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EXPERIMENTATION IN CONCRETE:
JOHN J. EARLEY AT MERIDIAN HILL PARK, WASHINGTON, DC
HISTORY, TECHNOLOGY, AND CHARACTERIZATION OF EXPOSED AGGREGATE CONCRETE

Lori Renée Aument

A THESIS

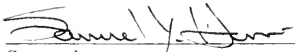
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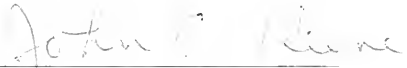
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Supervisor
Samuel Y. Harris
Adjunct Professor



Reader
John Keene
Professor of City and Regional Planning



Graduate Group Chair
David G. De Long
Professor of Architecture

Final A+ / NA

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1.1 Introduction

The exposed aggregate, reinforced concrete work at Meridian Hill Park physically manifests the experimentation in concrete undertaken by John J. Earley and later contractors. At the beginning of the construction of Meridian Hill Park in 1915, concrete remained a new material whose full potential and possibilities remained uncharted. John J. Earley approached the problem of constructing the concrete at Meridian Hill Park in the spirit of experimentation, demanding an expression of the artistry and honesty of the material. These goals remained with him throughout his distinguished career. The evolution of Meridian Hill Park during its construction period from 1915 to 1936 evidences the various experiments that were carried out in exposed aggregate concrete work by Earley and later contractors. A current condition summary and material analysis identifies the traces of the historic development in the physical concrete the current state of the concrete, and composition of the exposed aggregate concrete. An understanding of the context for the creation of the concrete at Meridian Hill Park, as well as the physical conditions and deterioration mechanisms at work, will aid in future restoration work.

This thesis will focus on the perimeter walls of Meridian Hill Park and the associated entrances. Perimeter walls served as the testing ground for the earliest experiments in exposed aggregate concrete at Meridian Hill Park and are representative of most periods of construction. It is here that John J. Earley first worked through the difficulties of constructing strong, durable, and aesthetically pleasing concrete. Further, the walls exhibit many of the deterioration conditions found throughout the site.

This study of the concrete at Meridian Hill Park begins with an overview of the physical site today, its history and cultural significance. Next, a discussion of the debate and use of concrete as an architectural material at this period gives outlines the context for the beginning of experimentation in concrete at the park. The following history of John J. Earley places Meridian Hill Park at the beginning of a lifetime of achievements in concrete characterized by innovation and artistry. The chronological stages of construction at the park and the techniques used in each period are detailed as a guide to the development of the concrete. A survey of the current conditions found at the site provide information on the deterioration mechanisms which may endanger the concrete. Analyses of the concrete complements the history of the concrete

work through characterization of the composite material and identification of internal deterioration mechanisms. Through these stages of the thesis, the structures at Meridian Hill Park are examined at many levels to produce a complete picture of the concrete work. The concrete at Meridian Hill Park is more than just a material or an aesthetic expression. It requires an analysis of its history, structure, and material and an appreciation for its artistry.

1.2 Description: Overview

Meridian Hill Park is located on two city blocks in Washington, DC, bounded on the east by 16th Street, NW, on the west by 15th Street, on the south by W Street and by Euclid Street on the north (see figs. 1 & 2). Perimeter walls formally define the entire area. The north end of the park is a level rectangular area planned on axis in the manner of a French formal mall. Benches run along each of the main converging paths which lead to the Grand Terrace. Here, fountains and a statue of Jeanne d'Arc mark the overlook area which has a view over the city of Washington and the lower, southern portion of the park. At the Grand Terrace, the topography dramatically drops to the plaza area at the southern end of the park. A series of basins form cascades designed in the manner of Italian Renaissance gardens lead down the center of the slope, flanked by descending walks on either side (see fig. 3). On the lower plaza level there is a reflecting pool in the center, a memorial to President Buchanan on the west, and a semi-circular exedra area to the south. A low level balustrade lines the extreme southern end of the park.

All of the architectural features and decorative elements found at Meridian Hill Park are executed in exposed aggregate, reinforced concrete. The entire park area is delimited by perimeter walls with textured panels and heavily rusticated posts. Throughout the park, elements as varied as fountains, benches, the architecture of the Grand Terrace, paving, planting beds and urns are all constructed of exposed aggregate, reinforced concrete. These features are remarkable for the use of various aggregate sizes to create subtle textures while defining crisp corners and turning smooth curves. The coloring of the concrete in the park is also striking from the modulations of brown and cream on the architectural elements to the bright colors found in paving mosaics.

