Springville Performance Evaluation & Pavement Design for Minor Collectors

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CEEn-2018CPST-013

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Introduction, Project Tasks, and Deliverables

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Several Minor Collectors Throughout Springville Are Failing Pre

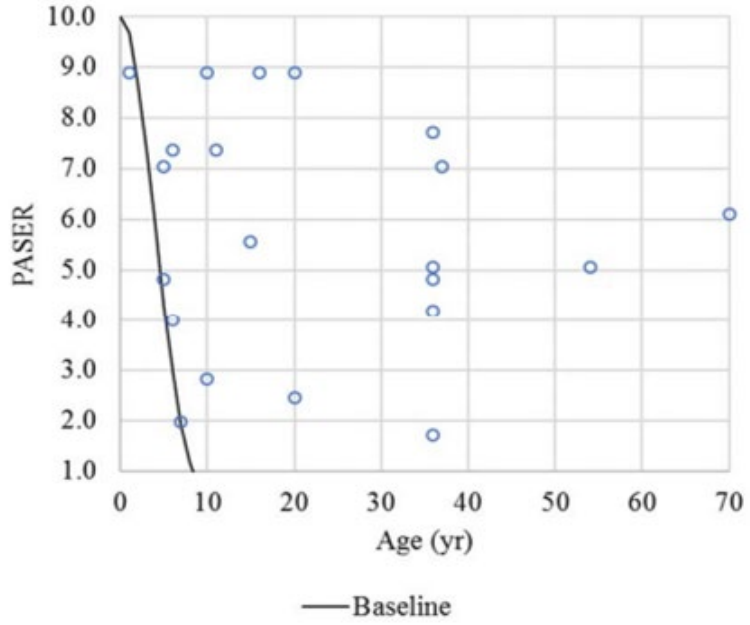


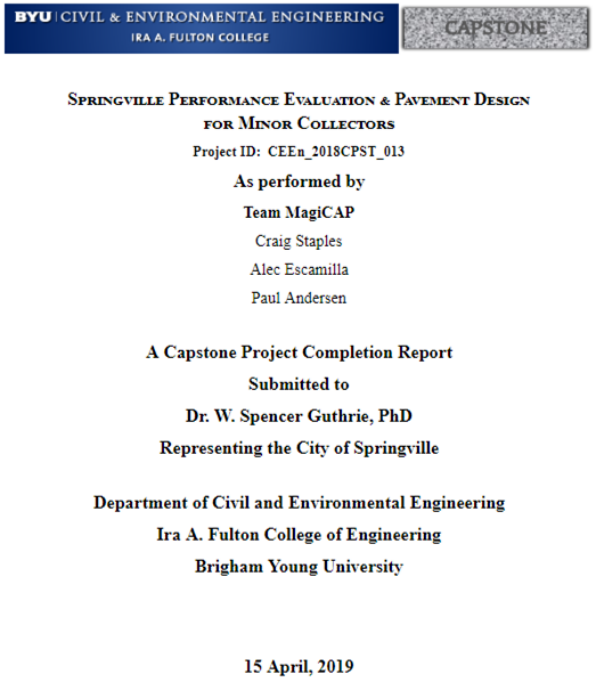
Figure 1. Baseline deterioration curve for minor collector streets

A study previously completed by Infrastructure Research, LLC found that the expected pavement service life of minor collector streets in Springville City was unsatisfactory. The same five streets, identified in Table 1, were used this study.

Table 1. Pavement Segment Information

Geographic Region	Segment Number	Location	Pavement Age (yr)	Average PASER Value
West	1438	550 N, 750 to 800 W	11	5.0
	1053	550 W, 300 to 400 S	10	3.3
Southeast	1085	900 S, 1600 to 1650 E	20	10.0
	193	800 E, 800 to 900 S	21	2.5
Northeast	873	400 E, 1000 to 1050 N	5	4.0

The Project Consisted of Three Main Tasks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CAPSTONE

SPRINGVILLE PERFORMANCE EVALUATION & PAVEMENT DESIGN FOR MINOR COLLECTORS

Project ID: CEEn_2018CPST_013

As performed by

Team MagiCAP

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A Capstone Project Completion Report

Submitted to

Dr. W. Spencer Guthrie, PhD

Representing the City of Springville

Department of Civil and Environmental Engineering

Ira A. Fulton College of Engineering

Brigham Young University

15 April, 2019

Task 1: Determine the lifetime ESAL experienced by the five streets studied.

