Yeh and Associates, Inc.
Geotechnical • Geological • Construction Services

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March 7, 2024 Project No. 223-108

Jeff Wulliman, PE
Project Manager
Muller Engineering Company
7245 W. Alaska Driver, Suite 300
Lakewood, Colorado 80226

Re: Spruce Creek Road in Blue River, Colorado
Discussion on Paving with HMA Versus Annual Treatment with Magnesium Chloride

Dear Jeff:

Yeh and Associates have been asked to provide information and discussion addressing different possible treatments for the gravel road section of Spruce Creek Road between Colorado State Highway 9 (CO 9) and Crown Drive. This section of road is constructed with grades of up to 10 or 12 percent and the current practice of maintaining this section is grading as needed and an annual treatment of Magnesium Chloride (MgCl). We believe that the steep grade on this section of Spruce Creek Road causes a greater loss of aggregate on a regular basis from traffic accelerating up the steep grade and braking downhill on the approach to CO 9 than is experienced on more level roadway sections. We believe the uphill and downhill traffic also cause wash boarding to occur sooner than on level roads.

Site Reconnaissance

We inspected the section of road on October 17, 2023 after a recent treatment with MgCl and the road was observed to be in good condition and ready for winter. During the site visit, we also took soil samples of the subgrade adjacent to the road. The trip report is presented in Attachment A.

Aggregate Surface Treatment Options

Attachment B presents a review of numerous aggregate treatments that could be considered as alternatives to the current MgCl treatment. Following is a summary of the most likely treatments presented.

MgCl treatment is the treatment currently used and stabilizes the roadway and binds fine particles to prevent dust. The treatment may also help during winter to prevent the formation of ice pack. This section of roadway is currently treated on an annual basis with the application of MgCl and additional aggregate, as needed. Some of the advantages and disadvantages of the MgCl treatment are presented below.

Magnesium Chloride

Advantages:	**Disadvantages:**
Relatively low cost of Initial Treatment	Dust in warm weather prior to winter
MgCl prevents ice pack for easy plowing	Annual Treatment Required
Fair to good for dust control	Traffic disruption for treatment
	MgCl pollution in drainage runoff

	Loss of aggregate and wash boarding because of traffic accelerating uphill or braking down the slope

An emulsified asphalt treatment such as Earthbind would similarily help prevent dust and stabilize the existing roadway. Since the asphalt is not soluble, there would be little additional help with snowpack formation, but there would be less erosion of fines from rain and snowmelt. This type of treatment should last several years. One problem with this type of treatment is that in later years, as the asphalt treated aggregate stiffens over time, failures resemble potholes and patching these potholes requires similar effort to patching Hot Mix Asphalt pavement. Some comments on this treatment are as follows:

Emulsified Asphalt Treatment

Advantages:	**Disadvantages:**
Relatively low cost of Initial Treatment	Patching pothole failures problematic
Good for dust control	Failures tend to form potholes.

We do not recommend the use of Bentonite, because while it will help retain the larger gravel particles, it will not perform as well as the MgCl or emulsified asphalt. It is merely an aggregate treatment to provide cohesive fines to retain the larger aggregate. We believe the cost for this section would be too high to justify the treatment and would still have dust problems.

Hot Mix Asphalt (HMA) Option

If Spruce Creek Road is to be paved with HMA, we recommend that it be treated as a Local Access Road in accordance with the Summit County Standards which call for 4 inches of HMA over 4 inches of aggregate base course (ABC). The standards are presented in Attachment C. To verify the 4 inch recommendation, a pavement design following the AASHTO 1993 Pavement Design Guide is presented in Attachment D.

To address the subgrade and aggregate base course, we recommend following CDOT Specifications. We recommend the HMA mix meeting the CDOT requirements for SX(75) with asphalt binder PG 58-28 and that the new HMA be placed in two 2-inch lifts. We also recommend that the existing aggregate surface be reused as ABC with additional ABC imported, as needed. Sample specifications for imported subgrade soil and ABC are presented in Attachment D following the pavement design program printout.

Following is a summary of some advantages and disadvantages of HMA.

