PAVEMENT INVESTIGATION REPORT
SOUTH SHIELDS STREET
FORT COLLINS, COLORADO

Project No. C91-02
September, 1991

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PE 23614

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PAVEMENT INVESTIGATION REPORT
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INTRODUCTION

This report presents the results of my pavement investigation performed for a one-half mile section of South Shields Street located south of Harmony Road. Plans are being prepared to widened the existing variable width pavement to a 70-foot wide road. Purpose of this investigation was to evaluate the structural condition of the existing pavement and, if needed, recommend appropriate remedial treatment.

The project north limit is located at about one-half mile south of Harmony Road at station 27+72. Fossil Creek Drive at station 53+11 is the south limit. Plan View of the project is illustrated on the attached Plate 1. The existing asphalt concrete (AC) pavement has a variable width with acceleration and passing lanes at the intersections of Hilldale Drive and Fossil Creek Drive. Most of the pavement length has a width of about 26 feet.

Nondestructive deflection test (NDT) equipment was used to evaluate the strength of the existing pavement structural section. Tests were performed at 50-foot intervals along the pavement length in both the northbound and southbound travel

lanes. Using a Corps of Engineers pavement design model, over 100 tests were statistically analyzed. Information obtained from pavement coring and previous engineering investigations were reviewed. Conclusions and recommendations were developed from the resulting information.

SUMMARY OF RECOMMENDATIONS

The following is a summary of the primary recommendations.

- Zone B shown on Plate 1 exhibited sufficient strength to support the traffic loads anticipated during a 20-year design period.

- Zone C will require a 2.5-inch asphalt concrete overlay (ACO) to add needed strength for support of future traffic loads.

- A paving fabric and 1.5-inch minimum ACO thickness should be placed over both Zones B and C to help waterproof the existing AC pavement. This will result in a paving fabric over the entire pavement surface and a 1.5-inch ACO in Zone B and 2.5-inch ACO in Zone C.

NONDESTRUCTIVE DEFLECTION TESTING

Nondestructive Deflection Testing (NDT) involves imposing a dynamic load on the pavement surface and measuring the resulting surface bending (deflection) under the load. The dynamic loads

range from 1000 to 4000 pounds (1 to 4 Kips) and deflections are measured in one one-thousandth of an inch (mils). At each test location NDT procedures were used to determine the dynamic stiffness modulus (DSM) of the pavement structural section. Three tests were performed at each location with each test imposing a different dynamic force on the pavement surface resulting in different surface deflections. The linear ratio of force to deflection with units of Kips/inch was defined as the DSM at the particular test location. Figure 1 shown on the next page illustrates the relationship of DSM values to location along the project length. The attached appendix contains the numerical deflection data.

PAVEMENT ANALYSIS DATA

The graph shown in Figure 1 reveals six plateaus where the DSM values are relatively consistent. From station 25+00 to the approximate start of the project at station 27+75 shows results of tests taken on newer pavement outside of the project limits. This area was labeled Zone A and the results were used only to show a comparison between newer pavement and the older pavement within the project limits. Between stations 27+25 to 32+25, 40+75 to 43+75, and 52+25 to 53+00 the DSM results were approximately the same and these areas were labeled Zone B. The areas between stations 32+25 to 40+75 and 43+75 to 52+25 had similar results and were labeled Zone C.

