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RESEARCH PROGRAMS

Project Summary Report: 8228-001

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Development of a 3/4-inch Minus Base Course Type A Specification for Montana

http://www.mdt.mt.gov/research/projects/mat/crushed_base_course.shtml

Introduction

Gravel bases are a critical component of roads, providing drainage, structural support, and load distribution to reduce pressures on subgrade soils. Roadway designers currently have a number of options for specifying the base course material on Montana Department of Transportation (MDT) highway projects. Montana specifications currently exist for a 2-in. minus (Grade 5A) and 1½-in. minus (Grade 6A) crushed base course (Section 701.02.4); however, gravel sources in Montana are becoming limited, particularly in the eastern regions of the state, making the option to use a ¾-inch gravel base desirable. The primary objective of this project was to develop a standard specification for a new gravel base course with a nominal maximum aggregate size of ¾ in. This objective was met by analyzing two specific aspects of the ¾-inch minus gradations:

1. Whether aggregates whose maximum particle size was ¾ inch would perform at least as good as Montana's current CBC-5A and/or CBC-6A crushed aggregate base course materials, and
2. What effect changes in the gradation had on the material properties within the specified limits.

The first goal was accomplished by comparing data from the ¾-inch minus materials tested during this project to the results from laboratory tests conducted on CBC-6A and CBC-5A materials (Mokwa et al., 2007). The second goal was accomplished by qualitatively analyzing the performance data from finer and coarser gradations for each of the eight Montana sources. The results from this analysis were used to suggest a viable ¾-inch minus gradation specification for crushed base course materials for the state of Montana.

What We Did

The first step in this investigation was to review other state and federal standard specifications to document standard ¾-inch minus base course specifications. Information from that review helped identify a starting point from which to develop a standard specification for Montana crushed aggregate courses. Of the limited number of ¾-inch minus gradation specifications found, only the ones from Colorado and Nebraska were considered useful as base course materials for Montana. Further investigation found federal ¾-inch minus base specifications that dated back more than a half century were

also viable options. These existing specifications were found to be similar to a preliminary ¾-inch minus base course specification that has been used by MDT in the Glendive District. It was determined from this review that the Colorado specification would be used to generate ¾-inch minus mixes for laboratory testing.