Hot Mix Asphalt

Advantages:	**Disadvantages:**
Minimal Annual Maintenance	Higher Speeds
Dust Elimination	Replacement Cost
SH 9 Intersection improvement	Snow & Ice Control*
No aggregate thrown by traffic.	

*We do not know what the current arrangements for snow removal in Blue River are, however, with paved roads, cities and CDOT routinely use some type of agent (Sand / Salt / MgCl) to prevent ice and packed ice formation along with plowing. Because of the steep slope of Spruce Creek Road, we anticipate that some type of treatment will be periodically required in winter.

Cost Comparison of HMA and MgCl

The following is a very coarse comparison of the cost of treatment with MgCl and paving with HMA. The cost comparison is based on an expected 14 year service life of an HMA pavement prior to the need for an overlay. This is the time often used by CDOT for HMA performance before needing major structural improvements. With paving, there will also be required improvements along the ditches and at the intersection with CO 9, which are not included in our cost comparison.

The section of Spruce Creek Road between CO 9 and Crown Drive is approximately 800 feet long and is constructed at a steep grade. The width varies from 19 feet to 25 feet with an average width of approximately 23 feet. Our cost estimates are based on 2,250 square yards of pavement. Based on this area of pavement, we calculated costs based on the new pavement consisting of 4 inches of hot mix asphalt (HMA) placed over a minimum of 4 inches of aggregate base course (ABC). The existing aggregate will be reused to lower the cost for the new aggregate base course (ABC).

This pavement section will require about 500 tons of HMA for the surface and 100 cubic yards of additional ABC to address grading, leveling and improvements at the intersection with CO 9. Using these quantities and a high cost for HMA, $300/ton, the total initial cost for pavement would be approximately $160,000. We calculated the annual cost for the 4 inch HMA and ABC pavement to be approximately $11,500 over the 14-year period.

Using the rates and treatment information from G & G Services for MgCl treatments, we estimate the annual cost is approximately $8,000. Over the same 14-year design life as HMA, the total cost for MgCl is $112,000.

These estimates are coarse and should be taken for discussion only. It could be said that the Annual Costs of HMA and MgCl treatments are of the same order of magnitude.

The major factor in the comparison is the initial cost for HMA. It should be noted that the cost of HMA is quite sensitive for small quantities. A review of the CDOT bids has shown the cost ranging from $120/ton to $300/ton. We used the initial cost is $300/ton as a conservative estimate.

Recommendations

If paving is chosen, the client has requested recommendations for the limits of paving. We recommend that if the entire section is to be paved, that the HMA be carried across the width of Crown Drive. If the entire intersection is paved, vehicles coming from the gravel road will come on the pavement on a relatively level surface to make the turn onto Spruce Drive and would carry less aggregate onto the paved section than if the transition is done on a slope.

If the cost to pave the entire segment is not possible, we recommend that the road be paved from CO 9 to across Gold Nugget Drive since that is the most level spot on the remaining section. That will

also let cross traffic enter the paved section at the most level section to prevent tracking gravel onto the pavement.

Another item requested was to recommend other treatments that could be tried on an experimental basis to obtain performance information. We would recommend that the emulsified asphalt treatment be tested if evaluation of another option is desired. It will control dust and should last longer than the current MgCl treatment. We recommend that you use the proprietary treatment mentioned above if the evaluation is to be constructed.

Please contact us if you have any questions or need more information.

Sincerely,

Yeh and Associates, Inc.

Robert F. LaForce, P.E.
Senior Project Manager

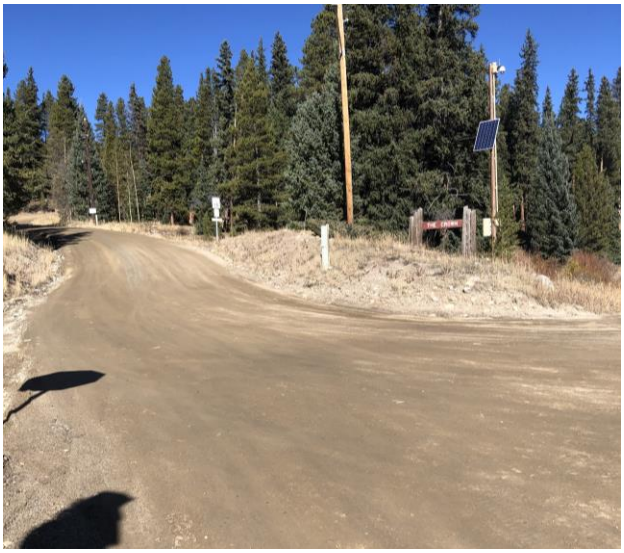
Reviewed by:
Todd Schlittenhart, PE
Principal Engineer