Task 2: Characterize the structural properties of the asphalt and base materials.

Task 3: Perform a mechanistic-empirical analysis for pavement design options.

The findings from this project are summarized in a final report which is submitted with this presentation.

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Traffic Counts Were Used to Obtain a Better Understanding of L ESALs

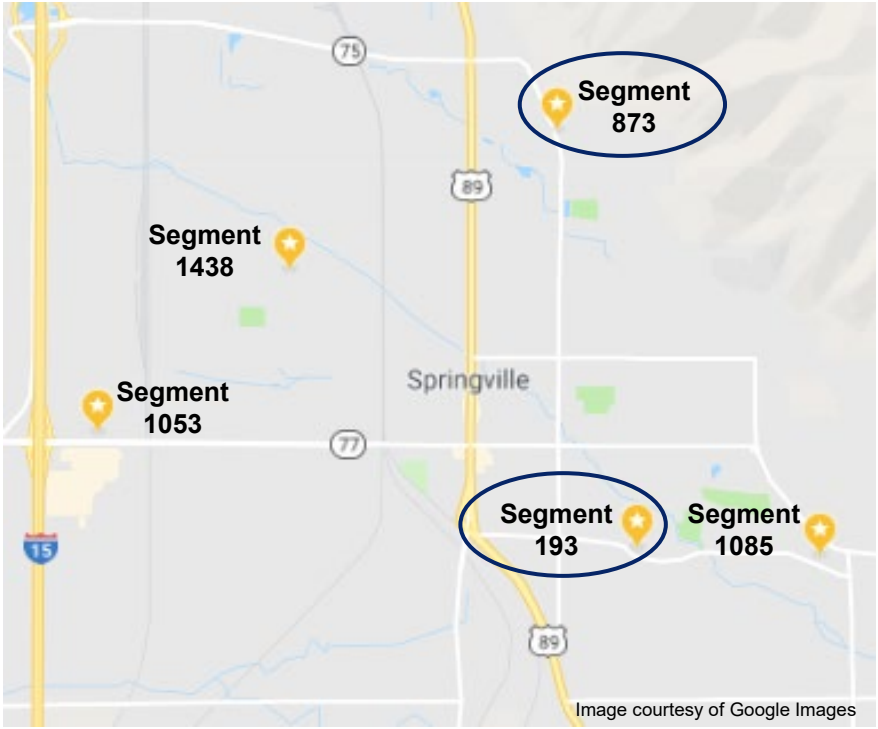
24-hour traffic counts were performed on five minor collectors in Springville. Lifetime ESAL values were determined for each of these locations. It was observed for the critical pavement section that after ½ of its 20-yr. design life it had already been subjected to 117% of its allowable ESAL loads, as limited by the base course material.

Due to the limitations of our traffic study, a more conservative estimate of the average daily traffic from the Springville City Transportation Master Plan was used in conjunction with our data to more accurately predict and forecast the expected lifetime ESALs. Source: Springville City TMP 2016

Two Streets Were Selected for Further Pavement and Soil Analy

In the interest of time, resources, and weather, only two streets were able to be studied beyond the traffic counts.

Segments 193 and 873 were chosen because each performed at an opposite extreme during a previously conducted infiltration study of the base material. Segment 873 allowed 0 $in.^3$ water ingress after 30 minutes of soaking, whereas segment 193 allowed 10.7 $in.^3$ of water ingress in 30 minutes.



4” and 12” Asphalt Cores Were Taken at Two Locations for Furt

Marshall Stability and Marshall Flow measurements were taken for each of the core samples in the BYU pavement laboratory. These measurements revealed that there was some significant inconsistency in the stability of the pavements, particularly between new overlays and the original pavement material.

