

REPORT OF PAVEMENT DESIGN

**ENGLISH RANCH SOUTH PUD
SECOND FILING PHASE I
FORT COLLINS, COLORADO**

**PROJECT NO. 20985077
May 11, 1998**

Prepared for:

**BARTRAN AND COMPANY INC.
P. O. BOX 277
TIMNATH, COLORADO 80547
ATTN: MR. BILL BARTRAN**

Prepared by:

**Terracon
301 North Howes Street
Fort Collins, Colorado 80521**

Terracon

May 11, 1998

Terracon

301 N. Howes • P.O. Box 503
Fort Collins, Colorado 80521-0503
(970) 484-0359 Fax: (970) 484-0454

Bartran and Company, Inc.
P. O. Box 277
Timnath, Colorado 80547

Attn: Mr. Bill Bartran

Re: **Report of Pavement Design**
English Ranch South PUD Second Filing Phase I
Fort Collins, Colorado
Project No. 20985077

Terracon has completed a pavement design for the proposed street improvements for English Ranch South PUD Phase I located between Edmonds Road and Kingsley Drive, Fort Collins, Colorado. This study was performed in general accordance with our proposal number D2098099 dated April 27, 1998.

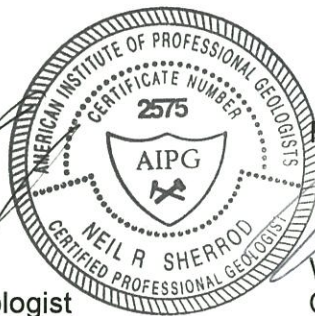
The results of our pavement design including design criteria and the pavement recommendations are attached. A preliminary geotechnical report containing subsurface data was prepared for the site by Terracon May 6, 1998.

We appreciate the opportunity to be of service to you on this phase of your project. If you have any questions concerning this report, or if we may be of further service to you, please do not hesitate to contact us.

Sincerely,
TERRACON

Prepared by:


Neil R. Sherrod
Senior Engineering Geologist



Reviewed by:


William J. Attwool, P.E.
Office Manager



Copies to: Addressee (2)
City of Fort Collins Engineering - Mr. Keith Meyers (1)

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REPORT OF PAVEMENT DESIGN

ENGLISH RANCH SOUTH PUD SECOND FILING PHASE I FORT COLLINS, COLORADO

**Project No. 20985077
May 11, 1998**

INTRODUCTION

This report contains the results of our pavement design for the proposed street improvement for English Ranch South PUD Phase I located between Kingsley Drive and Edmonds Road, Fort Collins, Colorado. The site is located in the Northeast 1/4 of Section 32, Township 7 North, Range 68 West of the 6th Principal Meridian.

The purpose of these services is to provide pavement sections for the proposed site improvements in the Phase I portion of the English Ranch South PUD, Fort Collins, Colorado.

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. A preliminary geotechnical engineering report was prepared for the site by Terracon dated May 6, 1998.

PROPOSED CONSTRUCTION

The proposed improvements are to consist of the construction of Kingsley Drive between Paddington Road and Stonehaven Drive, Paddington Road between Edmonds Road and Kingsley Drive, Sunstone Drive between Kingsley Drive and Edmonds Road, and Stonehaven Drive between Kingsley Drive and Kentford Road.

PAVEMENT RECOMMENDATIONS

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. Asphaltic concrete underlain by crushed aggregate base course, full-depth asphalt pavement and nonreinforced concrete pavement are feasible alternatives for the proposed pavement sections. Based on the subsurface conditions encountered at the site, it is

recommended that all street improvements be designed using an "R" value of 13. The equivalent daily axle loads (EDLAs) were provided by the City of Fort Collins.

Pavement Design and Construction

Design of pavements for the project have been based on the procedures outlined in the 1986 Guideline for Design of Pavement Structures by the American Association of State Highway and Transportation Officials (AASHTO) and City of Fort Collins criteria and the following data. For flexible pavement design, a design life of 20 years was utilized. Using a correlated design R-value of 13, appropriate ESAL/day, environmental criteria and other factors, the structural numbers (SN) of the pavement sections were determined on the basis of the 1986 AASHTO design equation.