Attachments:
Attachment A – Field Trip Report
Attachment B – Various Treatment Discussion
Attachment C – Summit County Standards
Attachment D – Pavement Design

Attachment A – Field Trip Report

Blue River – Spruce Creek Road Site Visit 10/17/2023

On October 17, 2023, Bob LaForce with Yeh and Associates visited the section of Spruce Creek Road between SH 9 and Crown Drive to inspect the condition of the road and become familiar with the project site before winter snows cover the area.



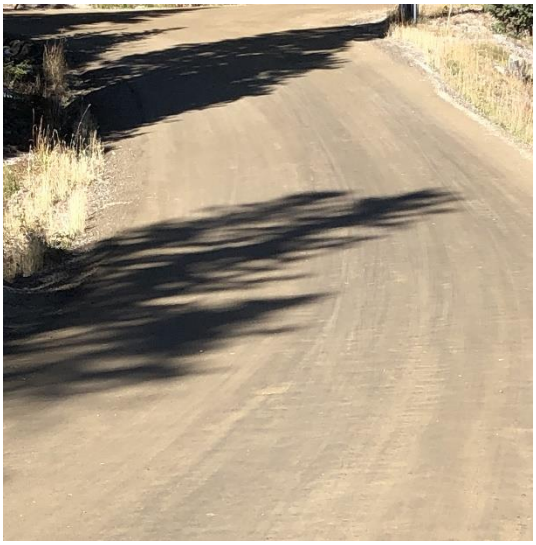


Figure 1 - Typical Surface Condition

The aggregate surface had recently been treated with magnesium chloride to retain aggregate and help promote drainage off the roadway surface. As noted in the above photos, the surfacing was very uniform and is providing a smooth travelling surface. The roadway was inspected from SH 9 to Crown Drive and the treatment appears to be very uniform for the length of the section.