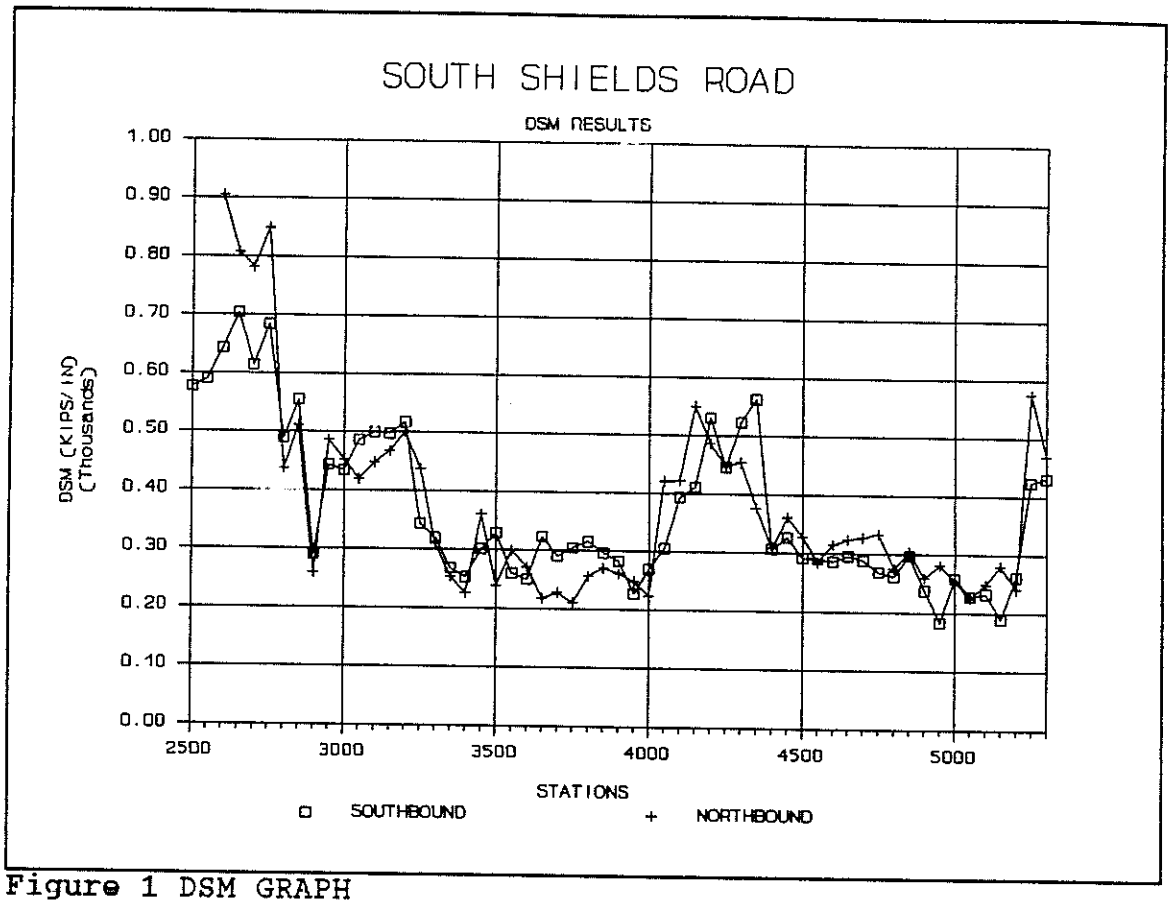

Figure 1 DSM GRAPH

The following is the results of a statistical analysis of the DSM data within each zone.

ZONE	A	B	C
AVERAGE (AVG)	715	462	282
STANDARD DEVIATION (STD)	109	67	47
AVG - STD	606	395	235

units of Kips/inch

The DSM average minus one standard deviation was used as the representative design DSM value for the strength analysis. It is interesting to note that Zone B appears to be located in the roadway cut area whereas Zone C is over fill areas.

Additional information for the analysis was obtained from inspection and recording of the pavement surface condition. The inspection reveled low to moderate severity rutting in the wheel paths in both the northbound and southbound travel lanes. The surface consisted of a chip seal coat that had experienced moderate bleeding in the wheel paths. It is understood that the chip seal coat had been applied in summer of 1987. There were areas of moderate severity random cracking located outside the wheel paths.

To obtain information regarding the pavement structural section, exploratory boring were excavated through the existing road pavement at three different locations. Boring B-1 was excavated in a roadway cut section near the Hilldale Drive intersection. B-2 was located over a deep fill section. Boring B-3 was also located in a cut section near to what appeared to be sandstone outcroppings. The boring were excavated by Terracon Consultants SE, Inc. with the resulting data contained in their letter dated August 21, 1991, Job Number 12915031. The table contained on the following page is a summary of the data.

Boring Number	B-1	B-2	B-3
Station	42+00	36+00	30+00
Thickness (inches)			
AC Pavement	2.69	2.50	3.00
Base	6.0	6.0	6.0
Pitrun Subbase	18.0	18.0	24.0
Subgrade Properties (%)			
Passing #200 Sieve	91.5	57.0	62.8
In Situ Moisture	25.5	16.6	11.0
Liquid Limit	62	23	33
Plasticity Index	22	5	13
Subgrade Description			
B-1	Brown Fat Clay		
B-2	Brown Sandy Lean Clay		
B-3	Brown Siltstone/Sandstone		

The retrieved AC cores reveled a 1/8" to 1/4" thick seal coat on the surface. The cores showed what appeared to be a relative high amount of small interconnected voids.

Vehicle traffic data was obtained from personnel of Fort Collins engineering department. It was decided to use a 20-year design period for remedial analysis of the existing pavement. The average daily traffic (ADT) numbers for the present time and end of design period are 8,500 and 15,000, respectively. Both present and future truck volume is 4% of the ADT. It is assumed that approximately 60% of the trucks will be single-axle and 40% multi-axle. A straight line growth rate was assumed and average values were used to calculated the 18-Kip equivalent single-axle load (ESAL) value. The calculated ESAL is about $1.4X10^6$. It is assumed that this ESAL value will be evenly divided between two lanes, north and southbound single travel lanes.

ANALYSIS AND CONCLUSIONS

The DSM data, pavement structural section thicknesses, and design traffic data were used as input to the Corps of Engineer design model to evaluate the structural adequacy of the existing pavement section. The work sheets are contained in the attached appendix. Zones B and C were analyzed separately. For Zone B a design DSM value of 395 Kips/inch was used as the strength parameter with a structural section consisting of 3 inches of asphalt concrete over 6 inches of aggregate base over 24 inches of subbase. For Zone C a design DSM value of 235 Kips/inch was used. The assumed structural section was 2.5 inches AC over 6 inches base over 18 inches subbase.

