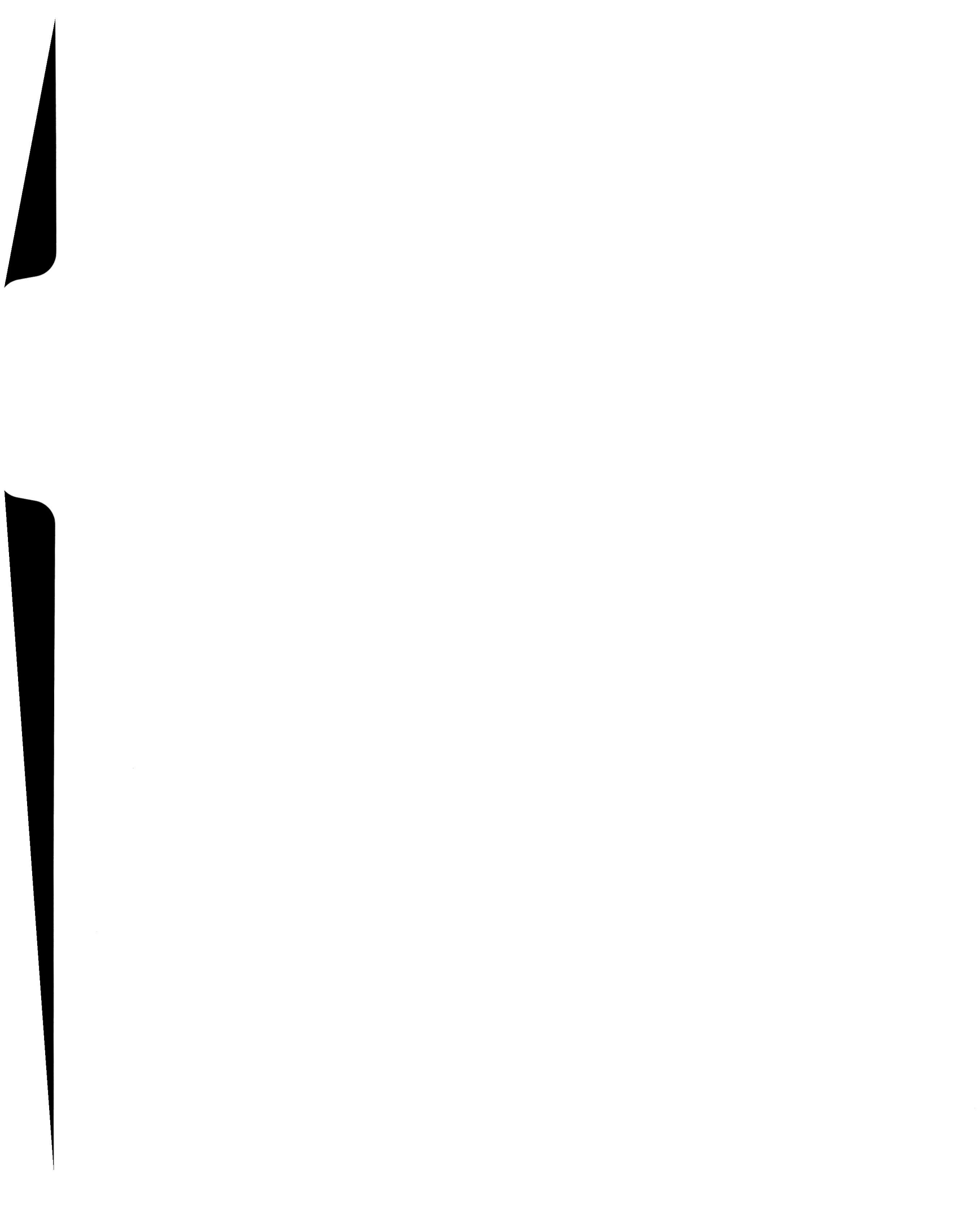


**CHAPTER VII**



## CHAPTER VII

### MORTAR ANALYSIS

#### INTRODUCTION

The mortar analysis on the exterior materials of the Housing and Urban Development Building, located at 451 Seventh Street SW, Washington, DC, was performed in July and November, 1994. The mortar analysis performed was an on-site visual and laboratory examination of the building's mortar for the purposes of determining the composition of the mortar used in the construction of the building; visual characteristics of the mortar used; and types and causes of deterioration. Based on this analysis, recommendations have been made to describe the proper materials and methods for repointing so that future pointing will be compatible with the materials being pointed, act as an integral part of the masonry surface, and match the appearance of the original pointing mortar. Areas of pointing on the building include the joints of the exterior granite walls of the first floor and corner end wall stair towers, joints in the precast concrete triangular screen walls, joints in the bluestone paving of the plaza and bluestone flooring of the first floor.

#### METHODOLOGIES

The methodology followed in the preparation of the mortar analysis included on-site examination of the pointing material to determine the condition and appearance of the existing mortar; recording the locations, types and quantity of deteriorated mortar on drawings; and recording original joint profiles and joint treatments. A location of bluestone paving with sound original pointing material was located and a sample of this pointing material removed for laboratory analysis. Original documentation on the construction of the Housing and Urban Development Building was reviewed to determine what the original designer intended for the composition and appearance of the pointing. Information describing alterations and maintenance was also reviewed to identify work that involved repointing or altering the original pointing mortar.

#### DOCUMENTATION

The only reference to the pointing mortar on the original construction drawings is to indicate that the joint color for both the bluestone and granite is to be "gray."<sup>1</sup> The original drawing for the precast concrete screen walls (Drawing #5-7) described the joints as "1/2" x 1" negative mortar joints between blocks." The intent was for the joint to appear as a dark shadow line between the triangular units. Correspondence from the

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<sup>1</sup>Interior Finish Schedule, Drawing No. 5-1, April 14, 1965.