Street Name/Street Type	18 kip EDLA	ESALs	Reliability	Terminal Service-ability	Structural No.
Kingsley Drive/Collector	40	292,000	85	2.5	2.58
Paddington Road/Collector	25	182,500	85	2.5	2.39
Sunstone Drive/Local/Collector	20	146,000	70	2.0	2.09
Stonehaven Drive/Local	10	73,000	70	2.0	1.87

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 and 140 pounds per cubic inch (pci) for the subgrade soil was determined by correlation to the laboratory tests results. A modulus of rupture of 600 psi (working stress 450 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:

Street	Alternative	Recommended Pavement Thicknesses (Inches)				
		Asphalt Concrete Surface	Aggregate Base Course	Plant-Mixed Bituminous Base	Portland Cement Concrete	Total
Kingsley Drive	A	4	8			12
	B	3		4		7
	C				6½	6½
Paddington Road	A	4	6			10
	B	2		4½		6½
	C				6	6
Sunstone Drive	A	3½	6			9½
	B	2		4		6
	C				6	6
Stonehaven Drive	A	3½	6			9½
	B	2		4		6
	C				6	6

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 and/or plant-mixed bituminous base course should be composed of a mixture of aggregate, filler and additives, if required, and approved bituminous material. The bituminous base and/or asphalt concrete should conform to approved mix designs stating the Hveem properties, optimum asphalt content, job mix formula and recommended mixing and placing temperatures. Aggregate used in plant-mixed bituminous base course and/or asphalt concrete should meet particular gradations. Material meeting Colorado Department of Transportation Grading C or CX specification is recommended for asphalt concrete. Aggregate meeting Colorado Department of Transportation Grading G or C specifications is recommended for plant-mixed bituminous base course. 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 to a minimum of 95% Hveem density (ASTM D1560) (ASTM D1561).

Where rigid pavements are used, the concrete should be obtained from an approved mix design with the following minimum properties:

- Modulus of Rupture @ 28 days 600 psi minimum
- Strength Requirements ASTM C94
- Minimum Cement Content 6.5 sacks/cu. yd.
- Cement Type Type I Portland
- Entrained Air Content 4 to 8%
- Concrete Aggregate ASTM C33 and CDOT Section 703
- Aggregate Size 1 inch maximum
- Maximum Water Content 0.49 lb/lb of cement
- Maximum Allowable Slump 4 inches

Concrete should be deposited by truck mixers or agitators and placed a maximum of 90 minutes from the time the water is added to the mix. Other specifications outlined by the Colorado Department of Transportation should be followed.

Longitudinal and transverse joints should be provided as needed in concrete pavements for expansion/contraction and isolation. The location and extent of joints should be based upon the final pavement geometry and should be placed (in feet) at roughly twice the slab thickness (in inches) on center in either direction. Sawn joints should be cut within 24-hours of concrete placement, and should be a minimum of 25% of slab thickness plus 1/4 inch. All joints should be sealed to prevent entry of foreign material and dowelled where necessary for load transfer.

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 or across the site. The nature and extent of such variations may not become evident until construction. If variations appear, it will be necessary to reevaluate the recommendations of this report.

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. 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.

Pavement Analysis:

AASHTO '86 Design Equations

READY

Page: 6

***** Rigid Pavement Analysis *****

**** Flexible Pavement Analysis ****

[1] Design E 18's 292,000
 [2] Reliability 85.00
 [3] Overall Deviation 0.34
 [4] Modulus of Rupture 600.0
 [5] Modulus of Elasticity 3,420,000
 [6] Load Transfer, J 3.20

[1] Design E 18's 292,000
 [2] Reliability 85.00
 [3] Overall Deviation 0.44

[7] Mod. of Subgrade Reaction 100
 [8] Drainage Coefficient 1.00
 [9] Initial Serviceability 4.50
 [10] Terminal Serviceability 2.50

[4] Soil Resilient Mod. 8,215.0
 [5] Initial Serviceability 4.50
 [6] Terminal Serviceability 2.50