The analysis also considered the physical condition of the existing road pavement and underlying supporting environment. Any remedial treatment must address the pavement surface rutting and cracking. The relatively high void content of the existing AC material point to the need for special waterproofing considerations. The aged properties of the existing pavement may cause problems during the planed excavation of several areas along the project length. Heavy construction equipment needed for the excavation operation will impose high concentrated loads on a relatively brittle pavement. This may cause additional pavement cracking and require replacement of pavement sections outside the excavation areas.

RECOMMENDATIONS

The following is a list of the recommendations. These recommendations along with information used for the analysis is shown on Plate 1.

1. In terms of pavement strength, only Zone C requires an asphalt concrete overlay. An overlay of 2.5 inches is need to add sufficient strength to the existing pavement to support the anticipated traffic for the 20-year design period.

2. To help waterproof the existing pavement it is recommended that all moderate and high severity pavement cracks be filled and all potholes repaired. These operations should be performed in accordance with city specifications or procedures.

3. It is also recommended that a paving fabric be place over the entire existing pavement surface as an additional waterproofing measure. A 1.5-inch minimum thickness ACO is needed to protect the fabric. This results in a fabric being place along the entire length and across the width of the pavement surface. As a result a 1.5-inch ACO will be needed in Zone B and 2.5 inches in Zone C. This excludes newly reconstructed areas.

4. If possible, heavy construction equipment should not use the

existing pavement surface. Close monitoring of the pavement surface before, during, and after the excavation operations should be used to record and additional distress. Additional remedial work may be needed to address any change conditions.

5. One alternative work schedule should consider the use of staged construction. During this year the lower lifts of the new pavement could be placed. On the existing pavement the cracks could be filled and pot holes repaired. A seal coat could then be placed over the surface to protect the pavement structure over the winter and spring thaw months. In 1992 any additional pavement distress areas that have appeared should be corrected. The final lifts and paving fabric could then be placed over the entire pavement surface. This work could possibly be coordinated with Fort Collin's 1992 street overlay program.

   One possible problem with this alternative is the curb/gutter structure to be build adjacent to the east pavement edge. Plans need to be developed to prevent the water accumulation on the pavement surface.

6. For the excavation areas a replacement structural section has been designed by Terracon (Job No. 12915031, June 7, 1991). It was assumed that a stockpile would be used for

the pavement supporting soil and a reported representative sample had a tested R-value of 11. The traffic EDAL used for their analysis was 145. A twenty year design period was used and a growth factor was incorporated into the EDAL figure. One alternative structural section recommendation was four inches of asphalt concrete over eight inches aggregate base over eight inches subbase (4"AC/8"Base/8"Subbase). It may be worthwhile to test the specific material that will be used to support the pavement structural section. Perhaps a higher on-site R-value material can be used and thereby reducing the pavement structural section component thicknesses. This is suggested considering that the existing pavement structural section of 2.5"AC/6"Base/18"Subbase has performed fairly well over the past 20-year life span.

APPENDIX

SOUTH SHIELDS ROAD, FORT COLLINS FILE: C92-02.WK1
DYNAMIC STIFFNESS MODULUS TEST RESULTS FOR SOUTHBOUND LANE
LIMITS: FROM 1/2 MILE SOUTH OF HARMONY TO FOSSIL CREEK RD