Segment 873

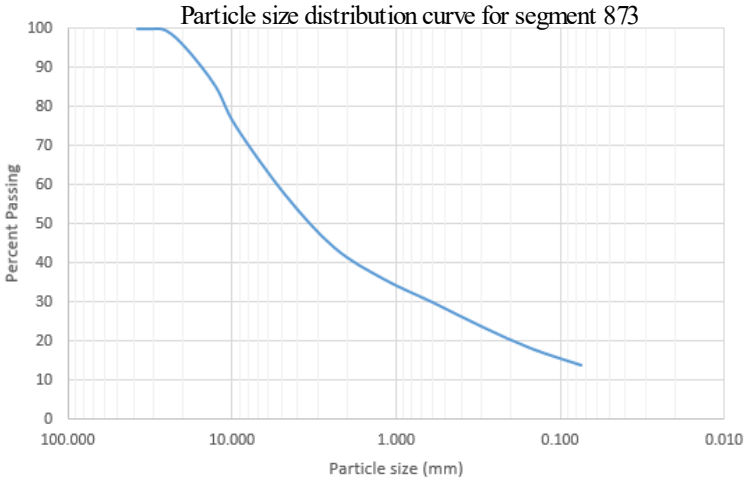
Average Flow (in)	**Top Layer**	Average Stability (lbs)
20		2414
Average Flow (in)	**Bottom Layer**	Average Stability (lbs)
20		1677

Segment 193

Average Flow (in)	**Top Layer**	Average Stability (lbs)
25		793
Average Flow (in)	**Bottom Layer**	Average Stability (lbs)
30		2529

Gradations Indicated That the Base Material Contained High Fir

Particle size distribution curves were generated for both a dry sieve and a washed sieve of the base material at segment 193 and 873. The dry sieve resulted in ~3% passing the No. 200. The washed sieve, however, reported 14% passing the No. 200. This is above the permissible as per Springville City Engineering Specifications.



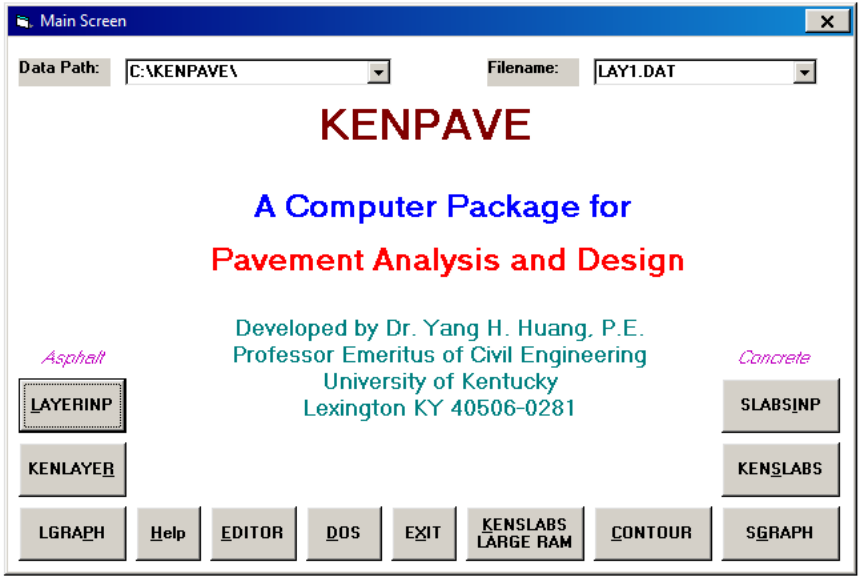
Springville City Roadway Construction Engineering Specifications

Source: Springville City Website

Sieve	1.5”	1”	3/4”	1/2”	3/8"	No. 4	No. 8	No. 200
Percent Passing by Weight	100	90-100	<90	-	-	-	19-45	1-7

A Mechanistic-Empirical Analysis Was Performed to Determine Pavement Thicknesses

The analysis was two-fold. First, the computer software, KENPAVE, was used to determine pavement thicknesses for the mechanistic analysis. 168 combinations of asphalt and CTB thicknesses were analyzed, based on a 7-day unconfined compressive strength (400, 450, and 500 psi) for the CTB material and assumed subgrade Modulus of Elasticity values for the West and East locations in Springville.



Mechanistic-Empirical Analysis Continued

Second, an empirical analysis was performed on each of the pavement designs to determine the allowable ESALs to failure. Failure was determined to be less than 1,000,000 ESAL passes. Empirical transfer function formulas were taken from Guthrie, Crane and Eggett (2009). CTB passes were determined using the Uzan method.