In 1930, Horace Peaslee, the principal architect involved in design of the park, described Meridian Hill Park as consisting of:

approximately eleven acres, located at Sixteenth Street and Florida Avenue, just outside the original boundary line of the city of Washington as planned by L'Enfant, at the point of an abrupt change in

grade which made possible a difference in elevation, as between the high and the low levels of the park, of seventy-five feet. It is surrounded, in the main, by fine residential property, including a number of embassies.¹

Today the park retains much of its original design. At present the landscape at Meridian Hill Park has lost a significant amount of its integrity though there are current efforts to restore the original planting design. In contrast, the concrete work has stood up remarkably well, despite showing signs of deterioration and loss in a few areas. The original aesthetic of the park within the perimeter walls as an integrally designed architectural landscape remains impaired by the loss of the planting design. Views out from the park have been altered by the change in the neighborhood from one of fine residences to one of rowhouses and apartment houses. The Roosevelt apartment house on the southern end of the park blocks the significant view over Washington from the Grand Terrace (see fig. 4).

The use of the park has altered from its original conception. Originally, the park was to be a formal park in an upper class, embassy neighborhood, made for strolling, leisurely contemplation, and musical events. Soon after completion the demographics in the surrounding neighborhood began to change. The park was in demand to provide playgrounds for the lower class families moving into the neighborhood. In the 1960s the area had become a largely minority neighborhood. The park was later a site of race riots in the early 1970s and remains to this day a gathering site for occasional political demonstrations. Currently, local residents desire recreational space which was not envisioned in the original design. In addition, security problems demand constant patrolling of park premises. These outside factors, in combination with the physical features of Meridian Hill Park, influence how the park is used and how it is experienced and presents challenges concerning its restoration.

1.3 History of the Park

In 1901, the McMillan Commission developed a plan to improve the park system within the District of Columbia. Meridian Hill was marked as a property suitable for a government reservation because of its views over the capitol city. On June 25, 1910, Congress approved an act to acquire public land to create Meridian Hill Park as recommended by the McMillan

¹ Horace W. Peaslee, "Notes on the Concrete Work of Meridian Hill Park, Washington" in *Landscape Architecture*, (V. 21, n. 1 (October 1930): 31-38): 31.

Commission. In April of 1913, George Burnap (1885-1938), landscape architect for the Office of Public Buildings and Grounds, proposed a design for a formal urban space at Meridian Hill Park. The design was constantly modified until its current form was completed in 1936. The main design concept, consisting of a formal park patterned on French and Italian garden precedents, remained constant throughout the many changes. Plans for the park were minutely scrutinized by the newly formed Commission of Fine Arts, whose members included Cass Gilbert (1859-1934) and contemporaries, during every phase of construction.

In 1914, Horace Peaslee (18??-19??) accompanied George Burnap on a trip to study the gardens of Europe to find inspiration for the design of Meridian Hill Park. Peaslee was to become the principal architect in charge of the park when Burnap resigned from the Office of Public Buildings and Grounds in 1917. The Italian gardens they visited and sketched during this trip became the main concept for the park. The scale of the park and its elements prohibited the use of costly masonry. For this reason, concrete was chosen as the construction material in the hopes that it could achieve the warmth and color of the walls found in the Italian gardens.

Construction of the park commenced in 1915, soon after Burnap and Peaslee returned from Europe. The first stage of construction required that a mock-up be approved before construction could begin. Preliminary mock-ups were prepared for review by John J. Earley (1881-1945) and the Earley Studio. Construction work progressed during the period 1915-1922 primarily on the walls and walks of the upper park which was officially opened in 1923.² The street level west wall from the northwest corner to the lower 16th Street entrance was constructed in 1915-16.³ During 1917-1923 many changes were made to the design of the park under Peaslee's direction while the upper portions of the west and east walls, the north wall, and the paving on the upper mall were completed. The main 16th Street Entrance was completed in 1918.⁴ The upper retaining wall along 16th Street was completed in 1919 to the lower, circular 16th Street overlook.⁵ The north wall with its iron grille and the east wall from the northeast corner to the Belmont Street entrance were completed in 1922.