DIST	FORCE #1	DEFL1	FORCE #2	DEFL2	FORCE #3	DEFL3	CORR	DSM (u)	ADJ	DSM (a)
2500	1.14	1.57	2.43	3.66	3.41	5.51	0.998	577	1.0	577
2550	0.98	1.23	2.34	3.19	3.06	4.78	0.987	590	1.0	590
2600	1.19	1.6	2.27	3.16	3.17	4.68	0.998	643	1.0	643
2650	0.93	1.05	2.19	2.73	3.1	4.14	0.998	704	1.0	704
2700	1.14	1.48	2.23	3.19	3.09	4.66	0.999	614	1.0	614
2750	1.15	1.33	2.26	2.86	3.05	4.11	0.998	685	1.0	685
2800	1.06	1.56	2.37	4.13	3.25	6.04	0.999	490	1.0	490
2850	1.06	1.44	2.17	3.29	3.22	5.33	0.998	555	1.0	555
2900	1.23	3.04	2.12	5.77	3.09	9.4	0.997	291	1.0	291
2950	1.36	2.1	2.22	3.85	3.11	6.03	0.997	444	1.0	444
3000	1.19	1.92	2.3	4.25	3.24	6.63	0.997	435	1.0	435
3050	0.87	1.1	2.36	3.82	3.45	6.41	0.994	486	1.0	486
3100	0.69	0.89	2.28	3.67	3.44	6.4	0.993	499	1.0	499
3150	1.13	1.42	2.4	3.7	3.34	5.87	0.995	497	1.0	497
3200	1.12	1.33	2.27	3.29	3.4	5.72	0.996	517	1.0	517
3250	1.24	2.31	2.37	5.24	3.3	8.28	0.996	345	1.0	345
3300	1.18	2.38	2.07	4.76	3.16	8.5	0.995	321	1.0	321
3350	1.12	2.42	2.15	5.69	3.2	10.1	0.994	269	1.0	269
3400	1.41	3.55	2.24	6.48	3.16	10.4	0.997	254	1.0	254
3450	1.17	2.51	2.26	5.75	3.21	9.26	0.996	302	1.0	302
3500	1.06	2.24	2.17	5.3	3.15	8.57	0.997	330	1.0	330
3550	1.34	3.59	2.16	6.51	3.05	10.1	0.998	260	1.0	260
3600	1.18	3	2.13	6.35	3.2	11.0	0.996	250	1.0	250
3650	1.24	2.5	2.19	5.01	3.26	8.68	0.995	324	1.0	324
3700	1.38	3.07	2.4	6.25	3.22	9.4	0.996	291	1.0	291
3750	1.17	2.45	2.35	6.01	3.22	9.18	0.997	305	1.0	305
3800	1.51	3.26	2.28	5.36	3.19	8.53	0.995	316	1.0	316
3850	1.19	2.56	2.12	5.28	3.19	9.24	0.996	297	1.0	297
3900	1.12	2.42	2.18	5.75	3.09	9.36	0.995	283	1.0	283
3950	1.35	3.52	2.19	6.78	3.14	11.3	0.996	227	1.0	227
4000	1.17	2.85	2.16	6.16	3.19	10.3	0.997	270	1.0	270
4050	1.41	2.93	2.36	5.73	3.29	9.05	0.997	306	1.0	306
4100	1.07	1.82	2.26	4.46	3.36	7.61	0.995	394	1.0	394
4150	1.39	2.46	2.19	4.19	3.28	7.02	0.997	412	1.0	412
4200	1.3	1.7	2.35	3.5	3.34	5.54	0.997	530	1.0	530
4250	1.34	2.14	2.25	4.03	3.19	6.28	0.998	446	1.0	446
4300	1.17	1.66	2.41	3.79	3.37	5.87	0.996	523	1.0	523
4350	1.28	1.54	2.35	3.27	3.28	5.09	0.997	563	1.0	563
4400	1.22	2.49	2.16	5.07	3.2	8.88	0.993	307	1.0	307
4450	1.12	2.14	2.13	4.87	3.13	8.25	0.996	328	1.0	328
4500	1.39	3.08	2.25	5.61	3.3	9.56	0.995	292	1.0	292
4550	1.6	3.64	2.39	6.03	3.21	9.14	0.996	291	1.0	291
4600	1.34	2.97	2.18	5.49	3.09	9.02	0.995	287	1.0	287
4650	1.51	3.49	2.2	5.56	3.15	8.99	0.997	296	1.0	296
4700	1.33	2.96	2.25	5.83	3.17	9.3	0.997	289	1.0	289
4750	1.59	3.84	2.12	5.56	3.1	9.39	0.998	269	1.0	269
4800	1.53	3.89	2.21	6.17	3.08	9.76	0.997	262	1.0	262
4850	1.32	2.97	2.11	5.27	3.05	8.73	0.996	298	1.0	298
4900	1.23	3.25	2.23	6.94	3.09	11.0	0.995	239	1.0	239

SOUTH SHIELDS ROAD, FORT COLLINS FILE: C92-02.WK1
DYNAMIC STIFFNESS MODULUS TEST RESULTS FOR SOUTHBOUND LANE
LIMITS: FROM 1/2 MILE SOUTH OF HARMONY TO FOSSIL CREEK RD

DIST	FORCE #1	DEFL1	FORCE #2	DEFL2	FORCE #3	DEFL3	CORR	DSM (u)	ADJ	DSM (a)
4950	1.64	5.81	2.25	8.62	3.12	13.7	0.995	184	1.0	184
5000	1.61	4.17	2.39	6.8	3.13	10	0.995	260	1.0	260
5050	1.57	4.71	2.29	8.52	3.12	11.4	0.986	228	1.0	228
5100	1.13	3.06	2.17	6.97	3.16	11.7	0.995	233	1.0	233
5150	1.05	3.56	2.11	8.5	3.07	14.1	0.995	190	1.0	190
5200	1.4	3.63	2.19	6.19	3.23	10.5	0.995	263	1.0	263
5250	1.58	2.55	2.41	4.27	3.17	6.28	0.995	425	1.0	425
5300	0.97	1.53	2.26	4.27	3.24	6.8	0.997	431	1.0	431

SOUTH SHIELDS ROAD, FORT COLLINS FILE: C92-02.WK1
DYNAMIC STIFFNESS MODULUS TEST RESULTS FOR NORTHBOUND LANE
LIMITS: FROM 1/2 MILE SOUTH OF HARMONY TO FOSSIL CREEK RD