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architect<sup>2</sup> requested that the joints be pointed flush with the faces of the units instead, however, this was not done and the joints were recessed. The drawing for the granite facing of the end walls at the stair towers<sup>3</sup> indicates that the horizontal joints at the relieving angles located at each floor were to be pointed with sealant. The original specification for "Exterior Stone," Section #16, paragraph 16-06, "Mortar and Grout" references the Mortar specification section.<sup>4</sup> The Mortar Specification, Section #13, is fairly broad and does not indicate the type of mortar or mix proportions of the mortars to be used.<sup>5</sup> The specification is specific about the materials to be used defining the ASTM requirements of the Portland Cement, Masonry Cement, Slag Cement, Hydrated Lime, Lime for Putty, and Aggregates. This specification section does not describe the pointing methods to be used, joint profiles, pigments or joint color. The section's only reference to color is to indicate that the portland cement is to be white. Section #40, Interior Stone, describes the requirements for the bluestone paving indicating that the "joint width shall be 1/2 inch maximum," that joints shall "be finished flush with stone surface" and that "Laticrete liquid shall be added to pointing mortar."<sup>6</sup> This section also indicated that the surface of the stone was to be cleaned with a weak solution of muriatic acid prior to waxing the stone.

Alterations that have included repointing or removal and reinstallation of the masonry include: repointing and resealing the stone at the end wall granite facing of the corner stair towers; replacing the bluestone paving at the east plaza; removing and relaying the bluestone paving at the south and west plazas; and removing and relaying the bluestone paving and flooring at the southeast and northeast entrances.

### ON-SITE ANALYSIS

The mortar at the exterior granite stair tower walls is in good condition. The mortar is dark grey in color to match the color of the granite and is struck flush with the face of the stone panels. These walls were repointed in 1972 when repairs to the stone soffits of the stair tower were made. The mortar in the granite walls at the first floor is also in good condition. These walls are protected from the weather by the overhang of the building above. The color of this pointing mortar is also grey, however, the joint is struck recessed  $\pm 1/4$  inch below the face of the granite panels.

