APPROVED

By: RCR Date: 6-30-02

City of Fort Collins
Engineering Department

Terracon

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REPORT OF FINAL PAVEMENT DESIGN

PAVEMENT EVALUATION FOR SOUTH SHIELDS STREET
COTTONWOOD RIDGE SUBDIVISION
FORT COLLINS, COLORADO

TERRACON PROJECT NO. 20025046

JUNE 3, 2002

INTRODUCTION

This report contains the results of a geotechnical engineering exploration and pavement evaluation for the acceleration and deceleration lanes in conjunction with the proposed Cottonwood Ridge Subdivision, located south of Westbury Drive, and west of South Shields Street, in southwest Fort Collins, Colorado. The site is located along the eastern boundary of the Northeast 1/4 of Section 3 Township 6 North, Range 68 West of the 6th Principal Meridian.

This report provides the geotechnical engineering subsurface field exploration and laboratory data results along with the required minimum pavement thicknesses for the project.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- groundwater conditions
- field and laboratory test results for pavement design, and
- provide alternative pavement thickness sections for the proposed site improvements.

The conclusions and recommendations contained in this report are based upon the results of field and laboratory testing, engineering analyses, our experience with similar soil conditions and our understanding of the proposed project.

PROPOSED CONSTRUCTION

In conjunction with the proposed Cottonwood Ridge residential development, South Shields Street is required to be widened to accommodate acceleration and deceleration lanes. It is our understanding this section of roadway will be classified as an arterial roadway with a reported 18 kip equivalent daily load application (EDLA) value of 325.

SITE EXPLORATION

The scope of the services performed for this addendum to our initial scope included a site reconnaissance by a geotechnical engineer, a subsurface exploration program, laboratory testing and engineering analysis.

Field Exploration

A total of 2 additional test borings were hand augered on May 21, 2002 to approximate depths of 3-feet below existing site grades at the locations shown on the Site Plan, Figure 1. The hand augered test borings were located within the proposed widening portions of South Shields Street to accommodate the acceleration and deceleration lanes. The borings were completed in general accordance with the City of Fort Collins pavement design criteria.

Continuous lithologic logs of each hand augered test boring were recorded by the geotechnical engineer during the drilling operations. At selected intervals, samples of the subsurface materials were taken by pushing thin-walled Shelby tubes. A representative bulk sample of subsurface materials was obtained from both Pavement Boring Nos. 9 and 10. Groundwater measurements were made in each boring at the time of site exploration.

Laboratory Testing

All samples retrieved during the field exploration were returned to the laboratory for observation by the project geotechnical engineer, and were classified in accordance with the Unified Soil Classification System described in Appendix C. At that time, the field descriptions were confirmed or modified as necessary and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials. Boring logs were prepared and are presented in Appendix A.

Selected soil samples were tested for the following engineering properties:

- Water content
- Dry density
- Swell-Consolidation
- Plasticity Index
- R-Value

Laboratory test results are presented in Appendix B, and were used for the geotechnical engineering analyses, and the development of pavement and earthwork recommendations. The significance and purpose of each laboratory test is described in Appendix C. All laboratory tests were performed in general accordance with the applicable ASTM, local or other accepted standards.

SUBSURFACE CONDITIONS

Soil Conditions

The subsoils at the site consisted of sandy lean clay fill material extending to native sandy lean clay extending to the depths explored, approximately 3-feet.

Field and Laboratory Test Results

Field and laboratory test results indicate the clay soils are medium stiff to stiff in consistency, exhibit low to moderate subgrade strength characteristics and low swell potential. A composite sample of the subsoils obtained at approximate depths of 0 to 3-feet below existing site grades from Test Boring Nos. 9 and 10 exhibited an R-Value of 16. The swell index values for the soil sample tested at an approximate 150 psf inundation pressure was 0.24%, which is well below the 2 percent criteria set by the City of Fort Collins for stabilization of the subgrade for expansive potential.

Groundwater Conditions

At the time of field exploration, no free groundwater was encountered in the hand augered test borings extended to a depth of 3-feet. These observations represent only current groundwater conditions, and may not be indicative of other times, or at other locations. Groundwater levels can be expected to fluctuate with varying seasonal and weather conditions.

ENGINEERING ANALYSES AND RECOMMENDATIONS

Geotechnical Considerations

Based on the subsurface conditions encountered at the site, it is our opinion the proposed pavement construction is feasible at the site from a geotechnical engineering point of view. The purpose of this report is to provide subsurface data for pavement design as well as the pavement thickness sections for the proposed acceleration and deceleration lanes. The subsoils at the test boring locations are non-to-slightly plastic. The subgrade soils may require stabilization at the time the pavement is constructed depending on weather conditions prior to and during road construction.

Asphalt concrete underlain by crushed aggregate base course, a composite full-depth asphalt pavement underlain by a minimum of 6-inches of base course and non-reinforced concrete pavement are feasible alternatives for the proposed pavement sections. Based on the subsurface conditions encountered at the site we recommend the proposed acceleration and deceleration lanes be designed using an R-value of 16. The City of Fort Collins provided the equivalent daily axle loads (EDLAs) at 325 for the project. The roadway should be constructed for a design life of 20 years.

Pavement Design and Construction

Design of pavements for the project have been based on the procedures outlined in the 1993 Guideline for Design of Pavement Structures by the American Association of State Highway and Transportation Officials (AASHTO), City of Fort Collins criteria, and the following data. For flexible pavement design, a design life of 20 years was utilized. The City of Fort Collins provided the equivalent daily axle loads (EDLAs) for the project. Using a correlated design R-value of 16, appropriate ESAL/day, environmental criteria and other factors, the structural numbers (SN) of the pavement sections were determined on the basis of the 1993 AASHTO design equation.

