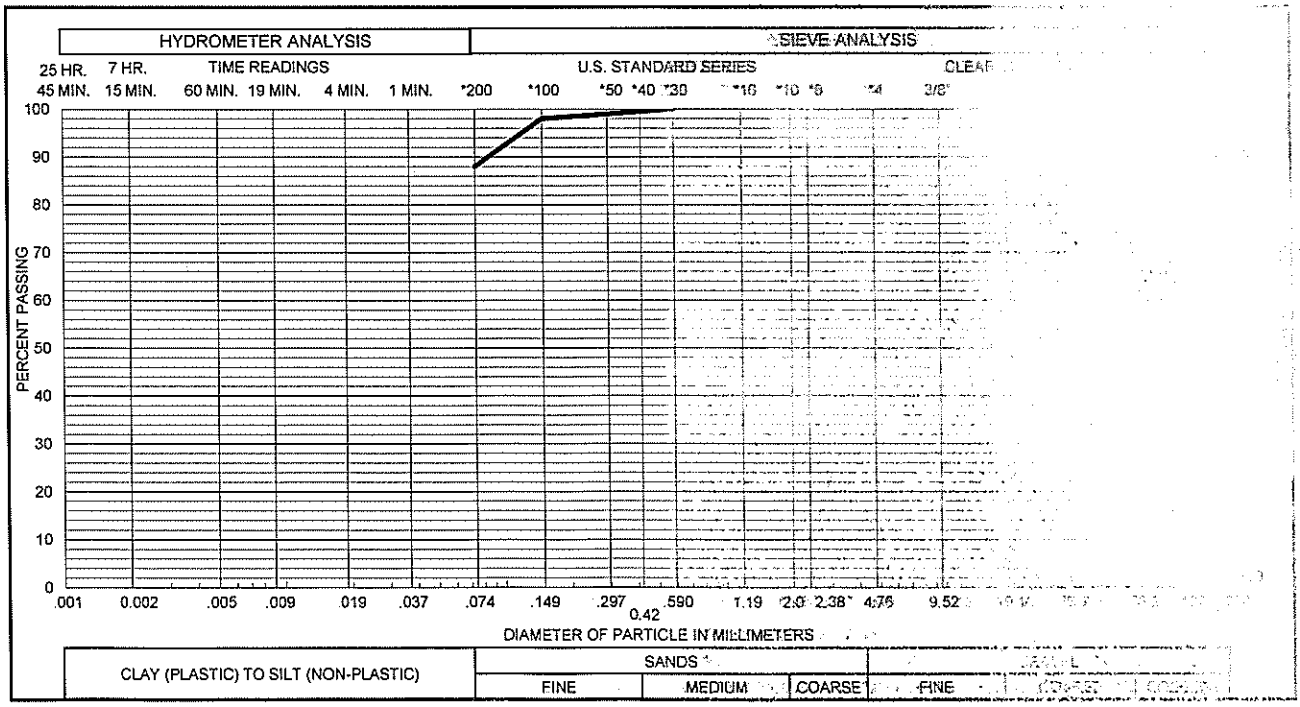
Gradation Test Results

FIGURE A-3



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

GRAVEL 2
SILT & CLAY 76
PLASTICITY INDEX



Sample of CLAY, SANDY (CL)
From TH - 1 AT 2 FEET

GRAVEL 0 %
SILT & CLAY 88 %
PLASTICITY INDEX

SAND 12 %
LIQUID LIMIT 36 %
20 %

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Gradation Test Results

FIGURE A-2