Rigid Pavement Thickness 5.56

Flexible Structural Number 2.58

Press Enter to Continue or (dit your Inputs

Special Keys: F1: HELP F2: EXIT F5: MENU (PgUp) (PgDn) (

Pavement Analysis:

Flexible Thickness Determination

READY

Page: 7

Layer Number	Layer Coefficient == a (i) ==	Drainage Coefficient == m (i) ==	Layer Thickness === t ===	a(i)*Cd*t =====	Thickness Needed =====
Upper	0.44	1.00	4.00	1.76	
2	0.11	1.00	8.00	0.88	
3					
4					
5					
6					

=====

2.64

SN Required = 2.58 (Ok)

Press [F10] to Clear an Input & (PgDn) to Continue when finished.

Special Keys: F1: HELP F2: EXIT F5: MENU (PgUp) (PgDn) (

Pavement Analysis:

Flexible Thickness Determination

READY

Page: 7

Layer	Layer	Drainage	Layer	Thickness
-------	-------	----------	-------	-----------

Number =====	Coefficient == a (i) ==	Coefficient == m (i) ==	Thickness === t ===	a(i)*Cd*t =====	Needed =====
Upper	0.44	1.00	3.00	1.32	
2	0.34	1.00	4.00	1.36	
3					
4					
5					
6					

=====

2.68

SN Required = 2.58 (Ok)

Press [F10] to Clear an Input & (PgDn) to Continue when finished.

Special Keys: F1: HELP F2: EXIT F5: MENU (PgUp) (PgDn) (

***** Rigid Pavement Analysis *****

**** Flexible Pavement Analysis ****

[1] Design E 18's 182,500
 [2] Reliability 85.00
 [3] Overall Deviation 0.34
 [4] Modulus of Rupture 600.0
 [5] Modulus of Elasticity 3,420,000
 [6] Load Transfer, J 3.20

[1] Design E 18's 182,500
 [2] Reliability 85.00
 [3] Overall Deviation 0.44

[7] Mod. of Subgrade Reaction 100
 [8] Drainage Coefficient 1.00
 [9] Initial Serviceability 4.50
 [10] Terminal Serviceability 2.50

[4] Soil Resilient Mod. 8,215.0
 [5] Initial Serviceability 4.50
 [6] Terminal Serviceability 2.50

Rigid Pavement Thickness 5.08

Flexible Structural Number 2.39

Press Enter to Continue or (dit your Inputs

Special Keys: F1: HELP F2: EXIT F5: MENU (PgUp) (PgDn) (

Layer Number	Layer Coefficient == a (i) ==	Drainage Coefficient == m (i) ==	Layer Thickness === t ===	a(i)*Cd*t =====	Thickness Needed =====
Upper	0.44	1.00	4.00	1.76	
2	0.11	1.00	6.00	0.66	
3					
4					
5					
6					

=====
 2.42
 SN Required = 2.39 (Ok)

Press [F10] to Clear an Input & (PgDn) to Continue when finished.

Special Keys: F1: HELP F2: EXIT F5: MENU (PgUp) (PgDn) (

Layer	Layer	Drainage	Layer	Thickness
-------	-------	----------	-------	-----------

Number =====	Coefficient == a (i) ==	Coefficient == m (i) ==	Thickness === t ===	a(i)*Cd*t =====	Needed =====
Upper	0.44	1.00	4.00	1.76	
2	0.11	1.00	6.00	0.66	
3					
4					
5					
6					

=====

SN Required = 2.39 (Ok)

Press [F10] to Clear an Input & (PgDn) to Continue when finished.

Special Keys: F1: HELP F2: EXIT F5: MENU (PgUp) (PgDn) (

Pavement Analysis: Flexible Thickness Determination READY Page: 7

Layer Number =====	Layer Coefficient == a (i) ==	Drainage Coefficient == m (i) ==	Layer Thickness === t ===	a(i)*Cd*t =====	Thickness Needed =====
Upper	0.44	1.00	2.00	0.88	
2	0.34	1.00	4.50	1.53	
3					
4					
5					
6					

=====

SN Required = 2.39 (Ok)

Press [F10] to Clear an Input & (PgDn) to Continue when finished.