Street Name/Street Type	18 kip EDLA	ESALs	Reliability	Terminal Serviceability	Structural No.
South Shields Street – Acceleration and Deceleration Lanes	325	2,372,500	90	2.5	3.48

Local drainage characteristics of proposed pavement areas are considered to vary from fair to good depending upon location on the site. For purposes of this design analysis, fair drainage characteristics are considered to control the design. These characteristics, coupled with the approximate duration of saturated subgrade conditions, results in a design drainage coefficient of 1.0 when applying the AASHTO criteria for design.

In addition to the flexible pavement design analyses, a rigid pavement design analysis was completed, based upon AASHTO design procedures. Rigid pavement design is based on an evaluation of the Modulus of Subgrade Reaction of the soils (K-value); the Modulus of Rupture of the concrete, and other factors previously outlined. The design K-value of 100 pounds per cubic inch (pci) for the subgrade soil was determined by correlation to the laboratory tests results. A modulus of rupture of 650 psi (working stress 488 psi) was used for pavement concrete. The rigid pavement thicknesses for each traffic category were determined on the basis of the AASHTO design equation. Recommended alternatives for flexible and rigid pavements, summarized for each street, are as follows:

Traffic Area	Alternatives	*Recommended Minimum Pavement Thickness – inches*						
		(1) Asphalt Concrete Surface Grading S or SX	(1) Asphalt Concrete Surface Grading S or SG	Aggregate Base Course – Class 5 or 6	(2) Fly Ash Treated Sub Base	Portland Cement Concrete	Total	Actual versus Required S_N
Fairchild Drive	(3) A	3	3	8			**14**	**3.52/3.78**
	(4) B	3	3-1/2	6			**12-1/2**	**3.52/3.48**
	(5) C	3	3	6	12		**24**	**4.50/3.48**
	(6) D					8	**8**	**N/A**

(1) If the asphalt surface course is to consist of Grading S, then the required minimum thickness placed should be 2-inches. If the asphalt surface course is to consist of Grading SX, the required minimum thickness placed should be 1-1/2-inches. If the asphalt pavement section is to be placed in conjunction with either S or SG, then the required minimum thickness placed should be 3-inches.

(2) If flyash is utilized for portions of the proposed roadway construction and is to be considered as part of the strength coefficient equation, it is recommended that the upper 12-inches of the subgrade be treated with flyash. Terracon used a strength coefficient value of 0.10 for the required minimum

thickness of 12-inches, which results in a total strength value of 1.2 in the pavement thickness formula. Using a minimum thickness of 12-inches of flyash treated subgrade could reduce the required asphalt thickness by approximately 2-1/2-inches. However, in most cases the required minimum asphalt pavement thickness values may take precedent in the pavement thickness sections. Therefore no reduction may be provided and the use of flyash may not be economical, ***unless needed for subgrade stabilization***. Due to the swell potential exhibited by the swell consolidation tests, inundated at 150 psf, stabilization of subgrade soils are recommended. Use of flyash should be considered as a stabilization technique.

(3) Alternative A: Provides the minimum pavement thicknesses for use of asphalt concrete surface material, Grading S, SX and SG, underlain by Class 5 or 6 aggregate road base material.

(4) Alternative B: Provides the minimum pavement thicknesses for use of full-depth asphalt concrete surface material, Grading S or SX, underlain by asphalt concrete surface material, Grading SG with a minimum thickness of 6-inches of aggregate base course.

(5) Alternative C: Provides the minimum pavement thicknesses for use of asphalt concrete surface material, Grading S, SX and SG, underlain by a minimum of 6-inches of Class 5 or 6 aggregate road base material, and a minimum of 12-inches of flyash treated subgrade.

(6) Alternative D: Provides the minimum required pavement thicknesses for use of Portland Cement Concrete pavement.

Each alternative should be investigated with respect to current material availability and economic conditions. Aggregate base course (if used on the site) should consist of a blend of sand and gravel, which meets strict specifications for quality and gradation. Use of materials meeting Colorado Department of Transportation (CDOT) Class 5 or 6 specifications is recommended for base course. Aggregate base course should be placed in lifts not exceeding six inches and should be compacted to a minimum of 95% Standard Proctor Density (ASTM D698).

Asphalt concrete should be composed of a mixture of aggregate, filler and additives, if required, and approved bituminous material. Asphalt concrete should conform to approved mix designs stating the SuperPave and/or Hveem properties, optimum asphalt content, job mix formula and recommended mixing and placing temperatures. Aggregate used in asphalt concrete should meet Colorado Department of Transportation Grading S, SX or SG specifications. Mix designs should be submitted prior to construction to verify their adequacy. Asphalt material should be placed in maximum 3-inch lifts and should be compacted within a range of 92 to 96% of Maximum Theoretical Density.

Preventative maintenance should be planned and provided for through an on-going pavement management program in order to enhance future pavement performance. Preventative maintenance activities are intended to slow the rate of pavement deterioration, and to preserve the pavement investment.

Preventative maintenance consists of both localized maintenance (e.g. crack sealing and patching) and global maintenance (e.g. surface sealing). Preventative maintenance is usually the first priority when implementing a planned pavement maintenance program and provides the highest return on investment for pavements.

Recommended preventative maintenance policies for asphalt and jointed concrete pavements, based upon type and severity of distress, are provided. Prior to implementing any maintenance, additional engineering observation is recommended to determine the type and extent of preventative maintenance.

GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide testing and observation during excavation, grading, and pavement construction phases of the project. In the event that any changes of the proposed project are planned, the conclusions and recommendations contained in this report should be reviewed and the report modified or supplemented as necessary.

The analyses and recommendations in this report are based in part upon data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations, which may occur between borings, across the site, or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental assessment of the site or identification of contaminated or hazardous materials or conditions. If the owner is concerned about the potential for such contamination, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report, are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes, and either verifies or modifies the conclusions of this report in writing.

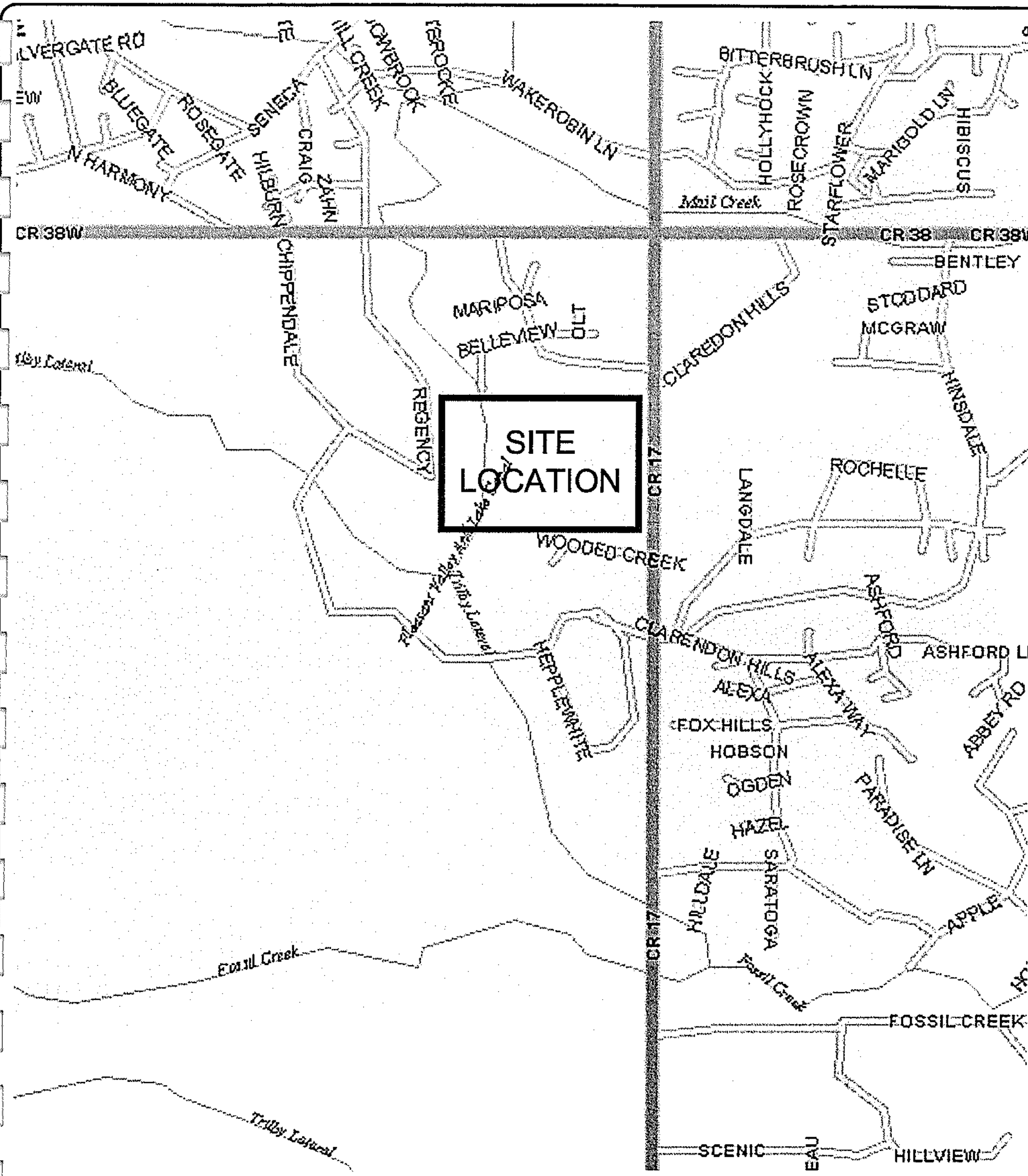
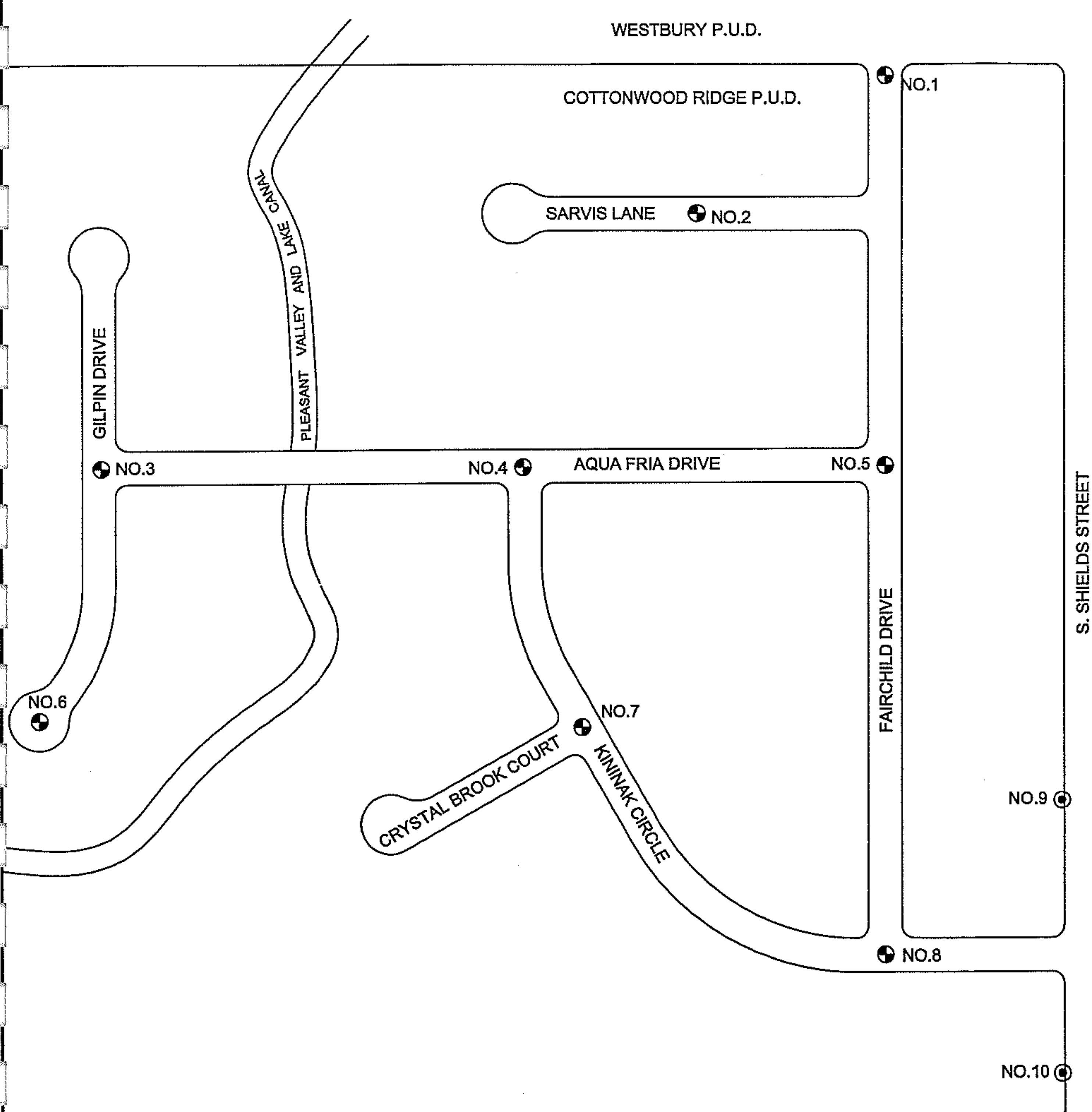


