




**GROUND**  
ENGINEERING  
APPROVED

April 25, 2014

Subsurface Exploration, Pavement  
Thickness Design recommendations,  
**Banner Health Medical Campus –  
Cinquefoil Lane: Fly Ash Subgrade  
Treatment**, Fort Collins, Colorado

By: RGR Date: 4-25-14  
 City of Fort Collins  
Engineering Department

**Job Number: 13-0604**

**Banner Health Development and Construction**  
1801 16<sup>th</sup> Street  
Greeley, Co 80631  
**Attn: Mr. Mark Ostrand**

GROUND Engineering Consultants has previously performed a subsurface exploration program to develop geotechnical recommendations for flexible pavements for Cinquefoil Lane, located in Fort Collins, Colorado. The results were summarized in GROUND's letter, titled, *Subsurface Exploration, Pavement Thickness Design recommendations, Banner Health Medical Campus – Cinquefoil Lane, Fort Collins, Colorado*, Job No. 13-0604, dated March 14<sup>th</sup>, 2014. Reference is made to our March 14<sup>th</sup> letter for a description of the site surface and subsurface conditions, our general geotechnical findings and recommendations, and the limitations on our work, which also apply to GROUND's conclusions and recommendations provided herein. We consider all recommendations in that report not specifically superseded herein to remain valid.

The City of Fort Collins, Colorado has presented concerns of failing proof roll testing at the subject roadway. Therefore JE Dunn has requested additional recommendations for fly ash stabilization under the proposed pavement sections.

**FLY ASH STABILIZATION:**

Subgrade materials can often become saturated several inches during seasonal weather events and become difficult to stabilize by moisture density treatment alone prior to paving. Other times it has been observed that some silt/clay subgrades will become unstable at moisture contents at or slightly above the optimum (during moisture treatment) that are still within the project moisture specifications. Fly-ash stabilization has been a popular subgrade treatment in the Larimer County area to provide stability even during times of inclement weather conditions and provide additional insurance for

**Fly Ash Stabilization for Pavements  
Cinquefoil Lane**

the integrity of the subgrade materials. Where required or preferred, chemical stabilization consisting of fly-ash treatment should be performed to a depth of approximately 12 inches in thickness. Based on our experience with the subgrade materials present at this site and other fly-ash treated subgrades, a minimum of 12% Type C Fly Ash by dry unit weight shall be used.

**UPDATED PAVEMENT DESIGN**

Based on the Larimer County Streets Standards, the updated minimum pavement thickness design accounting for the inclusion of 12 inches of Fly Ash treated subgrade is provided below (See Appendix A for pavement thickness calculations):

Street I.D.	Road Classification	Assumed Traffic EDLA Values	Minimum ESAL Values	Composite Pavement Section* Asphalt / Base (in. / in. )
Cinquefoil Lane	Minor Collector	25	182,500	4.5 / 6.0

It should be noted that per the Larimer County Urban Area Street Standards thickness credit for chemically treated subgrade shall be 2 inches less than the maximum specified tilling depth. Therefore the pavement design calculations only provide credit for 10 inches of Fly Ash subgrade treatment.

The following guidelines should be utilized in the construction of the fly ash stabilized section:

***WEATHER LIMITATION***

The Fly Ash shall not be mixed or compacted if the temperature of the treated soil is below 35°F.

***EQUIPMENT***

The equipment required shall include all equipment necessary to complete this item such as; grading and scarifying equipment, a spreader for the Fly Ash, mixing, pulverizing equipment or roto-miller, sheeps foot and pneumatic or vibrating rollers, grading equipment, sprinkling equipment and trucks as approved by the owner.

### **GENERAL CONSTRUCTION METHODS**

The contractor shall provide a completed subgrade containing a uniform Fly Ash mixture, free from loose or segregated areas, of uniform density and moisture content, well bound for its full depth and width; with a smooth surface suitable for placing subsequent courses. It shall be the responsibility of the Contractor to regulate the sequence of his/her work, to use the proper amount of Fly Ash, maintain the work, and rework the courses as necessary to meet the requirements.

Prior to beginning any treatment the subgrade shall be constructed and finished to smooth and uniform surfaces conforming to the grades and typical sections specified. The in-place density and moisture content should conform to the recommendations provided in March 14<sup>th</sup> Letter.

After the subgrade has been finished and approved as specified, the subgrade shall then be cut and pulverized by a cutting and pulverizing machine to the depth and width shown on the Drawings. The machine shall cut and pulverize uniformly to the specified depth and shall have cutters that plane the base of the cut and pulverized zone to a smooth surface over the entire width of the cut. The machine must give visible indication at all times that it is cutting to the proper depth.

### **APPLICATION**

Fly Ash shall be spread only on that area where the mixing operations can be completed during the same working day.

The distribution of Fly Ash shall be attained over a measured section of subgrade until the proper amount of Fly Ash has been spread. The amount of Fly Ash spread shall be the amount required for mixing to the specified depth which will result in the percentage required.

### **COMPACTION**

Compaction of the Fly Ash/soil mixture shall begin immediately after final mixing with Fly Ash. The material shall be aerated or sprinkled as necessary to maintain the mixture within the specified moisture content limits during and following compaction. The field density for the compacted mixture shall be at least 95 percent of the maximum density of laboratory specimens prepared from samples taken from the treated soil material in

Fly Ash Stabilization for Pavements  
Cinquefoil Lane

place after curing and prior to compacting. The specimens shall be compacted and tested in accordance with ASTM D 698. The in-place field density shall be determined in accordance with ASTM D 1556, ASTM D 2167 or ASTM D 2922, as determined by the owner. Any mixture that has not been compacted shall not be left undisturbed for more than 30 minutes. The optimum moisture content shall be determined in accordance with ASTM D 698. All compaction and compaction testing shall be completed within 1 hour of mixing the Fly Ash into the soil.

**FINISHING AND CURING**

The completed section shall be cured for a minimum of 5 days before further courses are added or any traffic is permitted, unless otherwise directed by the owner. The surface should be kept moist for a minimum of 5-days by repeated sprinkling and watering in a manner acceptable to the owner and soil engineer.

Sincerely,

**GROUND Engineering Consultants, Inc.**

Kelsey Van  
Bemmel

Digitally signed by Kelsey Van Bemmel  
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By Kelsey Van Bemmel, P.E.

Reviewed by Joseph Zorack, P.E.



Appendix A  
Pavement Thickness Calculations

# 1993 AASHTO Pavement Design

## DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare  
Computer Software Product  
Network Administrator

### Flexible Structural Design Module

Banner Health Medical Campus  
Cinquefoil Lane with Fly Ash Treated Subgrade  
Fort Collins, Colorado

Composite Pavement Section

### Flexible Structural Design

18-kip ESALs Over Initial Performance Period	182,500
Initial Serviceability	4.5
Terminal Serviceability	2.3
Reliability Level	75 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,337 psi
Stage Construction	1
Calculated Design Structural Number	3.10 in

### Specified Layer Design

<u>Layer</u>	<u>Material Description</u>	Struct Coef. <u>(Ai)</u>	Drain Coef. <u>(Mi)</u>	Thickness <u>(Di)(in)</u>	Width <u>(ft)</u>	Calculated <u>SN (in)</u>
1	Asphalt	0.44	1	4.5	-	1.98
2	Aggregate Base Course	0.11	1	6	-	0.66
3	Fly Ash Treated Subgrade	0.05	1	10	-	0.50
4	Fly Ash Treated Subgrade	0	1	2	-	0.00
Total	-	-	-	22.50	-	3.14