² *Annual Report Chief of Engineers, U.S. Army, Public Buildings and Grounds, District of Columbia, 1917-1923.*

³ *Annual Report Chief of Engineers, U.S. Army, Public Buildings and Grounds, District of Columbia, 1917.*

⁴ *Annual Report Chief of Engineers, U.S. Army, Public Buildings and Grounds, District of Columbia, 1918.*

⁵ *Annual Report Chief of Engineers, U.S. Army, Public Buildings and Grounds, District of Columbia, 1919.*

From 1923-1928 work progressed on the perimeter walls. In 1925, the Main 15th and Service Entrances and the middle section of the East Wall between the entrances were constructed. The remainder of the 15th Street wall was completed in 1927, while the remainder of the west wall and the south wall were completed in 1928.⁶

Construction was completed in the period 1929-36 on the Italian garden features of the lower park. Work progressed on the lower plaza (1929), the Great Terrace wall (1930), the Cascades (1933), the paving of the upper area of the Great Terrace (1936) and the completion of the East Ascent (1936).⁷ Landscaping for the park was planned, discussed, and implemented during the construction of the architectural features by the landscape architect Ferruccio Vitale (1898-19??) of Vitale, Brinckerhoff & Geiffert (see Appendix A).⁸

In 1974 Meridian Hill Park was listed on the National Register in acknowledgement of its aesthetic and historic value and for the integrity of its design. Aesthetically the park is a combination of art deco and neo-classical Italian villa garden design formed from a collaboration between some of the best architects and landscape architects of the period. Landscape and architectural elements were skillfully designed as integral components of the park. Historically, the park represents an important thread in the development of Washington, DC.⁹

HABS documented the park in 1984.¹⁰ In 1994, the park was approved as a National Historic Landmark in recognition of the outstanding quality and importance of the work. At this date, the value of the concrete work was acknowledged as experimental ground for John J. Earley and the Earley Studio in developing a new way of proportioning aggregate to create a more beautiful finish. The pioneering work at Meridian Hill Park marked the beginning of a technique which was used extensively in Washington, DC and throughout the country.¹¹

⁶ See *Meridian Hill Park: Cultural Landscape Report, 50% Draft*, April 1, 1998.

⁷ Meridian Hill historic photographs, National Park Service- National Capitol Region, Rock Creek Park Cultural Resource Management Archives.

⁸ See *Meridian Hill Park: Cultural Landscape Report, 50% Draft*, April 1, 1998.

⁹ *Meridian Hill Park*, National Register Nomination, 1974.

¹⁰ *Meridian Hill Park*, HABS DC-532, 1984.

¹¹ *Meridian Hill Park*, NHL Nomination, 1994.

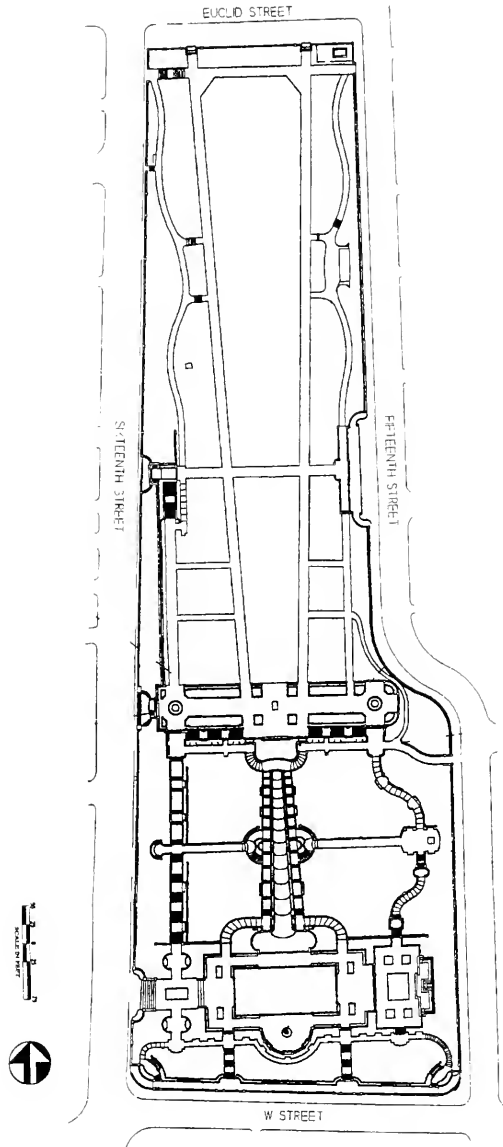


Figure 1: Site Plan of Meridian Hill Park
Cultural Landscape Report, 50% Draft. Land Ethics, Inc.