Special Keys: F1: HELP F2: EXIT F5: MENU (PgUp) (PgDn) (

Pavement Analysis: Flexible Thickness Determination READY Page: 7

Layer Number =====	Layer Coefficient == a (i) ==	Drainage Coefficient == m (i) ==	Layer Thickness === t ===	a(i)*Cd*t =====	Thickness Needed =====
Upper	0.44	1.00	2.00	0.88	
2	0.34	1.00	4.50	1.53	
3					
4					
5					
6					

***** Rigid Pavement Analysis *****

**** Flexible Pavement Analysis ****

[1] Design E 18's 146,000
 [2] Reliability 70.00
 [3] Overall Deviation 0.34
 [4] Modulus of Rupture 600.0
 [5] Modulus of Elasticity 3,420,000
 [6] Load Transfer, J 3.20

[1] Design E 18's 146,000
 [2] Reliability 70.00
 [3] Overall Deviation 0.44

[7] Mod. of Subgrade Reaction 100
 [8] Drainage Coefficient 1.00
 [9] Initial Serviceability 4.50
 [10] Terminal Serviceability 2.00

[4] Soil Resilient Mod. 8,215.0
 [5] Initial Serviceability 4.50
 [6] Terminal Serviceability 2.00

Rigid Pavement Thickness 4.50

Flexible Structural Number 2.09

Press Enter to Continue or (dit your Inputs

Special Keys: F1: HELP F2: EXIT F5: MENU (PgUp) (PgDn) (

Layer Number	Layer Coefficient == a (i) ==	Drainage Coefficient == m (i) ==	Layer Thickness === t ===	a(i)*Cd*t =====	Thickness Needed =====
Upper	0.44	1.00	3.50	1.54	
2	0.11	1.00	6.00	0.66	
3					
4					
5					
6					

=====
 2.20
 SN Required = 2.09 (Ok)

Press [F10] to Clear an Input & (PgDn) to Continue when finished.

Special Keys: F1: HELP F2: EXIT F5: MENU (PgUp) (PgDn) (

Layer	Layer	Drainage	Layer	Thickness
-------	-------	----------	-------	-----------

Number =====	Coefficient == a (i) ==	Coefficient == m (i) ==	Thickness === t ===	a(i)*Cd*t =====	Needed =====
Upper	0.44	1.00	2.00	0.88	
2	0.34	1.00	4.00	1.36	
3					
4					
5					
6					

=====

2.24

SN Required = 2.09 (Ok)

Press [F10] to Clear an Input & (PgDn) to Continue when finished.

Special Keys: F1: HELP F2: EXIT F5: MENU (PgUp) (PgDn) (

[8] Drainage Coefficient	1.00	[5] Initial Serviceability	4.50
[9] Initial Serviceability	4.50	[6] Terminal Serviceability	2.00
[10] Terminal Serviceability	2.00		
Rigid Pavement Thickness	3.94	Flexible Structural Number	1.87
Minimum PCC Thickness	4.00		

Press Enter to Continue or (dit your Inputs

Special Keys: F1: HELP F2: EXIT F5: MENU (PgUp) (PgDn) (

Pavement Analysis: AASHTO '86 Design Equations READY Page: 6

***** Rigid Pavement Analysis ***** ***** Flexible Pavement Analysis *****

[1] Design E 18's	73,000	[1] Design E 18's	73,000
[2] Reliability	70.00	[2] Reliability	70.00
[3] Overall Deviation	0.34	[3] Overall Deviation	0.44
[4] Modulus of Rupture	600.0		
[5] Modulus of Elasticity	3,420,000		
[6] Load Transfer, J	3.20		

[7] Mod. of Subgrade Reaction	100	[4] Soil Resilient Mod.	8,215.0
[8] Drainage Coefficient	1.00	[5] Initial Serviceability	4.50
[9] Initial Serviceability	4.50	[6] Terminal Serviceability	2.00
[10] Terminal Serviceability	2.00		

Rigid Pavement Thickness	3.94	Flexible Structural Number	1.87
Minimum PCC Thickness	4.00		

Press Enter to Continue or (dit your Inputs

Special Keys: F1: HELP F2: EXIT F5: MENU (PgUp) (PgDn) (

Pavement Analysis: Flexible Thickness Determination READY Page: 7

Layer Number	Layer Coefficient == a (i) ==	Drainage Coefficient == m (i) ==	Layer Thickness === t ===	a(i)*Cd*t =====	Thickness Needed =====
Upper	0.44	1.00	3.50	1.54	
2	0.11	1.00	6.00	0.66	
3					
4					
5					
6					

=====

2.20

SN Required = 1.87 (Ok)

Press [F10] to Clear an Input & (PgDn) to Continue when finished.