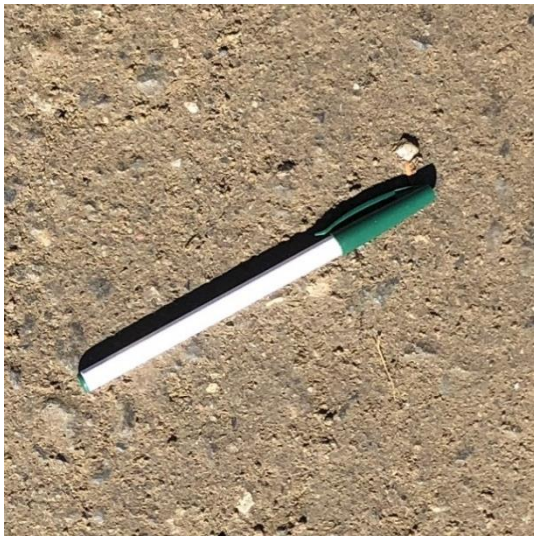


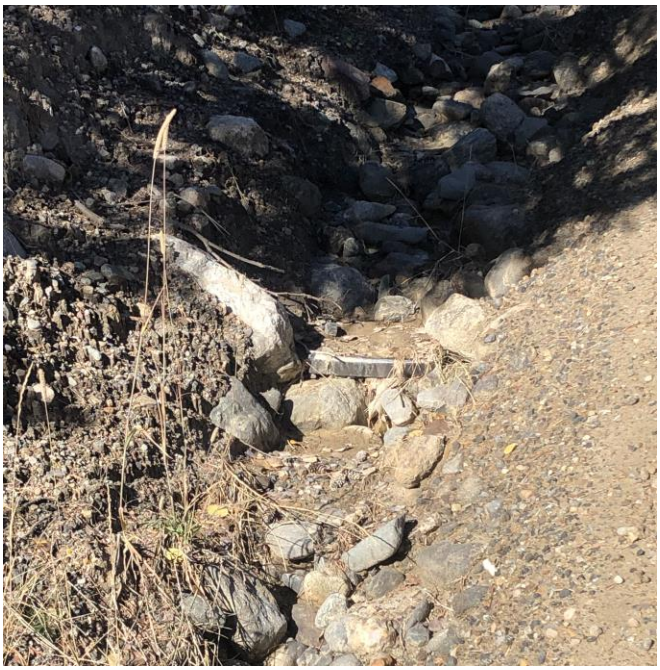
Figure 2 – Surface Texture

The texture of the surface was uniform for most of the area inspected with only one small area near SH 9 showing larger aggregate exposed through the compacted fine aggregate. These areas may be reviewed

Blue River – Spruce Creek Road Site Visit 10/17/2023

after the spring snow melts to determine if this was a segregated spot, or just a slight variation in the surfacing aggregate gradation.

In addition to the surfacing the ditches were inspected to determine if longitudinal drainage is causing extensive erosion and deterioration of the road. The following photo shows the area immediately above of SH 9 where the ditch is armored from past drainage. The second photo shows a section on a flatter section of roadway that at present only surfacing aggregate in the ditch. These areas will also be checked again in the spring.



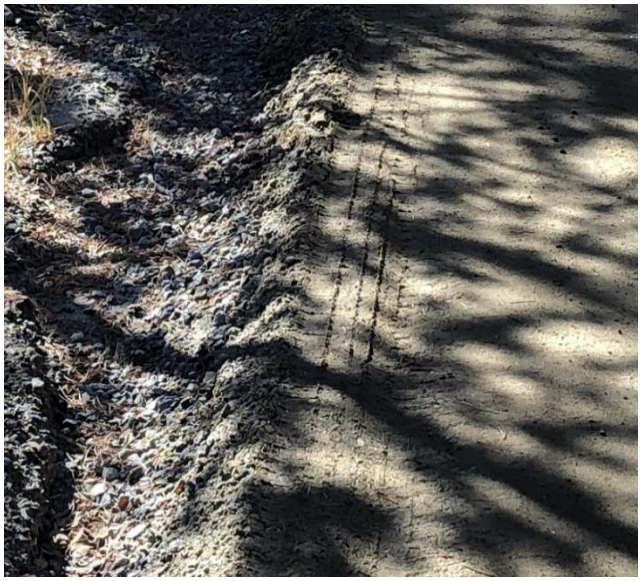


Figure 3 – Longitudinal Drainage Conditions

Soils samples believed to be representative of the roadway subgrade were also taken. Sample YA-B1 was taken to the north of the entrance near the SH 9 ROW and sample YA-B2 was taken south of Louise Placer Road. The soil was sampled from approximately 1 foot to 2+ feet. The holes were filled with surrounding soil for each boring. These soils samples will be tested for gradation, classification and maybe R-value which would provide a strength value for a pavement design if needed.