Asphalt Thickness (in)	CTB Thickness (in)	UCS 400 psi		UCS 450 psi		UCS 500 psi	
		West	East	West	East	West	East
3.0	6.0	0	45	2	374	12	2,424
3.0	8.0	104	15,920	907	134,035	6,180	883,297
3.0	10.0	22,659	2,643,000	200,681	22,572,579	1,388,606	69,799,835
3.0	12.0	2,613,749	167,459,178	23,415,229	179,792,712	47,222,659	192,087,989
3.5	6.0	1	186	8	1,535	55	9,935
3.5	8.0	393	55,882	3,421	469,009	23,240	3,081,343
3.5	10.0	72,837	7,998,103	642,455	68,077,447	4,424,055	89,707,856
3.5	12.0	7,571,930	209,908,241	55,673,054	224,789,760	59,676,864	240,216,243
4.0	6.0	4	725	35	5,983	237	38,658
4.0	8.0	1,419	187,697	12,299	1,571,226	83,300	10,296,395
4.0	10.0	225,498	23,381,701	1,980,779	107,102,381	13,588,476	113,903,693
4.0	12.0	21,225,577	261,152,376	69,968,727	278,791,134	74,723,772	297,909,580
4.5	6.0	17	2,706	145	22,284	970	143,687
4.5	8.0	4,886	593,838	42,292	4,961,857	286,047	32,454,509
4.5	10.0	674,674	66,261,849	5,906,050	135,052,640	34,633,175	143,287,273
4.5	12.0	57,725,159	323,016,000	87,229,031	344,746,907	93,228,536	367,006,050
5.0	6.0	67	9,700	567	79,690	3,776	512,892
5.0	8.0	15,840	1,790,167	136,739	14,918,214	922,396	64,038,651
5.0	10.0	1,956,676	158,423,061	17,074,734	168,446,601	43,921,191	179,257,069
5.0	12.0	101,321,728	396,651,054	108,248,777	423,109,146	115,764,130	450,106,063
5.5	6.0	249	33,501	2,114	274,611	14,047	1,763,011
5.5	8.0	49,698	5,254,555	427,997	43,694,558	2,880,057	81,899,884
5.5	10.0	5,518,333	197,413,147	47,991,898	209,908,241	55,418,001	222,686,152
5.5	12.0	125,298,534	484,618,902	133,924,054	516,530,055	142,477,036	551,050,048
6.0	6.0	893	111,840	7,567	914,627	50,160	5,858,391
6.0	8.0	151,390	15,060,287	1,300,304	98,446,158	8,729,660	104,025,519
6.0	10.0	15,159,477	244,078,272	65,267,055	259,464,618	69,463,546	275,149,492
6.0	12.0	153,906,883	590,729,175	164,539,099	628,970,108	175,041,459	670,283,760

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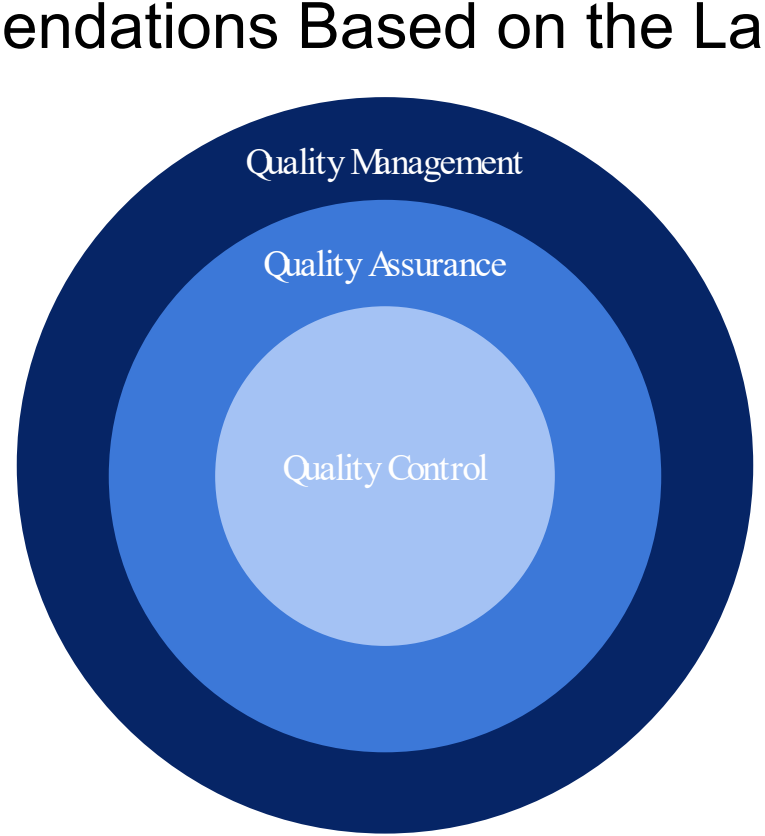
There Are Three Main Recommendations Based on the Laborat