DIST	FORCE #1	DEFL1	FORCE #2	DEFL2	FORCE #3	DEFL3	CORR	DSM (u)	ADJ	DSM (a)
2500		NO TEST								
2550		NO TEST								
2600	0.97	0.78	2.29	2.2	3.42	3.49	1.000	904	1.0	904
2650	1.13	1.13	2.18	2.31	3.31	3.82	0.998	808	1.0	808
2700	1.12	1.29	2.26	2.68	3.27	4.04	0.999	782	1.0	782
2750	0.95	0.91	2.19	2.28	3.13	3.48	0.998	850	1.0	850
2800	1.06	1.78	2.11	3.91	3.26	6.78	0.997	438	1.0	438
2850	0.95	1.45	2.17	3.59	3.22	5.88	0.996	512	1.0	512
2900	1.47	4.18	2.36	7.27	3.25	11.0	0.997	260	1.0	260
2950	0.95	1.31	2.17	3.55	3.15	5.83	0.995	487	1.0	487
3000	1.51	2.52	2.29	4.05	3.39	6.64	0.998	453	1.0	453
3050	1.04	1.92	2.27	4.53	3.16	6.98	0.995	420	1.0	420
3100	0.98	1.61	2.29	4.18	3.32	6.83	0.994	448	1.0	448
3150	1.22	1.8	2.15	3.51	3.28	6.16	0.995	469	1.0	469
3200	1.41	1.95	2.1	3.07	3.08	5.23	0.993	502	1.0	502
3250	1.02	1.65	2.4	4.37	3.28	6.83	0.990	438	1.0	438
3300	0.91	1.88	2.25	5.34	3.35	9.68	0.985	310	1.0	310
3350	1.08	2.86	2.27	7.01	3.39	11.9	0.996	254	1.0	254
3400	1.07	3.26	2.17	7.53	3.19	12.6	0.995	226	1.0	226
3450	1.44	3.03	2.34	5.27	3.47	8.62	0.998	361	1.0	361
3500	1.14	3.58	2.25	7.77	3.12	11.8	0.996	239	1.0	239
3550	1.01	2.53	2.2	6.04	3.23	9.91	0.995	300	1.0	300
3600	1.4	3.83	2.37	7.04	3.18	10.3	0.996	271	1.0	271
3650	1.22	4.13	2.15	7.82	3.09	12.6	0.994	218	1.0	218
3700	1.36	4.18	2.34	7.94	3.14	11.9	0.994	228	1.0	228
3750	1.39	4.61	2.2	8.03	3.1	12.6	0.997	211	1.0	211
3800	1.08	2.86	2.23	6.86	3.08	10.6	0.995	257	1.0	257
3850	1.36	3.31	2.13	5.79	3.15	9.87	0.996	271	1.0	271
3900	1.01	2.49	2.1	6.06	3.12	10.5	0.993	262	1.0	262
3950	1.33	3.49	2.15	6.41	3.1	10.5	0.996	248	1.0	248
4000	1.4	4.05	2.33	7.76	3.09	11.5	0.996	224	1.0	224
4050	1.07	1.86	2.18	4.24	3.19	6.88	0.997	422	1.0	422
4100	1.18	2.03	2.26	4.39	3.14	6.67	0.998	423	1.0	423
4150	1.03	1.38	2.15	3.25	3.11	5.16	0.997	550	1.0	550
4200	1.04	1.65	2.22	3.84	3.25	6.18	0.997	487	1.0	487
4250	1.1	1.78	2.24	4.1	3.24	6.56	0.997	447	1.0	447
4300	0.99	1.5	2.23	3.99	3.36	6.71	0.997	454	1.0	454
4350	0.97	1.76	2.16	4.45	3.16	7.54	0.992	378	1.0	378
4400	1.07	2.45	2.22	5.63	3.25	9.47	0.993	309	1.0	309
4450	1.06	2.12	2.12	4.66	3.15	7.86	0.994	362	1.0	362
4500	1.25	2.64	2.08	4.89	3.14	8.35	0.997	329	1.0	329
4550	1.65	4.42	2.24	6.09	3.17	9.66	0.994	285	1.0	285
4600	1.11	2.36	2.18	5.39	3.12	8.71	0.996	316	1.0	316
4650	1.43	3.17	2.25	5.45	3.13	8.38	0.997	325	1.0	325
4700	1	1.96	2.13	4.93	3.15	8.48	0.993	328	1.0	328
4750	1.03	2.09	2.1	4.91	3.09	8.22	0.995	335	1.0	335
4800	0.85	1.89	2.28	6.41	3.29	10.7	0.992	276	1.0	276
4850	0.91	1.78	2.17	5.4	3.2	9.27	0.994	305	1.0	305
4900	1.23	3.11	2.12	6.1	3.18	10.5	0.996	260	1.0	260
4950	1.12	2.51	2.1	5.47	3.21	9.86	0.994	282	1.0	282

SOUTH SHIELDS ROAD, FORT COLLINS FILE: C92-02.WK1
DYNAMIC STIFFNESS MODULUS TEST RESULTS FOR NORTHBOUND LANE
LIMITS: FROM 1/2 MILE SOUTH OF HARMONY TO FOSSIL CREEK RD

DIST	FORCE #1	DEFL1	FORCE #2	DEFL2	FORCE #3	DEFL3	CORR	DSM (u)	ADJ	DSM (a)
5000	1.19	2.94	2.16	6.25	3.15	10.5	0.995	255	1.0	255
5050	1.09	3.13	2.2	7.26	3.07	11.8	0.989	225	1.0	225
5100	1.25	3.18	2.09	5.99	3.18	10.8	0.994	250	1.0	250
5150	1.08	2.4	2.17	5.86	3.12	9.64	0.996	281	1.0	281
5200	1.3	3.86	2.26	7.54	2.92	10.5	0.997	241	1.0	241
5250	1.02	1.25	2.17	3.04	3.05	4.78	0.995	575	1.0	575
5300	1.16	1.68	2.14	3.51	3.18	5.96	0.996	469	1.0	469

