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1. **Design Criteria:**

- a. Petrographic Analysis/Examination of existing historic mortar shall be performed during the design phase of a maintenance or restoration project to determine the characteristics and mix type of existing mortar.
 - i. Hardness and color are to be determined and mortar type
 - ii. UVM will retain a contractor for testing, design consultant to coordinate locations and number of tests.
 - iii. A formal report that will be shared by UVM with the Vermont Department of Historic Preservation (VDHP) through the UVM PM and UVM PDC Planning Staff will be shared with the Design Consultant.
- b. A section of the existing wall shall be properly cleaned according to the Reference Standards and any agreement negotiated with VDHP indicated to create one or more small areas to be used in determining the color of existing historic mortar so new mortar matches the existing after normal weathering.

2. **Reference Standards:**

- a. Preservation Brief 1: Assessing Cleaning and Water-Repellent Treatments for Historic Masonry Buildings, National Park Service – Technical Preservation Services
- b. ASTM C1324 Standard Test Method for Examination and Analysis of Hardened Masonry Mortar

3. **Submittals to be reviewed by University:**

- a. Product Data for each type of product
- b. Samples for each exposed product and for each color and texture specified.
 - i. Owner, Architect, and Vermont Division of Historic Preservation (VDHP) to be involved in sample approval

4. **Products, Materials & Equipment:**

- a. Mortar Materials:
 - i. Match results of petrographic analysis for mix proportion (hardness) and color. Mockups to be constructed to verify color match to existing mortar

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- ii. ASTM C 150 Type 1 or Type 2, white or gray or both where required for color matching of exposed mortar
 - iii. Cement to include less than .60 percent total alkali by mix according to ASTM C 114. (to reduce likelihood of efflorescence)
- b. Hydrated Lime: ASTM C 207, Type S.
- c. Mortar Sand: ASTM C 144.
 - i. Match colors of existing mortars. Match texture and size of existing sand. Blend sands if required to achieve suitable match.
 - ii. Use natural and synthetic iron oxides, compounded for mortar mixes with a record of satisfactory performance in masonry mortars. Do not exceed pigment-to-cement ratio of 1:10 by weight.
- d. Standard Historic Mortar Proportions
 - i. To be compared to results of petrographic analysis and confirmed for use according to strength of masonry and level of exposure
 - ii. In the event petrographic analysis is not conducted or is inconclusive use the following mix proportions for historic restoration
 - 1. Very Soft: 1-part Portland cement, 4 parts lime, 11-15 parts sand.
 - 2. Type O (Soft): 1 part Portland cement, 2.5 parts lime, 8-10 parts sand
 - 3. Type N (Medium): 1 part Portland cement, 1.25 parts lime, 7-9 parts sand.
 - 4. Type S (Hard): 1 part Portland cement, 1.5 parts lime, 4-5 parts sand.
 - 5. Type M (very hard): shall not be used in existing walls.
 - iii. Typical Proportion applications to determine mortar mix in the absence of petrographic analysis:

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	Low Strength (marble, weak limestone or sandstone, common brick)	Average Strength (hard limestone or sandstone, facing brick)	High Strength (granite or vitrified brick)
Interior and Party Walls		Type O	Type O
Sheltered Exterior Walls	Type O	Type O	Type N
Normally Exposed Exterior Walls	Type O	Type O or N	Type N
Highly Exposed Exterior Walls	Type O or N	Type N	Type N or S

5. Installation, Fabrication, and Construction:

- a. Masons shall have a minimum of 5 years' experience in masonry restoration. Experience installing standard unit masonry is not enough experience for masonry restoration work. UVM reserves the right to reject masons based on review of qualifications.
 - i. Demonstrate mason's ability to repair a sample area, to replace units, and to patch holes at least 1 inch in diameter.
 - ii. Demonstrate mason's ability to repoint unit masonry.
 - iii. Demonstrate ability to remove mortar without cutting or spalling faces of surrounding brick.
- b. Mockups shall be used to demonstrate aesthetic effects and set quality standards for materials, execution, and for fabrication and installation.
 - i. Use of power and pneumatic tools to remove mortar is to be evaluated prior to use on the building.
 - ii. Rotary grinders and spinning blade cutting tools and rotary masonry bits are prohibited from being used on historic buildings to avoid undue damage to existing brick.
 - iii. Single and dual blade oscillating saws may be used if operator passes the demonstration tests.
- c. Repointing: remove mortar from joints to depth of 2 times the width, but not less than ½ inch, or not less than that required to expose sound, un-weathered mortar. Provide square surfaces at front of remaining mortar. Remove loose debris and dust from joints prior to replacing mortar.

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- d. Place new mortar in several layers not greater than 3/8 inch. Compact each layer and allow to be thumbprint hard before applying next layer.
 - e. Avoid widened joint faces by keeping mortar back from face of existing brick.
 - f. Use jointing tools to strike joints to match joint pattern on original structure. Do not use fingers or handles of trowels.
 - g. Clean wall using wood scrapers, stiff brushes, and low-pressure water spray. Do not use acidic or alkaline cleaners. Do not use metal scrapers or brushes.
6. **Warranties:**
- a. Installer's standard 1-year warranty of installation unless a longer warranty is needed by UVM.