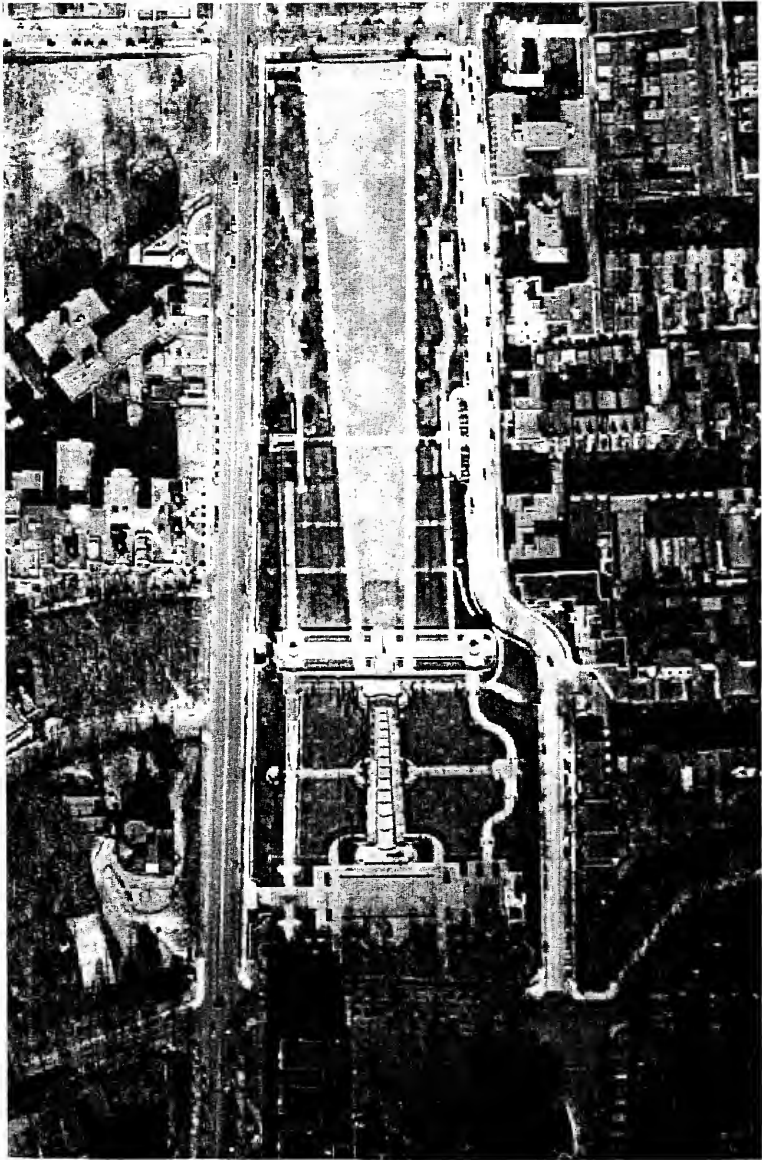


Figure 2: Aerial View of Meridian Hill Park, c. 1936-46
Rock Creek Park, Cultural Resource Management Archives

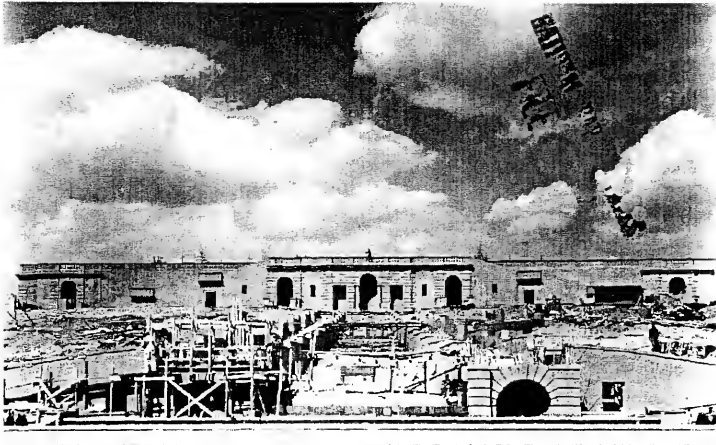


Figure 3: Looking North to Cascades from Lower Park, c. 1932
Rock Creek Park, Cultural Resource Management Archives



Figure 4: Great Terrace Historic View of Washington, c. 1936
Rock Creek Park, Cultural Resource Management Archives

To understand the contributions and achievements of John J. Earley at Meridian Hill Park a brief history of the development of concrete as an architectural material is presented.¹ Earley began experimenting in concrete at a time when the physical and structural properties of the material and the relationships between the ingredients were not completely understood. It was also a period for debate and development of an appropriate and aesthetically pleasing expression for this new architectural material. Earley entered the field when concrete was an experimental construction and fledgling architectural material. His work thrived in a period when the concrete industry and the architectural profession were constantly researching and experimenting with both the physical properties and the aesthetic potentials of concrete.