Blue River – Spruce Creek Road Site Visit 10/17/2023

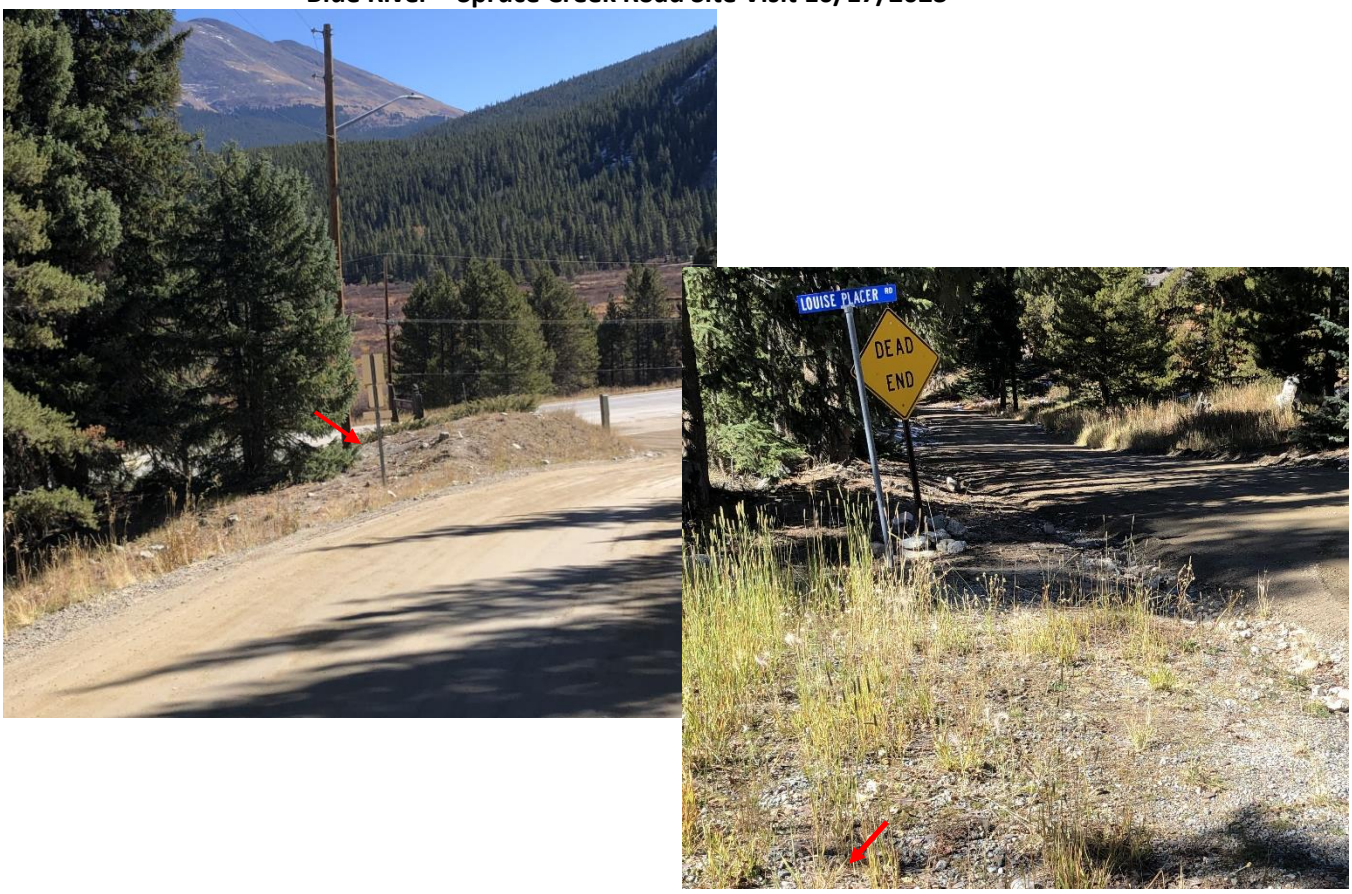


Figure 4 – Approximate Soil Sample Locations

The roadway surfacing will be inspected next spring to determine how well the treatment has performed over the winter.

Attachment B – Various Treatment Discussion

Aggregate Surfacing Options

Discussion: Pros and cons for various aggregate treatments

Gravel (Aggregate Surfaced) Roads are very common throughout the US and in Summit County, CO.

FHWA and other agencies require 10-14% minus 200 and PI 10 +/- 3 for surfacing aggregate. The plasticity (PI) in the aggregate helps retain aggregate by bonding the fine particles together, holding the larger aggregate in place. A lack of cohesive surface aggregate results in loss of large gravel from traffic. Traffic throws larger aggregates off the roadway and causes dust from loss of finer aggregate particles.

Dust Palliative – Caused fines to adhere to larger particles to prevent dust.
Usually a spray treatment

Some typical treatments often used to control dust and stabilize the surfacing to prevent loss of large aggregate.

Calcium Chloride / Magnesium Chloride / Lignosulfonate
Method 1 – top 2 inches wet, spray process smooth and compact
Method 2 – top 3 inches wet, spray process, second application process & compact

MgCl treatment is currently done once per year. Controls dust stabilizes roadway and helps with ice/snow control.