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<sup>2</sup>Letter from John A. Glen of Nolen-Swinburne and Associates to Mr. James R. Harris, Construction Engineer for General Services Administration.

<sup>3</sup>"End Wall Granite Facing, Alternate 'L'," Drawing No. 34-1, May 4, 1965.

<sup>4</sup>General Services Administration, "Housing and Home Finance Agency, 7th and D Streets SW, Washington, DC, Specifications and Bidding Forms," Volume I, Architectural and Structural, Contract No. GS-03B-14597, April 29, 1965.

<sup>5</sup>Ibid.

<sup>6</sup>Ibid.

The pointing mortar in the joints of the pre-cast concrete screen wall is off-white to match the color of the triangular concrete units. The joints are recessed  $\pm 1/2$  inch, not the full 1 inch shown on the original drawings. These joints are typically soiled but are in good condition. Cracks typically occur in the joints at the centers or ends of the walls in relationship to the structural support and natural movement and deflection of the structure. Many of the precast concrete copings on the tops of the screen walls are loose, missing or damaged due to corroding reinforcing.

The pointing mortar of the interior bluestone paving appears to be in good condition, however, because the paving is covered with a thick coating of wax and sealers, the exact condition of the pointing could not be determined. The joint width varies from 3/8" to 1/2" wide. The thick coatings were removed during cleaning tests (see Chapter VIII, Materials Cleaning Analysis) and revealed the interior pointing color is light grey. The pointing mortar is tooled smooth and flush with the surface of the bluestone flooring. The joint between the flooring and the walls is filled with sealant matching the color of the pointing. The pointing mortar in the joints of the bluestone paving on the exterior of the building is in poor condition. This pointing mortar is also grey in color and it too is tooled flush with the face of the pavers. The pointing on the plaza area of the building that is not protected from the weather is deteriorating primarily due to improper paver installation and damage from excessive weight of vehicles causing movement of the pavers and failure of the pointing. The mortar joints in the paving in line with the east face of the building are open due to the differential movement between the building and the underground parking garage. Water collects in these open joints and is allowing moulds and algae to grow in this shaded location. The pointing of the pavers under the building arcade and protected from the weather is in good condition.

### **QUANTITY OF REPOINTING REQUIRED.**

#### **GRANITE POINTING**

Northeast Stair Tower Walls	0 LF
Northwest Stair Tower Walls	0 LF
Southeast Stair Tower Walls	40 LF
Southwest Stair Tower Walls	5 LF
First Floor Granite Walls	10 LF

#### **PRECAST CONCRETE POINTING**

Screen Walls (Open joints should be sealed with sealant to allow further movement)	0 LF
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BLUESTONE POINTING

Bluestone Paving	700 SF
Bluestone Flooring	0 SF

SAMPLE LOCATION

Although there are three types of pointing mortar used on the building, one for granite, one for precast concrete screen walls and one for bluestone, the Scope of Work only requires the laboratory analysis of the bluestone pointing mortar.

The bluestone paving on the east, west and south plazas has been removed, relaid or repointed according to renovation and alteration drawings located in the GSA Technical Library Drawing Files.<sup>7</sup> The bluestone paving at the southeast and northeast entrances has also been removed and relaid in conjunction with the removal of the revolving door and installation of the existing entrances according to the drawings for this work.<sup>8</sup> The only original bluestone paving and pointing is on the first floor of the building and on the north plaza. The mortar sample for laboratory analysis was removed from the north plaza from under one of the displaced stanchions.

The mortar was sound and unweathered and appeared to be original. The mortar was dark grey in color and appeared to contain a pigment. The sample was approximately 27 grams.

LABORATORY REPORT

The results of the laboratory tests, ASTM C 1084-92, Standard Test Method for Portland Cement Content of Hardened Hydraulic-Cement Concrete and ASTM C136-93, Standard Test Method for Sieve Analysis of Fine and Course Aggregates follow in Exhibit A.