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES.

FIGURE 1: VICINITY MAP
COTTONWOOD RIDGE RESIDENTIAL DEVELOPMENT
PAVEMENT DESIGN THICKNESS EVALUATION
FORT COLLINS, COLORADO

Project Mngr: DAR	Terracon	Project No. 20025046
Designed By: DAR		Scale: NTS
Checked By: DAR	301 N. Howes Street	Date: 4/23/02
Approved By: DAR	Fort Collins, Colorado 80521	Drawn By: SDC
File Name:	25026FIG1	Figure No. 1



LEGEND

- TEST BORING NOs. 1-8 DRILLED APRIL 9, 2002.
- HAND AUGER BORING NOs. 9 & 10 DRILLED MAY 21, 2002.

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES.

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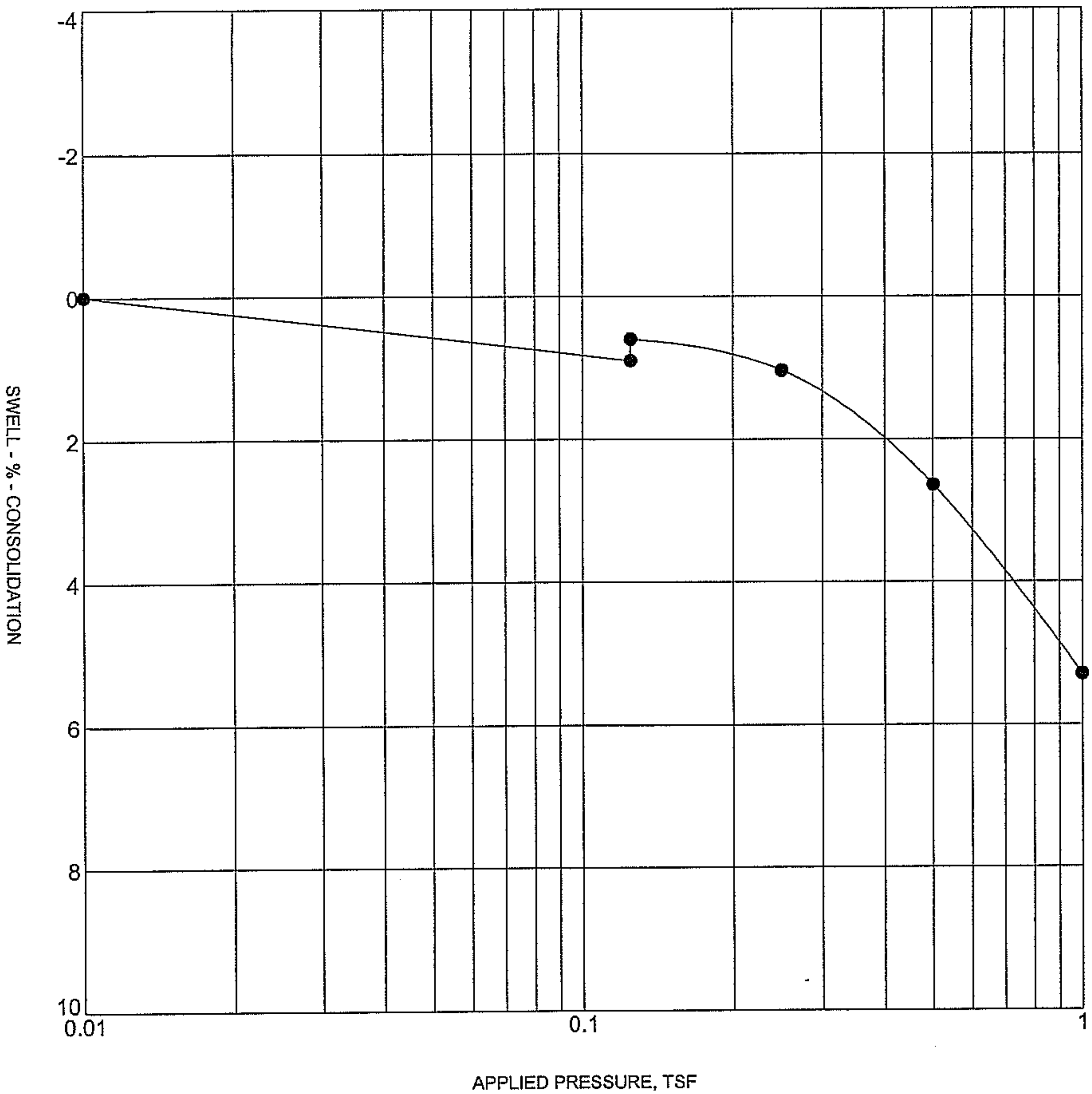
FIGURE 2: SITE DIAGRAM
COTTONWOOD RIDGE RESIDENTIAL DEVELOPMENT
PAVEMENT DESIGN THICKNESS EVALUATION
FORT COLLINS, COLORADO