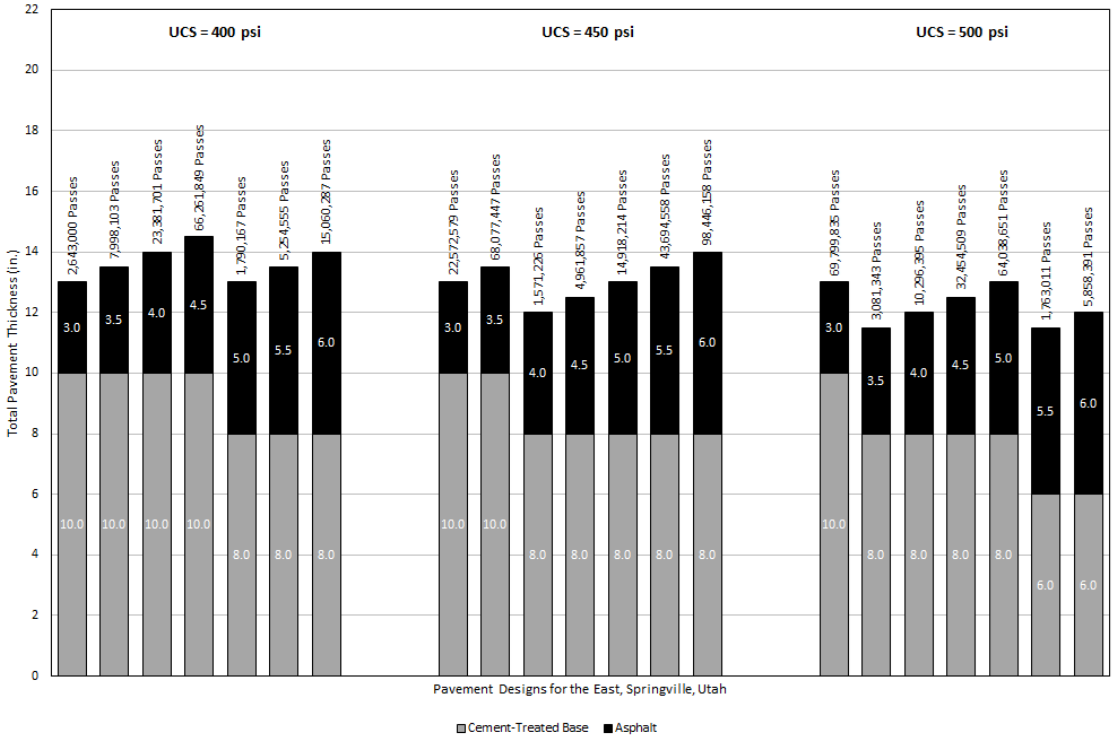
1. Improve base materials for construction
2. Enforce quality assurance and quality control during construction
3. Improve asphalt modulus of elasticity for stiffer overlays

These recommendations will improve the overall quality of the city's asset management program. Improved base materials will mitigate the effects of frost heave stresses. Better Quality Assurance, Quality Control and design specifications will elongate pavement life.