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<sup>7</sup>"Demolition Plan," "Construction Plan," "Lower Plaza Plan," and "Upper Plaza Plan," Drawings Nos. 525-528, West Plaza Renovation, Project RDC08250, Contract No. 11-B-08250, July 18, 1980.

<sup>8</sup>"Power Doors & Ramp Details," Drawing Nos. 3-1 - 3-3, Power Operated Doors, HUD, Forrestal, F.B. 108, Washington, DC, August 28, 1973.

**RECOMMENDATIONS**

The pointing mortar on the building is typically in good condition and not in need of immediate attention. Repointing of the deteriorated mortar joints should be performed in conjunction with exterior cleaning of the building. Joints in the precast concrete screen walls that are cracked due to movement of the structure should be pointed with sealant to allow further movement. Damaged and missing screen wall coping units should be replaced to match the originals and pointed to match the adjacent wall. Loose coping units should be removed, reset and pointed to match the adjacent wall.

The pointing mortar on the paving on the east side of the building is in poor condition and in need of immediate attention. The cause of the deterioration of the mortar must be addressed before effective and long lasting repairs can be made. The pavers must be removed and relaid on a suitable traffic bearing substrate. An expansion joint should be provided in the paving at the face of the building to accommodate differential movement between the building structure and the garage structure. The red and purple pavers not matching the color of the original pavers, and specifically excluded in the original building's specifications, should be removed and replaced with pavers matching the original paver colors.

**GRANITE POINTING****Color**

Granite pointing mortar should be dark grey in color to match the color of the cleaned granite. Sealant used at the relieving angles and at the expansion joints should be a custom color to match the pointing mortar. The mortar color should be verified and selected to match a cleaned section of granite. Samples of the mortar should be prepared using the actual proposed materials, and the color of the sand and cement adjusted until the cured mortar color matches that of the original mortar.

**Joint Profile**

Joints at the stone cladding at the corners of the building are to be struck flush with the face of the stone panels.

Joints in the granite walls of the first floor are to be struck recessed  $\pm 1/4$  inch below the face of the granite panels.

**Mortar Materials and Proportions**

Mortar analysis of the granite pointing mortar was not performed. New pointing mortar should comply with the recommendations of the National Building Granite Quarriers Association, Inc. and as follows.

Cement: 1 part by volume Portland Cement white and/or grey as necessary to achieve desired mortar color.

- Lime: 1 part by volume Hydrated Mason's Lime  
Aggregate: 5-6 parts sand ASTM C144 with 100% passing #16 sieve and a fineness modulus between 2.2 and 2.4. Select sand that will result in the desired mortar color.  
Water: Clean and potable to form a workable mix.

Note: This mixture contains twice as much sand as recommended by the National Building Granite Quarriers Association, Inc. The increase in the proportion of sand is to reduce the shrinkage of the mortar.

### PRECAST CONCRETE SCREEN WALL POINTING

#### **Color**

The pointing mortar in the joints of the pre-cast concrete screen wall is off-white to match the color of the cleaned triangular concrete units. Sealant matching the color of the pointing mortar should be used at the cracked joints where movement is anticipated. The mortar color should be verified and selected to match a cleaned section of the screen wall. The mortar color should be achieved by adjusting the color of the aggregate and white and grey cement. Pigments should not be used. Samples of the mortar should be prepared using the actual proposed materials, and the color of the sand and cement adjusted until the cured mortar color matches that of the original mortar.

#### **Joint Profile**

The joints are to be recessed  $\pm 1/2$  inch below the face of the precast units. Raking out the joints and repointing the full 1 inch as shown on the original drawings would not leave enough mortar between the precast units and would compromise the integrity of the wall. Pointing the wall with flush joints as recommended during construction by the original architect will accentuate irregularities in the wall and cracks in the joints. Pointing to match the originally installed pointing is therefore recommended.