GEOCIVIL ENGINEERS 12-Sep-91

ROAD PAVEMENT ANALYSIS & OVERLAY DESIGN USING NDT DATA C91-02
PROJECT: SOUTH SHIELDS ROAD file; C91-02B.WK1
LOCATION: ZONE B

DESIGN DYNAMIC STIFFNESS MODULUS (DSM): DSM = 395 Kips/in

Allowable 18Kips Single-Axle Load Passes (ASALP): 2.4E+06 passes

EXISTING PAVEMENT STRUCTURAL SECTION:		FACTOR	THICKNESS	EQUIVALENT
ASPHALT CONCRETE	50%	2.30	3.0	3.4
TREATED BASE		2.00	0.0	0.0
AGGREGATE BASE	75%	1.50	6.0	6.8
AGGREGATE SUBBASE	75%	1.00	24.0	18.0
			Total =	28.2

TOTAL EQUIVALENT PAVEMENT SECTION THICKNESS (Teq) 19.65 inches

CALCULATE REQUIRED PAVEMENT THICKNESS (Tr):

ASALP = 2.4E+06 passes
Teq = 19.65 inches
S.F. = 4.4

TRAFFIC: 10 DESIGN,
EQUIVALENT STANDARD AXLE LOAD PASSES (ESAL) = 719,533

Teq = 19.65 inches
S.F. = 4.4
Traffic = 7.2E+05
Tr = 16.5 inches

COMPUTE REQUIRED OVERLAY THICKNESS (To) = 0.0 inches
RECOMMENDED THICKNESS = 0.0 inches
(1.5" minimum) **********

GEOCIVIL ENGINEERS 12-Sep-91

ROAD PAVEMENT ANALYSIS & OVERLAY DESIGN USING NDT DATA C91-02
PROJECT: SOUTH SHIELDS ROAD file; C91-02B.WK1
LOCATION: ZONE C

DESIGN DYNAMIC STIFFNESS MODULUS (DSM): DSM = 235 Kips/in

Allowable 18Kips Single-Axle Load Passes (ASALP): 4.8E+03 passes

EXISTING PAVEMENT STRUCTURAL SECTION:	FACTOR		THICKNESS	EQUIVALENT
ASPHALT CONCRETE	50%	2.30	2.5	2.9
TREATED BASE		2.00	0.0	0.0
AGGREGATE BASE	75%	1.50	6.0	6.8
AGGREGATE SUBBASE	75%	1.00	18.0	13.5
			Total =	23.125

TOTAL EQUIVALENT PAVEMENT SECTION THICKNESS (Teq) 11.04 inches

CALCULATE REQUIRED PAVEMENT THICKNESS (Tr):

ASALP = 4.8E+03 passes
Teq = 11.04 inches
S.F. = 5

TRAFFIC: 10 DESIGN,
EQUIVALENT STANDARD AXLE LOAD PASSES (ESAL) = 719,533

Teq = 11.04 inches
S.F. = 5
Traffic = 7.2E+05
Tr = 16.5 inches

COMPUTE REQUIRED OVERLAY THICKNESS (To) = 2.4 inches
RECOMMENDED THICKNESS = 2.5 inches
(1.5" minimum) **********

Terracon
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June 7, 1991

Land Development Services
4924 South Shields
Ft. Collins, CO 80526

ATTN: Mr. Dennis Donovan

RE: Pavement Section Evaluation
South Shields Street
(Clarendon Hills)
Ft. Collins, Colorado
Job No. 12915031

Mr. Donovan:

Enclosed, herewith, are the results of the structural pavement section evaluation you requested for the referenced project. We understand this project involves the widening and paving of South Shields Street adjacent to the Clarendon Hills Subdivision in Ft. Collins, Colorado. That development is located south of Harmony Road and east of South Shields. The project includes construction of under-road drainage structures. Minor cuts and fills of 10 to 15 feet are currently being placed to develop the pavement subgrades.

Terracon personnel obtained a representative sample of stockpiled site materials being used for fill in the roadway section. The Hveem stabilometer R-value of a remolded sample of those materials was determined in the laboratory to provide a basis for the pavement design. An R-value of 11.0 was established for the remolded sample and was used in the pavement evaluation.

The 1986 "AASHTO Guide for Design of Pavement Structures" was used to help evaluate alternative pavement sections. An average 18-kip equivalent daily axle load (EDAL) of 145 was provided by the City of Ft. Collins for use in the pavement design. A resilient modulus of 7100 psi was used for the design based on the AASHTO recommended

correlation. A design reliability of 90 percent was assigned to the arterial street with standard deviations of 0.44 and 0.34 used for flexible and rigid pavement designs, respectively. A serviceability loss due to traffic of 2.0 was used for both designs. The rigid concrete pavement was assumed to be non-reinforced with a modulus of rupture of 650 psi.