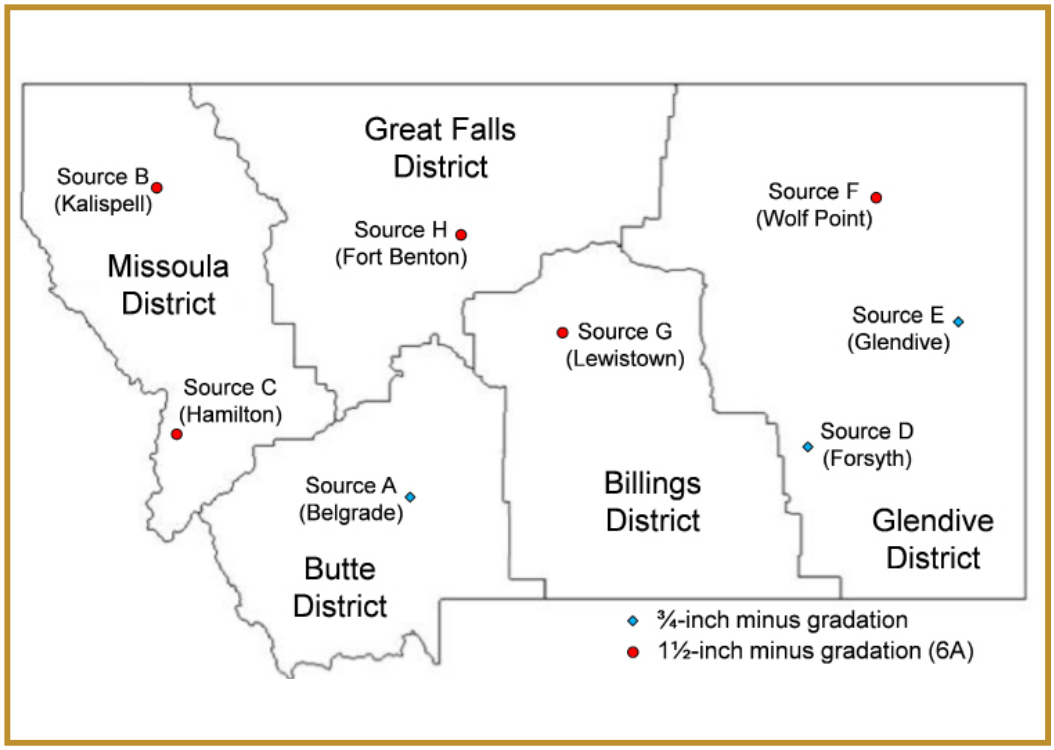

Figure 1: Map of material sources in Montana

Next, a variety of crushed aggregates from several sources throughout the state of Montana, having a ¾-inch minus gradation, were tested to determine their performance characteristics. These performance characteristics were compared to existing data from laboratory tests conducted on Montana CBC-5A and CBC-6A materials (Mokwa et al., 2007). Further analysis was done to determine the effect that changes in the ¾-in. minus gradation had on their performance characteristics.

Samples of aggregate were collected from eight different gravel pits located throughout Montana's five maintenance districts (Figure 1). Portions of these gravel samples were crushed to create ¾-inch minus mixes (Prepared mixes). These gradations were further modified to evaluate the effect that gradation had on their engineering properties (Modified mixes). The following lab tests were conducted to characterize the physical attributes and material properties of these gravel mixes.

- Particle size distribution
- Fractured face count
- Modified Proctor density
- Relative density (maximum and minimum index densities)
- Specific gravity
- R-value (tested by MDT)
- Direct shear
- Permeability

A statistical analyses of average values were conducted using a two-sided t-test (for samples having unequal variance) to determine if apparent trends in measured laboratory test results represent true differences between aggregate types. The two-sample t-test is a statistical test used to determine if the averages of the two data sets are statistically different from one another based on a mathematical evaluation of the data scatter. In cases where the averages are statistically different, a direct comparison of the mean values indicates which value is greater. Otherwise, the means are considered statistically equal.

What We Found

The analysis showed that, overall, ¾-inch minus base course materials are expected to perform at least as well as Montana CBC-6A and better than Montana CBC-5A materials based on the material properties determined during this study. It also showed that ¾-inch minus materials within the preliminary specified range performed better near the bottom of the specified range (i.e., coarser materials) than finer materials. The specification used in the Glendive district is similar to the Colorado specification (used as the preliminary specification in this project). Based on these results, it was recommended that a modified version of the Glendive specification be adopted as a viable ¾-inch minus base course specification within the state of Montana, now known as Montana CBC-7A. The practicality of producing mixes that fit within these suggested gradation limits needs to be determined.

What the Researchers Recommend

Three recommendations were made based on the results of this

study. First, it was recommended to incorporate a standard specification for ¾-in. minus crushed case course aggregates. This would require modifications to Section 701.02.4 of Montana's standard specifications for road and bridge construction to include Crushed Base Course Type 7A, having a maximum nominal size of ¾ in. This specification will allow gravel producers to maximize production of crushed aggregates, especially in areas where larger sized materials are becoming limited.

The second recommendation was to limit the amount passing #40 sieve to ensure good permeability. The range of particle sizes was selected based on information from federal and state sources as well as a preliminary specification from the Glendive District. These preliminary specifications allowed the researcher to create ¾-in. minus mixes for testing purposes. From these tests it was noticed that as the amount passing the #40 sieve approached the upper bound of the specification, permeability was significantly decreased. Limiting the amount passing the #40 sieve to 25 percent will help ensure acceptable drainage characteristics of the constructed aggregate layer. The practicality and constructability of producing mixes that fit within these modified bounds, however, should be evaluated prior to full implementation.

The third recommendation was to maintain current levels of plasticity, wear and fractured face requirements until definitive research has been conducted to specifically study the effect that changing these requirements has on the performance characteristics and the cost-benefit of these mixes.

References

Mokwa, R., Trimble, N. and Cuelho, E. (2007) "Experimental Assessment of Aggregate Surfacing Materials," Final report for the Montana Department of Transportation, FHWA/MT-07-011/8117-30, pp. 74.

For More Details . . .

The research is documented in Report FHWA/FHWA/MT-16-015/8228-001, http://www.mdt.mt.gov/research/projects/mat/crushed_base_course.shtml

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MDT Implementation Status: December 2016

Information from this research allowed a new standard specification to be suggested for ¾-inch minus crushed base course aggregates (CBC-7A) for the Montana Department of Transportation.