#### **Mortar Materials and Proportions**

Mortar analysis of the screen wall pointing mortar was not performed. New pointing and setting mortar should be ASTM C 270 Type N mortar.

- Cement: 1 part by volume Portland Cement white and/or grey as necessary to achieve desired mortar color.  
Lime: 1 part by volume Hydrated Mason's Lime.  
Aggregate: 5-6 parts sand ASTM C144 with 100% passing #16 sieve and a fineness modulus between 2.2 and 2.4. Select sand that will result in the desired mortar color.  
Water: Clean and potable to form a workable mix.



**BLUESTONE PAVER POINTING**

Mortar analysis was performed on a sample of the bluestone paving's original mortar (see Exhibit A). The tests were to determine the mix proportions and the type and gradations of the aggregate. Pigments and additives could not be identified, however, test results did indicate the presence of soluble materials that may have been pigments or the Laticrete liquid called for in the original specifications. Mix proportions were calculated as 1 part cement to 4.4 parts sand. No lime was identified in the mix. The aggregate was observed to be subrounded to subangular natural quartzitic sand. The sand grains ranged in color from clear to tan and buff with an overall aggregate color of buff. The sieve analysis of the sand falls within the parameters of the ASTM C 144 for aggregate although the fineness modulus of the aggregate is low. To achieve the dark grey color of the mortar with a light buff colored aggregate, a pigmented cement or mortar pigments must have been used. Specially formulated inorganic pigments or "lamp black" may have been used as pigments.

The mortar mix identified is similar to ASTM C 270 Type M mortar, though slightly oversanded. This mortar is typically hard, dense, high in compressive strength but not very elastic. The liquid admixture specified increases the flexibility and bond strength of the pointing mortar while improving its freeze resistance. This type of mortar is recommended for pointing and grouting paving.

**Color**

Bluestone paving pointing mortar should be dark grey in color to match the color of the cleaned paving. To match the color of the original mortar while using the buff sand as used in the original mortar, a pigment must be used. Pigments should be insoluble, inorganic, light stable, pigments or pigmented cement. Sealant used at the expansion and control joints should be a custom color to match the pointing mortar. The mortar color should be verified and selected to match a cleaned section of paving. Samples of the mortar should be prepared using the actual proposed materials, and the color of the sand and cement adjusted until the cured mortar color matches that of the original mortar.

**Joint Profile**

The joint width should be tooled smooth and flush with the face of the pavers. Joints are to be 1/2 inches wide maximum.

**Mortar Materials and Proportions**

Mortar materials and mix proportions for the paving mortar should match that originally specified and as determined through testing.

- Cement: 1 part by volume Portland Cement white, pigmented, and/or grey as necessary to achieve desired mortar color.
- Lime: 1/4 part by volume Hydrated Mason's Lime, ASTM C 207 Type S.

- Aggregate: 4 parts sand ASTM C144 with 100% passing #16 sieve and a fineness modulus between 2.2 and 2.4. Sand should be light buff in color to match the original sand color.
- Pigments: Insoluble, inorganic, light stable, pigments, suitable for use in mortar.
- Admixture: Latex admixture specially formulated for grout for paving.
- Water: Clean and potable to form a workable mix.

This mix has been modified from what was specified and determined through testing with the addition of a small amount of lime. The lime is to improve the mortar's plasticity and reduce shrinkage.



**LAW**

ENGINEERING AND ENVIRONMENTAL SERVICES

April 12, 1995

Mr. Reed A. Black, A.I.A.  
Oehrlein & Associates Architects  
1702 Connecticut Avenue, N.W.  
Washington, D.C. 20009

**Subject: Report of Mortar Testing Results  
Dept. of H.U.D. Building  
Bluestone Mortar Sample  
LAW, Atlanta, Job No. 5820854401**

Dear Mr. Black:

Law Engineering (LAW) has completed the analysis of mortar samples submitted to this office as authorized and directed by your letter dated March 14, 1995. The requested scope of work was clearly presented in your letter. However, LAW expressed some reservations about the extent to which some of the requested services could be provided. Our reservations were discussed with you by telephone on March 15, 1995. The subject mortar was observed to be dark gray. LAW can not estimate the amount of pigment which may have been used to color the mortar. This report presents test procedures, test results, and observations.