Based on the above-outlined design parameters, a rigid concrete pavement thickness of 8.5 inches and flexible pavement weighted structure number of 3.46 were calculated for the roadway. Alternative sections to meet the flexible pavement structural number would include: 8 inches of full-depth asphaltic concrete; 4 inches of asphaltic concrete overlying 14 1/2 inches of high-quality aggregate base course or; 4 inches of asphaltic concrete underlain by 8 inches of high-quality aggregate base course and 8 inches of lesser quality subbase material. Other alternatives could be used to meet the pavement structural number requirements and we would be pleased to evaluate those alternatives, at your request.

Portland cement concrete used for the pavement design should consist of high-quality, ready mix concrete with a minimum compressive strength of 3,500 psi. The pavement concrete should be air entrained. The recommended pavement section is based on a non-reinforced concrete with good surface drainages.

Asphalt for use in the roadway should consist of high-quality hot-bituminous pavement consistent with City of Ft. Collins standards for SC Type 1 or SC Type 2 asphaltic concrete. High-quality aggregate base should consist of either Class 5 or Class 6 base as defined by City of Ft. Collins criteria and the underlying subbase aggregate should be Class 1 material as defined by the city standards.

The analysis and recommendations presented in this report are based upon the information obtained from the laboratory testing and any other data discussed in this report. It is recommended that the geotechnical engineer be retained to review the plans and specifications so that comments can be made regarding the interpretation and implementation of our geotechnical recommendations in the design and specifications.

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 other warranty, expressed or implied, is made. In the event that any 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 the changes are reviewed and the conclusions of this report modified or verified in writing by the geotechnical engineer.

We appreciate the opportunity to be of service to you on this project. If you have any questions or require any additional information, please do not hesitate to contact us.

Very truly yours,

TERRACON CONSULTANTS SE, INC.

Lester L. Litton, P.E.
Colorado No. 23957

Craig K. Denny dmf
Craig K. Denny, P.E.

LLL/dmf

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July 23, 1991

Land Development Services
309 West Harmony Road
Ft. Collins, CO 80525

ATTN: Mr. Dennis Donovan

RE: Pavement Subgrade Evaluation
South Shields Street
(Clarendon Hills 4th Addition)
Ft. Collins, Colorado
Job No. 12915031

Mr. Donovan:

The additional evaluation of in-situ and stockpiled pavement subgrade materials you requested for the South Shields Street Reconstruction Project adjacent to the Clarendon Hills Development has been completed. Two samples of subgrade materials; one sample from an expected cut area near the north end of the project and a second sample from stockpiled borrow materials were obtained for laboratory evaluation. The materials were obtained from locations jointly identified by City of Ft. Collins and Terracon personnel.

Laboratory testing on the recovered samples included washed sieve analysis, Atterberg limits and Hveem stabilometer R-value tests. Materials recovered from both the stockpile and in-situ subgrade consisted of sandy lean clay with trace gravel observed in the stockpile sample. Hveem stabilometer R-values of 15.0 were determined for both samples. Results of the other laboratory tests are shown on the attached summary.

In our report of June 7, 1991 for this project, recommendations concerning structural pavement sections for the South Shields Street reconstruction were provided. Those recommendations were based on a laboratory Hveem stabilometer R-value of 11 and traffic data provided by City of Fort Collins personnel. In our opinion, the recommended pavement sections would still be applicable based on the additional evaluation of the on-site soils as outlined in this report.

We appreciate the opportunity to be of service to you on this project. If you have any questions or require any additional information, please do not hesitate to contact us.

Very truly yours,

TERRACON CONSULTANTS SE, INC.

Lester L. Litton, P.E.
Colorado No. 23957

LLL/dmf

TERRACON CONSULTANTS SE, INC.

Project: Pavement Subgrade Evaluation
South Shields Street
(Clarendon Hills 4th Addition)
Fort Collins, Colorado

Job No: 12915031
Date: July 1991

SUMMARY OF LABORATORY INDEX TESTS

Sample Location	Material	Atterberg Limits (%) LL	PL	PI	Minus #200 (%)	Unified Symbol
Stockpile	Brown Sandy Lean Clay, Trace Gravel	32	19	13	54.2	CL
STA 1+50	Brown Sandy Lean Clay	30	17	13	62.9	CL

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Lester L. Litton, PE

August 21, 1991

Land Development Services
309 West Harmony Road, Unit "B"
Ft. Collins, CO 80526

ATTN: Mr. Dennis Donovan

RE: Pavement Section/Subgrade Evaluation
South Shields Street
Ft. Collins, Colorado
Job No. 12915031

Mr. Donovan:

Attached with this letter are results of the pavement section evaluation you requested for South Shields Street adjacent to the Clarendon Hills development.

As requested, pavement section evaluations were performed at Stations 42+00, 36+00 and 30+00. Those evaluations were completed in the east (northbound) lane of South Shields Street. At those locations, asphalt cores were obtained using a 3-inch nominal diameter diamond bit core barrel. Below the asphalt pavement, the borings were advanced using a rotary drill rig equipped with continuous flight augers. As requested, one sample was obtained from the subgrade material encountered in each boring at a depth of approximately 1 foot below the base and/or subbase. The subgrade samples were obtained using thin-walled tube sampling procedures. For that sampling, pitrun aggregate (which was encountered below the road base material) was defined as subbase.