Number =====	Coefficient == a (i) ==	Coefficient == m (i) ==	Thickness === t ===	a(i)*Cd*t =====	Needed =====
Upper	0.44	1.00	2.00	0.88	
2	0.34	1.00	4.00	1.36	
3					
4					
5					
6					

=====

2.24

SN Required = 1.87 (Ok)

Press [F10] to Clear an Input & (PgDn) to Continue when finished.

Special Keys: F1: HELP F2: EXIT F5: MENU (PgUp) (PgDn) (

Pavement Analysis: Flexible Thickness Determination READY Page: 7

Layer Number =====	Layer Coefficient == a (i) ==	Drainage Coefficient == m (i) ==	Layer Thickness === t ===	a(i)*Cd*t =====	Thickness Needed =====
Upper	0.44	1.00	2.00	0.88	
2	0.34	1.00	4.00	1.36	
3					
4					
5					
6					

=====

2.24

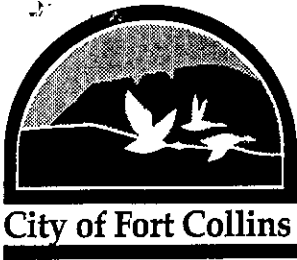
SN Required = 1.87 (Ok)

Press [F10] to Clear an Input & (PgDn) to Continue when finished.

Special Keys: F1: HELP F2: EXIT F5: MENU (PgUp) (PgDn) (

Pavement Analysis: AASHTO '86 Design Equations READY Page: 6

***** Rigid Pavement Analysis *****		***** Flexible Pavement Analysis *****	
[1] Design E 18's	73,000	[1] Design E 18's	73,000
[2] Reliability	70.00	[2] Reliability	70.00
[3] Overall Deviation	0.34	[3] Overall Deviation	0.44
[4] Modulus of Rupture	600.0		
[5] Modulus of Elasticity	3,420,000		
[6] Load Transfer, J	3.20		
[7] Mod. of Subgrade Reaction	100	[4] Soil Resilient Mod.	8,215.0



Transportation Services
Engineering Department

Neil R. Sherrod
Senior Engineering Geologist
Terracon Consultants Western, Inc.
301 North Howes Street
Fort Collins, CO 80521

RE: EDLA recommendations for English Ranch South - Second Filing Phase I

Dear Neil:

The following list shows the daily equivalent axle loading (EDLA) for the streets within the English Ranch South development. This EDLA data is to be used for the design of the roadway pavement structures.

<u>Street Name</u>	<u>Recommended EDLA</u>
Paddington Road	25
Sunstone Drive	20
Kingsley Drive	40
Stonehaven Drive	10

Roadway classifications can be obtained from your previous submittal for English Ranch South. If you have any questions or if I can be of further assistance, please do not hesitate to call.

Sincerely,

Keith Meyer
Project Engineer

cc: File

Pavement Design / EDLA Requests

5-11-98

Description Subdivision / PUD	Street Name	Person Requesting Info.	Company	Phone #
English Ranch South 2nd Filing	Paddington Rd. - 25	Neil	Terracon	484-0359
	Sunstone Dr. - 20			
	Kingsley Dr. - 40			
	Stonehaven Dr. - 10			

Date Information Requested	Date Promised	Company	Phone #
5-7	5-11	"	"

Traffic Study Submitted: Yes

If Yes:

Date Info. Given To Contact Person	Contact Person
5-11-98	Neil

If No:

Date Traffic Study Requested	Person Contacted	Phone #

NOTE: EDLA's matched to 1995 report. (See 1995 EDLA Data)

Engineer: KM