

**Mortar Evaluation**  
**Rumbaugh Creek Bridge**

Prepared by:

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## Introduction

Several large mortar samples were removed from the Rumbaugh Creek Bridge by the Town of Pagosa Springs and shipped to and tested in the Atkinson-Noland & Associates (ANA) laboratory for mortar composition. The objective was to identify binder/aggregate ratio, aggregate color, and aggregate size gradation to provide an appropriate compatible replacement mortar formulation.

## Aggregate Sieve Analysis

The mortar evaluation followed the requirements of ASTM C136, *Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates*. This method is based on the use of acid digestion of the binder and sieve analysis of the aggregate. The analysis process used does not distinguish between cement and lime-based binders.

The sample identification list is shown in Table 1. Note that all of the mortar provided was in a single bag.

*Table 1. Sample identification and location*

Sample ID	Location
S1	Portion of Sample provided by Town of Pagosa Springs
S2	Portion of Sample provided by Town of Pagosa Springs
S3	Portion of Sample provided by Town of Pagosa Springs

The results of acid digestion of the sample are shown in Table 2. The binder component was found to be approximately 29-34%, and the aggregate component was found to be approximately 66-71%. All samples contain binder/aggregate ratios that are typical of common masonry mortars.

The aggregate gradation curve, plotted in Figure 1, shows that the aggregate from all samples falls within the gradation range of coarse and fine aggregates as specified by ASTM C144, *Standard Specification for Aggregate for Masonry Mortars*. Sample S3 had a slightly different gradation than Samples S1 and S2, but we believe the aggregates are all from a common source.

The aggregate size distribution and colors are shown in Figure 2. Ideally, the aggregate for the replacement mortar should match the color and gradation of the existing aggregates. Trial mixtures may be required to produce a repair material that matches the original with respect to color and texture.

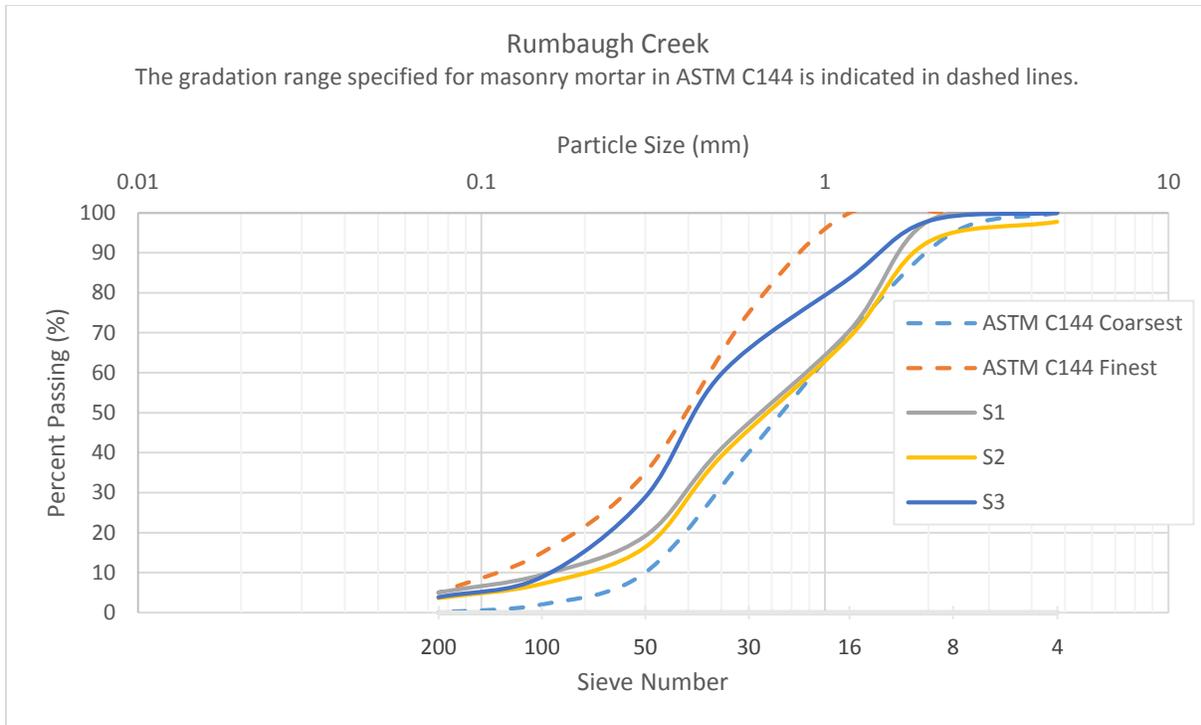
### Recommended Mortar Formulation

Based on the appearance and hardness of the tested mortars, it appears the original mortar is a sand-lime mortar formulation (i.e. does not contain any portland cement). Mortar used for repointing joints, crack repair, and rebuilding should meet the requirements of ASTM C270, *Standard Specification for Mortar for Unit Masonry*, for Type O mortar, with volumetric proportions of 1 part portland cement, 2 parts lime, and 8 to 9 parts sand. These relatively soft repointing mortars should be compatible with both the stiffness and the vapor permeability of the surrounding masonry materials, avoiding stress concentrations and moisture problems that could damage masonry units.

The use of pigments may be required to match the hardened mortar color. Pigments conforming to ASTM C979, *Standard Specification for Pigments for Integrally Colored Concrete*, are suitable for mortar, but should not exceed 5% by weight of binder content in the mortar. It is also likely that the use of white Portland cement will be required in lieu of typical gray cement in order to match the existing mortar color. Trial mixtures may be required to arrive at a mix that matches the original mortar with respect to color and texture.

*Table 2. Results of acid digestion of concrete samples*

Sample ID	Mass before acid digestion (g)	Mass after acid digestion (g)	Binder mass (g)	Aggregate mass (g)	Binder volume (cm <sup>3</sup> )	Aggregate volume (cm <sup>3</sup> )	Total volume (cm <sup>3</sup> )	Binder (%)	Aggregate (%)
1	61.02	50.52	10.50	50.52	16.39	39.42	55.81	29	71
2	60.48	49.36	11.12	49.36	17.35	38.52	55.87	31	69
3	56.07	44.40	11.67	44.40	18.21	34.65	52.86	34	66



*Figure 1. Aggregate distribution by sieve size for mortar sample.*



Sieve Size:	4	8	16	30	50	100	200	Pan
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*Figure 2. Aggregate distribution and color for mortar sample.*