Project Mngr: DAR	Terracon	Project No.	20025046
Designed By: DAR		Scale:	1"=120'
Checked By: DAR	301 N. Howes Street	Date:	4/23/02
Approved By: DAR	Fort Collins, Colorado 80521	Drawn By:	SDC
File Name:	25026FIG2	Figure No.	2

Laboratory Test Results
South Shields – Acceleration and Deceleration Lanes
Cottonwood Ridge – Fort Collins, Colorado
Terracon Project No. 20025046

TEST BORING NO.	DEPTH (FT)	IN-SITU CHARACTERISTICS		UNCONFINED COMPRESSIVE STRENGTH (PSF)	SOIL CLASSIFICATION (UNIFIED)			SWELL CONSOLIDATION TEST RESULTS		
		MOISTURE CONTENT %	DRY DENSITY (PCF)		(1) LIQUID LIMIT	(1) PLASTIC INDEX	(1) % PASSING NO. 200	MOISTURE CONTENT %	DRY DENSITY (PCF)	% SWELL (+) % CONSOLIDATION (-)
9	1.0	15.5	105	4815	38	18	65	--	--	--
10	1.0	12.5	102	6465				12	101	(+) 0.24

(1) Composite sample obtained from each test boring and combined together to determine subgrade characteristics for this portion of the project. R-Value of this composite sample revealed a value of 16.



Specimen Identification			Classification	γ_d, pcf	WC,%
●	10	0.0ft	**SANDY LEAN CLAY**	**101**	**12**

Notes:

TC CONSOL STRAIN 20025046.GPJ CONSOL.GDT 5/29/02

Terracon

CONSOLIDATION TEST

Project: Pavement Evaluation
Site: Cottonwood Ridge Development Fort Collins, Colorado
Job #: 20025046
Date: 5-29-02

Terracon

P.O. Box 503
301 North Howes Street
FORT COLLINS, COLORADO 80521
(970) 484-0359 FAX (970) 484-0454