Stabilization - Requires treatment at depth and will require mixing.

Calcium Chloride is a dry product distributed on surface with water and mixed to full depth of aggregate.

Magnesium Chloride is usually applied as a concentrated liquid tilled into the top 2-4 inches of the roadway. Annual treatment is done once per year and periodically requires that additional aggregate to make up for loss from traffic whipping large aggregate off the road and generating dust from small aggregate particles.

Mix in Pugmill

Bentonite – requires pugmill mixing. – extreme example of mixing highly plastic clay to cause aggregate to closely adhere providing extended life.
This treatment increases the cost of aggregate by an approximate factor of 3.
In the area, ABC costs about \$90/yd^3 , so treated aggregate would be approximately \$300/yd^2.

RAP - can be used to create a surface almost like a cold mix pavement – works well, but if it starts to fail, it requires patching much like a thin asphalt lift.
RAP mixed with ABC at 50 +/- percent acts like aggregate but has more cohesion and may help retain aggregate. - This treatment was used on some approaches to US 285 east of Bailey and has worked for low volume roads.

Aggregate Surfacing Options

References:

Surface Aggregate Stabilization with Chloride Materials, US Dept. of Agriculture, Dec. 2006 MgCL2 & CaCL2 – 39 treated and 40 untreated sections on 12 projects – 1.5% – 2% by weight of aggregate, 2 inches- monitored for 2 years. – MG & CA had similar results – reduced blading - Cost - $8K to 10-K per mile – Savings $3,300 /mile. – up to 8 times longer than untreated sections estimated after years monitoring. – eastern Wash. And Ore plus Montana. – Drainage 4% cross slope – moderately dry climates less than 250 ADT. – untreated sections required blading after 3,200 passes, treated sections required blading after 25,500 vehicle passes. – 90% dust reduction. - <2% grades

Gravel Roads, Maintenance and Design Manual – USDOT FHWA, Nov. 2000

So. Dakota Local Transportation Assistance Program (SD LAP)

Usually Chloride, MgCL2 and CA CL2 – Resins, Lignin Sulfonate - Asphalts (cutbacks, solvents, emulsions, special equipment), note: ADT = 200 equates to loss of 200 tons /year per mile – treatment allows reduced maintenance.

Attachment C – Summit County Standards

TABLE 5-3 Minimum Structural Sections

Road Class	Gravel	Paved
Primitive	Natural surface	Not Applicable
Low Volume	3" Base Course	3"Asphalt 3"Base course
Local Access	4" Base Course	4"Asphalt 4"Base course
Collector	Not Applicable	5"Asphalt 6" Base Course
Arterial	Not Applicable	6" Asphalt 6" Base Course
Shared Use Path/Trail	Not Applicable	3"Asphalt 4"Base Course
• Full depth asphalt or concrete designs will be considered and may be used with approval of the County Engineer • Sub base may be substituted with road base with prior approval		

TABLE 5-4 Coefficient of Runoff

Type of Surface	Vegetation Density	Value of C= (Rainfall)
Roofs		.97
Pavements		
Concrete or Asphalt		.97
Gravel from clean and loose, to clayey and compact		.60
Earth Surfaces		
Sand from uniform grain size, no fines to well graded, some, clay or silt	Bare Light Vegetation Dense Vegetation	.60 .45 .35
Clay, from coarse sandy or silty, to pure colloidal clay	Bare Light Vegetation Dense Vegetation	.70 .50 .40

TABLE 5-5 Prescribed Manning's "n" Values

Channel Material	"n"	Max Velocity (feet/sec)
Lines or well established grass	.05	5
Bunched grasses with exposed soil	.04	3
Fine sand or silt	.02	1
All other bare soils	.03	2

Attachment D – Pavement Design

Pavement Design Discussion

Base and Subgrade Materials:

As noted in the site visit last fall, the subgrade soils near Spruce Creek Road were sampled and testing showed that they have an R-value of 69. To be conservative, for the pavement design, an R-value of 60 was used to calculate a resilient modulus of 18,259 psi for input to the pavement design program.