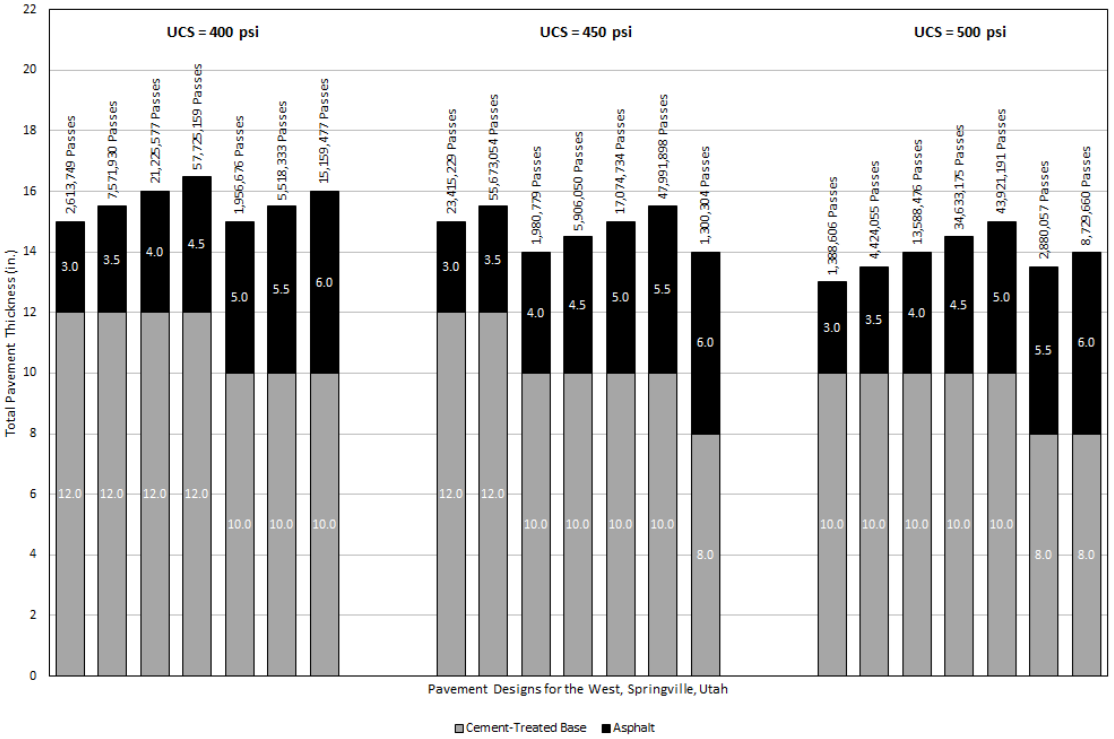
A New Cement-Treated Base Design for the East Section of Springville

These designs for the East side of Springville would withstand a lifetime ESAL of at least 1,000,000. The CTB layer would protect the asphalt layer above from early deterioration. Cost-benefit analyses should be conducted to determine asphalt and CTB thicknesses. Only CTB designs were considered for this project.



A New Cement-Treated Base Design for the West Section of Springville

These designs for the West side of Springville would withstand a lifetime ESAL of at least 1,000,000. The CTB layer would protect the asphalt layer above from early deterioration. Cost-benefit analyses should be conducted to determine asphalt and CTB thicknesses. Only CTB designs were considered for this project.



Further Analysis Should be Conducted to Classify the Soil on th


Photo acquired from https://www.utahvalley.com/listing/springville-city/652/

The West side of Springville is generally known to have a different native soil type than the East side of the city. These differences were not determined in this project and should be explored if a uniform minor collector pavement design is desired. Alternatively, an East versus West design could be produced.

The frost heave analysis performed did not produce reliable results. This too could be an area for future testing.

Thank You

Questions?

Appendix

Sources

- Springville City TMP: https://www.springville.org/wp-content/uploads/2016/10/Springville-TMP-Report-2016-09-30.pdf
- Springville City Website, design specifications: https://www.springville.org/engineering/files/2018/11/CHAPTER_-12-ROADWAY-CONSTRUCTION.pdf
- Guthrie, W. Spencer, R. A. Crane, and Dennis L. Eggett. "Statistical Comparison of Mechanistic-Empirical Models for Predicting Fatigue Life of Cement-Treated Base Layers Over Weak Subgrades." Cold Regions Engineering 2009. The 14th Conference on Cold Regions Engineering American Society of Civil Engineers. 2009.