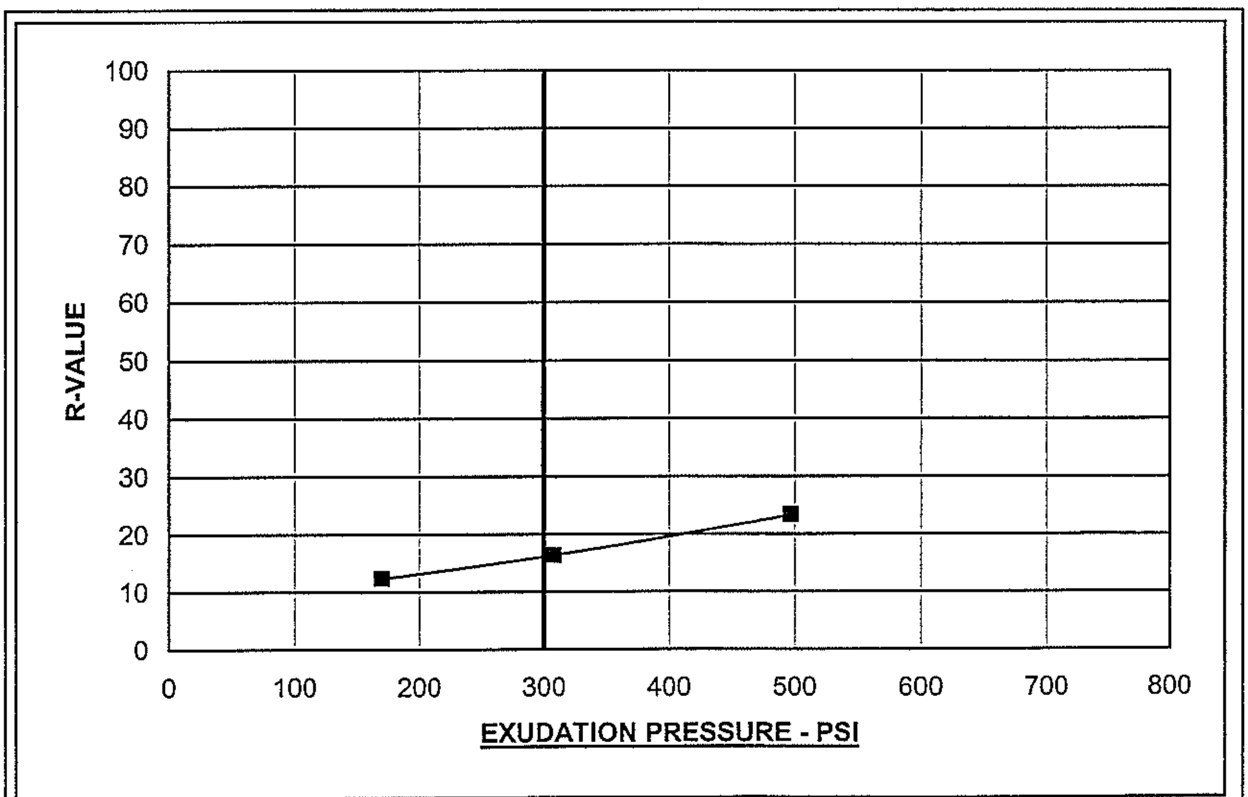
RESISTANCE R-VALUE & EXPANSION PRESSURE OF COMPACTED SOIL ASTM D2844

CLIENT: Progressive Living Structures **DATE OF TEST:** 24-May-02
PROJECT: Cottonwood Ridge Residential Development-South Shields Street Widening
LOCATION: Composite Sample Test Boring Nos. 9 and 10 @ 0.5' - 3.0'
TERRACON NO. 20025046 **CLASSIFICATION:** Sandy Lean Clay - CL; AASHTO A-6

SAMPLE DATA TEST RESULTS

TEST SPECIMEN NO.	1	2	3
COMPACTION PRESSURE (PSI)	75	150	200
DENSITY (PCF)	107.2	109.5	111.9
MOISTURE CONTENT (%)	19.3	17.6	15.9
EXPANSION PRESSURE (PSI)	-0.16	-0.06	0.00
HORIZONTAL PRESSURE @ 160 PSI	132	123	113
SAMPLE HEIGHT (INCHES)	2.57	2.53	2.69
EXUDATION PRESSURE (PSI)	169.5	307.9	497.2
CORRECTED R-VALUE	12.3	16.3	23.4
UNCORRECTED R-VALUE	12.0	16.3	21.7

R-VALUE @ 300 PSI EXUDATION PRESSURE = 16



GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS:	Split Spoon - 1-3/8" I.D., 2" O.D., unless otherwise noted	HS:	Hollow Stem Auger
ST:	Thin-Walled Tube - 2" O.D., unless otherwise noted	PA:	Power Auger
RS:	Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted	HA:	Hand Auger
DB:	Diamond Bit Coring - 4", N, B	RB:	Rock Bit
BS:	Bulk Sample or Auger Sample	WB:	Wash Boring or Mud Rotary

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value".

WATER LEVEL MEASUREMENT SYMBOLS:

WL:	Water Level	WS:	While Sampling	N/E:	Not Encountered
WCI:	Wet Cave in	WD:	While Drilling		
DCI:	Dry Cave in	BCR:	Before Casing Removal		
AB:	After Boring	ACR:	After Casing Removal		

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

DESCRIPTIVE SOIL CLASSIFICATION: Soil classification is based on the Unified Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-value (SS) Blows/Ft.	Consistency
< 500	<2	Very Soft
500 – 1,000	2-3	Soft
1,001 – 2,000	4-6	Medium Stiff
2,001 – 4,000	7-12	Stiff
4,001 – 8,000	13-26	Very Stiff
8,000+	26+	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Standard Penetration or N-value (SS) Blows/Ft.	Relative Density
0 – 3	Very Loose
4 – 9	Loose
10 – 29	Medium Dense
30 – 49	Dense
50+	Very Dense

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 – 29
Modifier	> 30

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 – 12
Modifiers	> 12

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300mm)
Cobbles	12 in. to 3 in. (300mm to 75 mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing #200 Sieve (0.075mm)

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1-10
Medium	11-30
High	30+

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]					Soil Classification: Group Symbol	Soil Classification: Group Name[B]
Coarse Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3[E]		GW	Well-graded gravel[F]
			Cu < 4 and/or 1 > Cc > 3[E]		GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH		GM	Silty gravel[F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3[E]		SW	Well-graded sand[I]
			Cu < 6 and/or 1 > Cc > 3[E]		SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH		SM	Silty sand[G,H,I]
			Fines Classify as CL or CH		SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI > 7 and plots on or above "A" line[J]		CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]		ML	Silt[K,L,M]
		organic	Liquid limit - oven dried	< 0.75	OL	Organic clay[K,L,M,N]
			Liquid limit - not dried			Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line		CH	Fat clay[K,L,M]
			PI lots below "A" line		MH	Elastic Silt[K,L,M]
		organic	Liquid limit - oven dried	< 0.75	OH	Organic clay[K,L,M,P]
			Liquid limit - not dried			Organic silt[K,L,M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