If any embankment (CDOT Item 203) is needed to be imported for this project, we recommend that it be required to have a minimum R-value of 60 when tested in accordance with AASHTO T190.

If any aggregate base course (ABC) (CDOT Item 304) is required, we recommend that it have a minimum R-value of 78, also measured in accordance with AASHTO T190.

Project special provisions for the above items are attached.

Hot Mix Asphalt (HMA)

The recommended HMA for this project is SX(75) with asphalt binder grade PG 58-28. We believe that this is the standard mix produced in the Blue River Valley. The HMA should conform to CDOT Specifications for SX(75) PG 58-28.

We recommend that the HMA be placed in two lifts.

Traffic Loading

Traffic loading was calculated based on the number of dwellings served by the roadway. In this case we used 50 dwellings, then increased the loading by 50% to address the Forest Service Trail Access. The calculation of the traffic loading is attached.

WinPAS

Pavement Thickness Design According to

1993 AASHTO Guide for Design of Pavements Structures

American Concrete Pavement Association

Flexible Design Inputs

Project Name: Spruce Creek Road
Route:
Location: Blue River, Colorado
Owner/Agency: Blue River
Design Engineer: New HMA Pavement

Flexible Pavement Design/Evaluation

Structural Number	1.62		**Subgrade Resilient Modulus**	18,259.00	**psi**
Total Flexible ESALs	90,908		**Initial Serviceability**	4.50	
Reliability	90.00	**percent**	**Terminal Serviceability**	2.00	
Overall Standard Deviation	0.44				

Layer Pavement Design/Evaluation

Layer Material	Layer Coefficient	Drainage Coefficient	Layer Thickness	Layer SN
Asphalt Cement Concrete	0.44	1.00	4.00	1.76
			Σ SN	1.76

Spruce Creek Road in Blue River Yeh No. 223-108

ESAL LOADING

Using MGPEC Default Equations based on number of dwellings.

$ESAL_{20}$ = 62,000 + 80 * R

R = Number of Housing Units Served

$ESAL_{20}$ = 20 Year Single Axle Loads for pavement design.

For Spruce Creek Road, We assumed that there would be 50 residences. Then doubled the number of ESALS because the road services a Forest Service Facility/Trailhead.

$ESAL_{20}$ = 62,000 + 80 * 50 = 66000

Plus 50% for Trail Traffic = 99000

62000 ESAL value to address construction of dwelings

80

50 R - number of dwellings Served

Cars & pickups	0.003
Trash & Snow Plow trucks	0.249

ADT of 500 plus construct

			% of vol.				
500	veh/da X	0.98	X	0.003	ESAL/veh =	1.47	ESAL /Day
500	veh/da X	0.02	X	0.249	ESAL/veh =	2.49	ESAL /Day
						3.96	ESAL /Day

ESAL /Day							
3.96	ESAL /Da X	365	da/yr X	20	yrs =	28908	ESAL
28908	+	62000	=	90908	Design ESALs		

* These equations were also used by CDOT when they followed the AASHTO 1993 Pavement Design Guide.

Revision of Section 203
Embankment Material

Revise Section 203 of the Standard Specifications for this project as follows:

Subsection 203.03, first paragraph, shall include the following:

Imported embankment material shall meet the following requirements for Atterberg limits and gradation:
The upper 2 feet of embankment material below the subgrade elevation shall have a resistance value of at least 60 when tested by the Hveem Stabilometer or the equivalent resilient modulus.

Work Sheet: 304abc
02-03-11 (Re-issued 07-03-17) Spruce Creek Road
(tech chk 01-13-23)
ADA 8.22.23

Revision of Section 304
Aggregate Base Course

Revise Section 304 of the Standard Specifications for this project as follows:

Subsection 304.02 shall include the following:

Materials for the base course shall be Aggregate Base Course (Class6) as shown in subsection 703.03

The aggregate base course (Class 6) must meet the gradation requirements and have a resistance value of at least 78 when tested by the Hveem Stabilometer method.

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Instructions to Designers (delete instructions and symbols from final draft):

♦ Use when appropriate, inserting the proper Class of base course.

▲ Use for all Classes of base course, inserting the correct figures.

♥ Insert the specified resistance values.