#### **Test Procedures**

Portions of the submitted sample were tested in accordance with ASTM C 1084-92, "Standard Test Method for Portland Cement Content of Hardened Hydraulic-Cement Concrete". For analysis purposes the mortar was assumed to contain lime and portland cement. The portland cement was assumed to contain the following soluble materials: 21.0 percent silica, 63.5 percent calcium oxide, and 1.5 percent magnesium oxide.

Acid-washed sand from the mortar was sieved using procedures presented in ASTM C 136-93, "Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates", and the fineness modulus of the sand was calculated. However, the size of the sand sample is very small (approximately 27 grams) and the test results obtained are considered to have a margin of error greater than those expressed in the standard.

A small portion of the mortar was polished and microscopically observed to visually classify the sand.

**LAW ENGINEERING, INC.**

396 PLASTERS AVENUE, N.E. • ATLANTA, GA 30324  
(404) 873-4761 • FAX (404) 881-0508

### Test Results

The results of the ASTM C 1084-92 testing are as follows:

Soluble Silica (SiO <sub>2</sub> )	5.00 percent
Soluble Calcium Oxide (CaO)	11.71 percent
Insoluble Residue	69.33 percent
Loss On Ignition	10.18 percent
Magnesium Oxide (MgO)	0.83 percent

The ASTM C 1084-92 test results indicate an excess of soluble silica as compared to the percent of soluble calcium oxide and the magnesium oxide content is higher than expected for the calculated cement content. This may be a result of soluble pigment materials or soluble aggregate particles. Because we do not have any information about the soluble constituents of the pigments or the aggregate used, we have analyzed the chemical results based on the amount of soluble calcium oxide in the mortar. It is our opinion that lime is not present in the mortar based on the chemical analysis indicating a lack of excess soluble calcium oxide. Based on the results of ASTM C 1084-92, we estimate the proportions of the mortar to be approximately:

<u>Constituent</u>	<u>Percent By Weight</u>	<u>Volume by Parts</u>
Cement	18.44	1.0
Sand	69.68	4.4

The remaining 11.88 percent by weight of the mortar consists of material lost on ignition and trace constituents which were not tested for quantities present.

The sand was observed to be a natural quartzitic sand with a subrounded to subangular texture.

The results of the sieve analysis performed on the acid washed sand are presented below:

<u>Sieve Size or Number</u>	<u>Percent Passing</u>
3/8 inch	100
No. 4	100
No. 8	100
No. 16	95
No. 30	64
No. 50	20
No. 100	4
No. 200	1.0
Fineness Modulus	2.17


The total sample size tested was approximately 27 grams and does not meet the minimum sample size requirements of ASTM C 136-93. The reported results may have a greater margin of error than results of tests conducted in strict accordance with ASTM C 136-93. The accuracy of the sieve analysis is also affected by the degree to which the acid washing was complete. A small amount of cementitious residue was observed on the sand after washing, and some fine sand particles may be bound together by cementitious material. Some of the sand particles may have been soluble in the acid and may have been altered or dissolved.


A sample of the acid-washed sand is being returned with this report.

Law Engineering appreciates the opportunity of providing this service. If there are any questions about this report, or if we may be of further service, please call.

Sincerely,

**Law Engineering, Inc.**

  
Terry L. Viness, P.E.  
Senior Materials Engineer  
Registered, GA No. 21791

  
Robert S. Jenkins, P.E.  
Corporate Materials Consultant  
Registered, GA No. 6083

cc: Michael Brown, LAW, Washington, D.C.

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