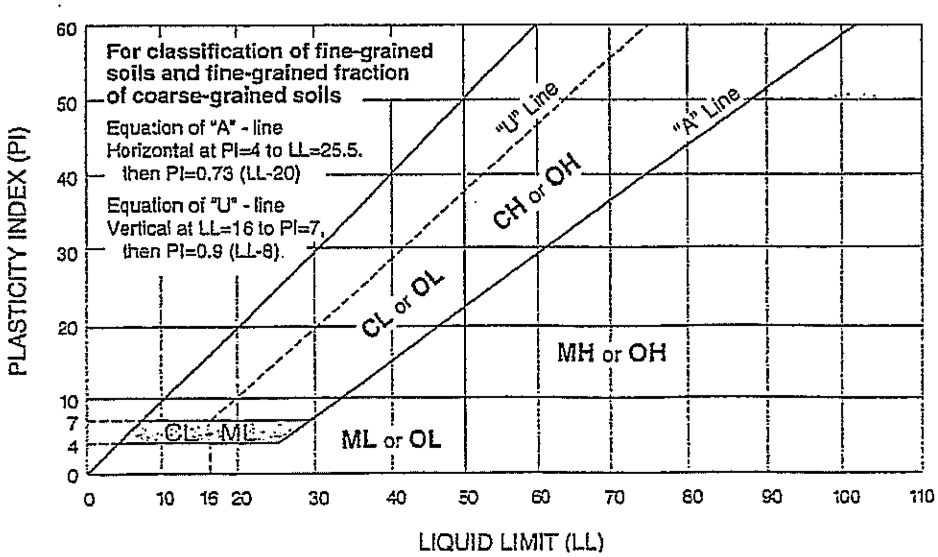
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



LABORATORY TESTS
SIGNIFICANCE AND PURPOSE

TEST	SIGNIFICANCE	PURPOSE
California Bearing Ratio	Used to evaluate the potential strength of subgrade soil, subbase, and base course material, including recycled materials for use in road and airfield pavements.	Pavement Thickness Design
Consolidation	Used to develop an estimate of both the rate and amount of both differential and total settlement of a structure.	Foundation Design
Direct Shear	Used to determine the consolidated drained shear strength of soil or rock.	Bearing Capacity, Foundation Design & Slope Stability
Dry Density	Used to determine the in-place density of natural, inorganic, fine-grained soils.	Index Property Soil Behavior
Expansion	Used to measure the expansive potential of fine-grained soil and to provide a basis for swell potential classification.	Foundation & Slab Design
Gradation	Used for the quantitative determination of the distribution of particle sizes in soil.	Soil Classification
Liquid & Plastic Limit, Plasticity Index	Used as an integral part of engineering classification systems to characterize the fine-grained fraction of soils, and to specify the fine-grained fraction of construction materials.	Soil Classification
Permeability	Used to determine the capacity of soil or rock to conduct a liquid or gas.	Groundwater Flow Analysis
pH	Used to determine the degree of acidity or alkalinity of a soil.	Corrosion Potential
Resistivity	Used to indicate the relative ability of a soil medium to carry electrical currents.	Corrosion Potential
R-Value	Used to evaluate the potential strength of subgrade soil, subbase, and base course material, including recycled materials for use in road and airfield pavements.	Pavement Thickness Design
Soluble Sulphate	Used to determine the quantitative amount of soluble sulfates within a soil mass.	Corrosion Potential
Unconfined Compression	To obtain the approximate compressive strength of soils that possess sufficient cohesion to permit testing in the unconfined state.	Bearing Capacity Analysis for Foundations
Water Content	Used to determine the quantitative amount of water in a soil mass.	Index Property Soil Behavior

REPORT TERMINOLOGY
(Based on ASTM D653)

Allowable Soil Bearing Capacity	The recommended maximum contact stress developed at the interface of the foundation element and the supporting material.
Alluvium	Soil, the constituents of which have been transported in suspension by flowing water and subsequently deposited by sedimentation.
Aggregate Base Course	A layer of specified material placed on a subgrade or subbase usually beneath slabs or pavements.
Backfill	A specified material placed and compacted in a confined area.
Bedrock	A natural aggregate of mineral grains connected by strong and permanent cohesive forces. Usually requires drilling, wedging, blasting or other methods of extraordinary force for excavation.
Bench	A horizontal surface in a sloped deposit.
Caisson (Drilled pier or Shaft)	A concrete foundation element cast in a circular excavation which may have an enlarged base. Sometimes referred to as a cast-in-place pier or drilled shaft.
Coefficient of Friction	A constant proportionality factor relating normal stress and the corresponding shear stress at which sliding starts between the two surfaces.
Colluvium	Soil, the constituents of which have been deposited chiefly by gravity such as at the foot of a slope or cliff.
Compaction	The densification of a soil by means of mechanical manipulation.
Concrete Slab-on-Grade	A concrete surface layer cast directly upon a base, subbase or subgrade, and typically used as a floor system.
Differential Movement	Unequal settlement or heave between, or within foundation elements of a structure.
Earth Pressure	The pressure or force exerted by soil on any boundary such as a foundation wall.
ESAL	Equivalent Single Axle Load, a criteria used to convert traffic to a uniform standard, (18,000 pound axle loads).
Engineered Fill	Specified material placed and compacted to specified density and/or moisture conditions under observations of a representative of a geotechnical engineer.
Equivalent Fluid	A hypothetical fluid having a unit weight such that it will produce a pressure against a lateral support presumed to be equivalent to that produced by the actual soil. This simplified approach is valid only when deformation conditions are such that the pressure increases linearly with depth and the wall friction is neglected.
Existing Fill (or man-made fill)	Materials deposited through the action of man prior to exploration of the site.
Existing Grade	The ground surface at the time of field exploration.

