APPENDIX C

MORTAR ANALYSIS INSTRUCTION GUIDE

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GENERAL MORTAR LAB INSTRUCTIONS

1. Clean all of the test tubes, beakers, and other materials used during the mortar analysis. Return the materials to their proper location when finished.

2. Wear protective clothing (gloves, smock, visor) when working with the chemicals. Please READ the chemical warning information on the wall in the lab. This will instruct you on how to handle the chemical, and familiarize you with its properties.

3. DO NOT mix or use the chemicals in a closed area without good ventilation. Inhaled acid fumes are extremely dangerous.

4. Make sure each mortar analysis test sheet is properly labeled as to project name, sample number, and the location of sample. Make the numbers legible so that others can correctly interpret the data.

5. If any materials are running low (chemicals, filter papers, distilled water, etc.), or if an item breaks, please tell Alan Tabachnick, who handles the orders with Thomas Scientific.

6. If there are any problems or questions, ask Alan.

GENERAL MORTAR INFORMATION

In general, CHRS will deal with a wide variety of mortars dating from the eighteenth through the twentieth centuries. Lime-sand mortars dominated construction until about 1880, afterwhich cement mortars were most common.

<u>Clay Mortar</u>: used for brick and stone walls in regions where lime was difficult to obtain. Consisted mainly of mud and clay, strengthened by straw, horse or hog hair. Also called "wattle or daub."

<u>Lime-Sand Mortar</u>: most common type of mortar used in structures located above the water level until the late 19th century. The lime was obtained mainly from burning limestone, marble, or shells. The mixture consists of lime, sand and water, in a variety of proportions.

<u>Hydraulic Mortars</u>: these are mortars that will set and harden in water, making use of hydraulic limes and natural cements. Hydraulic mortars are of several different compositions: (1) common lime plus pozzolana (trass) plus water (and sometimes sand); (2) hydraulic lime plus sand (sometimes omitted) plus water; (3) cement (natural or portland) plus sand (sometimes omitted) plus water (sometimes common lime).

Hydraulic limes were used in the 18th and early 19th centuries. Natural cements were manufactured as early as 1824 in New York State, and 1831 in Pennsylvania. Mixed with water, these will form hard water-resistant mortars. Sometimes natural cement was mixed with sand in a ratio of ca. 2 or 3 parts sand to 1 part cement.

<u>Portland Cement</u>: manufactured in the U.S. after 1871, this cement gradually replaced natural cement because it was more dependably uniform in quality. It is known for its strength, low absorbency and hardness. It became a major ingredient in mortar after 1880. Proportions commonly used were 1 part cement, to 6 to 10 parts sand, to 1/2 to 2 parts lime paste.

<u>Plaster</u>: this was used to cover exterior and interior walls and ceilings. Also called parging, and stucco. Clay plaster was used including for filling in frame and log houses, composed mainly of clay, hay, lime and hair. Lime plaster was a mixture of lime and sand with hair or other materials, applied directly on masonry or wood lath. Lime plaster was in use as early as 1641 in the U.S., generally on the interior. Stucco was used on exterior walls, composed of lime generally 2 parts sand to 1 part lime.

Cement mortars were used for below grade masonry. Underwater, or in heavy construction, Portland cement was used. In general, interior work was a high lime mixture for ease of working.

If desired, the proportions discovered through the mortar analysis testing can be studied against historical mixtures. This information can be found in the file entitled "Mortar Articles" in the Mortar Lab Area.

TEST ONE

Purpose: To determine the acid soluable fraction and quantity of lime in the mortar sample.

Part A

1. Grind 30g of mortar sample to coarse powder with mortar and pestle.

2. Weigh out 20g of ground sample.

3. Weigh glass container (beaker), and place sample in container. (Most of the containers have already been weighed and labeled, but check).

4. Add 20ml of 50% solution of HCL. (This will be in labelled bottle. If more is needed, follow the instructions)
   a) the solution is 1/2 and 1/2 distilled acid and water. Acid must be added to the water!!!

   b) add solution slowly to beaker, allowing time for the CO_2 to be released.

5. Wait until all bubbling has stopped. Keep adding small amounts of the 50% solution to mortar sample in beaker until there is no more reaction.

6. Weigh filter paper (almost always 1.2g), place in funnel, then place funnels in screen over bucket. Make sure you do not mix up the numbering of the samples. Filter the solution in the beakers into the bucket.

7. Pour 25ml of distilled water through the filter, to rinse out as much acid as possible.

8. Dry the residue and filter paper under the heat lamps. (Don't forget to turn off these lamps when samples are dry).

9. Weigh the filter and residue.
   a) calculate the weight of the residue (total weight - filter weight).

10. Subtract the final weight of the residue from the initial weight of the sample and divide by the initial weight to obtain the percent of <u>Soluable Fraction</u>. (see test sheet #9a and #9b).

Part B

11. Weigh the beaker, then scrape ALL of the residue out of the filter paper into the beaker.

12. Add 25ml distilled water (as much as necessary) to the beaker, and stir to separate the sand. The lighter residue will become suspended in the water.

13. Set up the funnels over the bucket again. Weigh filters and place them into the funnels. Pour off the liquid into the filter leaving sand in the beaker. Repeat until only sand is left in the beaker.

14. Dry both sand and residue and then weigh them.
    a) calculate weight of sand (subtract beaker from total).
    b) calculate weight of residue (subtract filter from total).

15. Calculate percent of sand and residue in total sample.
    a) weight of sand / total weight = percent of sand in total.
    b) weight of residue / total weight = percent of residue.

16. Observe the residue: clay = red to light tan
    Portland Cement = medium to dark grey

17. If the residue is indicated to be Portland Cement, calculate the weight of the cement soluable fraction. (see test sheet 16a and 16b).

18. Calculate the weight of the lime portion of the mix. (If there is no lime this number will be 0). (see test sheet 16c).

19. Calculate the percentage of lime in the sample: weight of lime / weight of total.

20. Calculate percent of cement in the mix: weight of cement soluable fraction + clay residue (step 14b) / total weight of sample.

21. Calculate the clay:lime ratio.

If it is necessary to determine the type of lime used in the mixture (usually not necessary), see the instructions for Test #2 in the files in the Mortar Lab.

BASIC CHEMICAL TERMS

Calcium carbonate $CaCO_3$	Occurring naturally as chalk, limestone, marble and other forms (colorless or white)
Calcium hydroxide $Ca(OH)_2$	Used in making mortar and cement. Also called "Slaked lime," a soft white powder.
Calcium oxide CaO	Used as a refractory, as a flux, in manufacturing steel, glass, and as an industrial alkali. Also called "lime, quick lime, unslaked lime, calx."
Calcium sulfate $CaSO_4$	What sulfuric acid changes calcium carbonate into by atmospheric pressure.
Carbonic Acid H_2CO_3	A weak, unstable acid, present in solution of carbon dioxide in water.
Carbon Dioxide CO_2	A gas formed during respiration, combustion, and organic decomposition.
Sulfuric Acid H_2SO_4	A corrosive dense oily liquid
Dolomite	A light tinted, especially grey, pink or white mineral used as a furnace refractory or construction material.
Sand SiO_2	Commonly used as a filler or grit in mortar. If rounded with opaque quartz it is river sand. If sharp with clear quartz, it is quarry or pit sand.