As requested, moisture content, Atterberg limits and washed sieve analysis tests were completed on each of the recovered subgrade samples. Those soils were also observed in the laboratory by an engineer and classified in accordance with the attached General Notes and the Unified Soil Classification System. A brief description of the Unified Classification System is included with this letter.

A brief summary describing the materials encountered in the test borings and providing results of the laboratory testing is attached. The stratification boundaries shown on the attached summary represent the approximate locations of changes in material types; in-situ, the transition of materials may be gradual and indistinct.

We have not been asked to interpret the attached data nor to make design and/or construction recommendations based on this information and cannot assume liability for interpretation of this data by others.

We appreciate the opportunity to provide services to you on this project. If you have any questions concerning this report, or if we can be of further service to you in any other way, please do not hesitate to contact us.

Very truly yours,

TERRACON CONSULTANTS SE, INC.

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TERRACON CONSULTANTS SE, INC.

Project: South Shields Street
(Clarendon Hills 4th Addition)
Fort Collins, Colorado

Job No: 12915031
Date: August 1991

SUMMARY OF PAVEMENT/SUBGRADE CORES

Boring	Location	Depth	Layer Thickness	Material Description	Moisture Content(%)	Minus 200 (%)	Atterberg Limits (%) LL	PL	PI
B-1	STA 42+00 East Lane	0 - 2 11/16"	2 11/16"	Asphalt Pavement					
		2 11/16" - 9"	6"	Aggregate Base					
		9" - 27"	18"	Pitrun Aggregate					
		27" - 39"	12"	Dark Brown Silty Sand					
		39" - 51"	12"	Brown Fat Clay	25.7	91.5	62	40	22
B-2	STA 36+00 East Lane	0" - 2 1/2"	2 8/16"	Asphalt Pavement					
		2 1/2 - 9"	6"	Aggregate Base					
		9" - 21"	12"	Pitrun Aggregate					
		21" - 39"	18"	Dark Brown Silty Sand					
		39" - 51"	12"	Brown Sandy Lean Clay	16.6	57.0	23	18	5
B-3	STA 30+00 East Lane	0" - 3"	3"	Asphalt Pavement					
		3" - 9"	6"	Aggregate Base					
		9" - 33"	24"	Pitrun Aggregate					
		33" - 51"	18"	Dark Brown Silty Sand					
		51" - 63"	12"	Brown Siltstone/Sandstone	11.0	62.8	33	20	13

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UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	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]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[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[E]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[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 / Liquid limit — not dried < 0.75	OL	Organic clay[K, L, M, N] / 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 plots below "A" line	MH	Elastic silt[K, L, M]
		organic	Liquid limit — oven dried / Liquid limit — not dried < 0.75	OH	Organic clay[K, L, M, P] / 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] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[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.

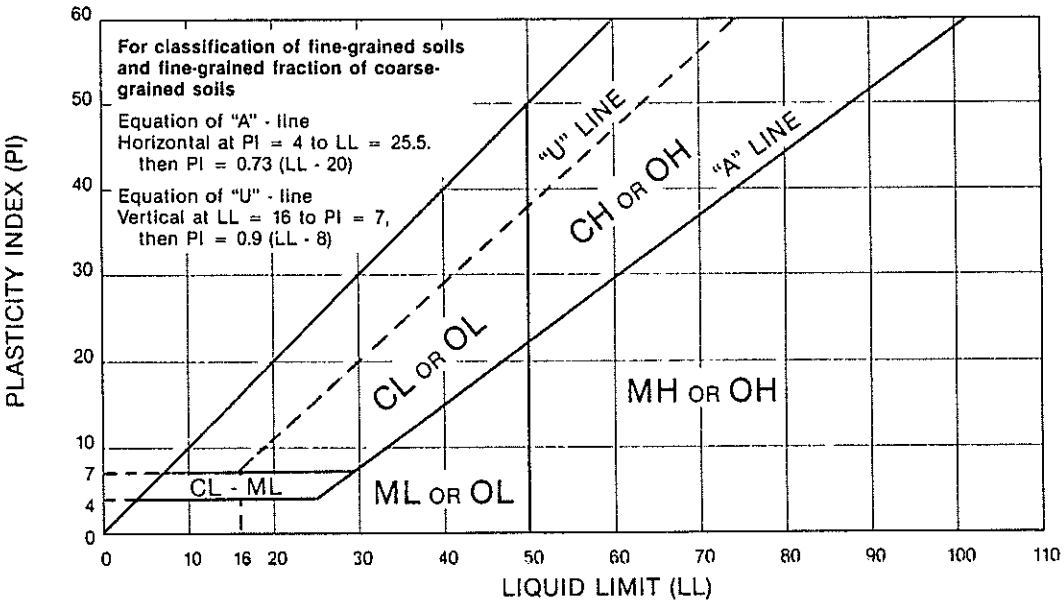
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[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.



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