REPORT TERMINOLOGY
(Based on ASTM D653)

Expansive Potential	The potential of a soil to expand (increase in volume) due to absorption of moisture.
Finished Grade	The final grade created as a part of the project.
Footing	A portion of the foundation of a structure that transmits loads directly to the soil.
Foundation	The lower part of a structure that transmits the loads to the soil or bedrock.
Frost Depth	The depth of which the ground becomes frozen during the winter season.
Grade Beam	A foundation element or wall, typically constructed of reinforced concrete, used to span between other foundation elements such as drilled piers.
Groundwater	Subsurface water found in the zone of saturation of soils, or within fractures in bedrock.
Heave	Upward movement.
Lithologic	The characteristics which describe the composition and texture of soil and rock by observation.
Native Grade	The naturally occuring ground surface.
Native Soil	Naturally occurring on-site soil, sometimes referred to as natural soil.
Optimum Moisture Content	The water content at which a soil can be compacted to a maximum dry unit weight by a given compactive effort.
Perched Water	Groundwater, usually of limited area maintained above a normal water elevation by the presence of an intervening relatively impervious continuing stratum.
Scarify	To mechanically loosen soil or break down existing soil structure.
Settlement	Downward movement.
Skin Friction (Side Shear)	The frictional resistance developed between soil and an element of structure such as a drilled pier or shaft.
Soil (earth)	Sediments or other unconsolidated accumulations of solid particles produced by the physical and chemical disintegration of rocks, and which may or may not contain organic matter.
Strain	The change in length per unit of length in a given direction.
Stress	The force per unit area acting within a soil mass.
Strip	To remove from present location.
Subbase	A layer of specified material in a pavement system between the subgrade and base course.
Subgrade	The soil prepared and compacted to support a structure, slab or pavement system.

RECOMMENDED PREVENTATIVE MAINTENANCE POLICY FOR JOINTED CONCRETE PAVEMENTS

Distress Type	Distress Severity	Recommended Maintenance
Blow-up	Low	None
	Medium	Full-Depth Concrete Patch/ Slab Replacement
	High	
Corner Break	Low	Seal Cracks
	Medium	Full-Depth Concrete Patch
	High	
Divided Slab	Low	Seal Cracks
	Medium	Slab Replacement
	High	
Durability Cracking	Low	None
	Medium	Full-Depth Patch
	High	Slab Replacement
Faulting	Low	None
	Medium	Grind
	High	
Joint Seal	Low	None
	Medium	Reseal Joints
	High	
Lane/Shoulder Drop-off	Low	Regrade and Fill Shoulders to Match Lane Height
	Medium	
	High	
Linear Cracking Longitudinal, Transverse and Diagonal Cracks	Low	Clean & Seal all Cracks
	Medium	
	High	Full-Depth Patch
Large Patching and Utility Cuts	Low	None
	Medium	Seal Cracks or Replace Patch
	High	
Small Patching	Low	None
	Medium	Replace Patch
	High	

Distress Type	Distress Severity	Recommended Maintenance
Polished Aggregate	No Severity Levels Defined	Groove Surface or Overlay
Popouts	No Severity Levels Defined	None
Pumping	No Severity Levels Defined	Underseal, Seal cracks/joints and Restore Load Transfer
Punchout	Low	Seal Cracks
	Medium	Full-Depth Concrete Patch
	High	
Railroad Crossing	Low	No Policy for this Project
	Medium	
	High	
Scaling Map Cracking Crazing	Low	None
	Medium	Slab Replacement, Full-depth Patch, or Overlay
	High	
Shrinkage Cracks	No Severity Levels Defined	None
Spalling (Corner)	Low	None
	Medium	Partial-Depth Concrete Patch
	High	
Spalling (Joint)	Low	None
	Medium	Partial-Depth Patch
	High	Reconstruct Joint

Terracon

RECOMMENDED PREVENTATIVE MAINTENANCE POLICY FOR ASPHALT CONCRETE PAVEMENTS

Distress Type	Distress Severity	Recommended Maintenance
Alligator Cracking	Low	None
	Medium	Full-Depth Asphalt Concrete Patch
	High	
Bleeding	Low	None
	Medium	Surface Sanding
	High	Shallow AC Patch
Block Cracking	Low	None
	Medium	Clean & Seal All Cracks
	High	
Bumps & Sags	Low	None
	Medium	Shallow AC Patch
	High	Full-Depth Patch
Corrugation	Low	None
	Medium	Full-Depth Asphalt Concrete Patch
	High	
Depression	Low	None
	Medium	Shallow AC Patch
	High	Full-Depth Patch
Edge Cracking	Low	None
	Medium	Seal Cracks
	High	Full-Depth Patch
Joint Reflection	Low	Clean & Seal All Cracks
	Medium	
	High	Shallow AC Patch
Lane/Shoulder Drop-Off	Low	None
	Medium	Regrade Shoulder
	High	
Longitudinal & Transverse Cracking	Low	None
	Medium	Clean & Seal All Cracks
	High	
Patching & Utility Cut Patching	Low	None
	Medium	Full-Depth Asphalt Concrete Patch
	High	
Polished Aggregate	Low	None
	Medium	
	High	Fog Seal
Potholes	Low	Shallow AC Patch
	Medium	Full-Depth Asphalt Concrete Patch
	High	
Railroad Crossing	Low	No Policy for This Project
	Medium	
	High	
Rutting	Low	None
	Medium	Shallow AC Patch
	High	Full-Depth Patch
Shoving	Low	None
	Medium	Mill & Shallow AC Patch
	High	
Slippage Cracking	Low	None
	Medium	Shallow Asphalt Concrete Patch
	High	
Swell	Low	None
	Medium	Shallow AC Patch
	High	Full-Depth Patch
Weathering & Ravelling	Low	Fog Seal
	Medium	
	High	