2.1 *History of Concrete*

Concrete is an ancient building material that has been used by many civilizations in one form or another. Roman civilization is most remembered for its use of cement because of the durability of its mortars. The use of natural cement as a construction material was practically forgotten in Europe until the nineteenth century. Its rediscovery as a building material in Europe is traditionally attributed to John Smeaton who used a natural hydraulic lime to finish the exterior of the Edystone Lighthouse in 1791. Though, several others in Europe began experimenting with the material around the same time.² Between 1830-1850 natural cement was widely used in the United States for canal building. Joseph Aspdin patented Portland cement in England in 1824 though his role in its invention is contested. Portland cement was made from burning limestone at high temperatures ranging from 1400-1500°C. Portions of the limestone, known as clinker, fused together during the burning and were finely ground with the lime producing a stronger cement. Portland cement became widely used around the turn of the century after the introduction of the rotary kiln made it more economical to achieve the high temperatures required.³ In 1902, the Portland Cement Association formed in the United States.

¹ For a more complete discussion of the history of concrete and the experimentation with concrete finishes see Yael Loewenberg, *Historic Concrete Finishes, 1900-World War II*, Columbia University Thesis, 1987.

² See Jasper O. Draffin, "A Brief History of Lime, Cement, Concrete and Reinforced Concrete" in *A Selection of Historic American Papers on Concrete 1876-1926*, Publication SP-52, Ed. Howard Newlon, Jr., (Detroit: American Concrete Institute, 1976: 3-40): 7.

³ Edward E. Bauer, *Plain Concrete*, (New York: McGraw-Hill, 1928): 26-27.

The newly formed American Society for Testing and Materials (ASTM) created the first standards for cement in 1904.⁴ Around this time, researchers were exploring the proportioning of the ingredients in concrete mixes to achieve optimum results.

2.1.1 Proportioning

As the use of concrete construction in the United States increased, testing began to focus on increasing strength and durability of the material through the proportioning of the mix. The ratio 1:2:4, one part cement, two parts sand to four parts aggregate, was an accepted standard used by Smeaton at the Edystone Lighthouse. In 1905, W.B. Fuller (1862-1923) and S.E. Thompson (1867-19??) based their studies of proportioning on the assumption that the densest concrete was the strongest. They experimented with different gradations of aggregate based on the diameter of the grains to achieve the densest packing. The coarse aggregate, sand and cement was so proportioned that the packing properties allowed for the smallest number of voids.⁵ In 1918, Duff Abrams refuted the idea that the strongest concrete was the densest. His studies led him to the conclusion that use of a coarser aggregate made stronger concrete; however, he argued that the amount of water present in the mix was a more important factor in determining strength than the gradation of aggregate.⁶

In a 1918 publication, Abrams concluded that the grading of the aggregate determined the amount of water needed for a workable mix. In turn, the amount of water needed for workability defined the amount of cement needed to achieve optimum strength. As had been long known through empirical knowledge, too much water weakened the concrete. According to Abrams, the size and grading of aggregate could widely vary without affecting the strength of the concrete as long as the water-cement ratio remained constant.⁷ This publication reached a wide audience and the concept of the ideal water-cement ratio influenced the use of mixing water in the concrete industry.⁸

⁴ Jasper O. Draffin, "A Brief History of Lime, Cement, Concrete and Reinforced Concrete": 9-19.

⁵ Sanford E. Thompson, "Proportioning Concrete" in *American Architect and Building News*, (v. 90 (1906): 59-61): 59.

⁶ Duff A. Abrams, "Design of Concrete Mixtures" in *Bulletin No. 1, Structural Materials Research Laboratory*, (Chicago: Lewis Institute, 1918): 4.

⁷ Duff A. Abrams, "Design of Concrete Mixtures": 2-4.

⁸ Jasper O. Draffin, "A Brief History of Lime, Cement, Concrete and Reinforced Concrete": 27.

2.1.2 Reinforced Concrete

During this same period, the structural properties of reinforced concrete were undergoing research and experimentation. Joseph Monier (1832-1906) is credited with the invention of reinforced concrete which he exhibited at the 1867 Paris Exposition and patented in the same year.⁹ Reinforced concrete greatly improved the tensile strength of concrete and allowed for more freedom in designing concrete structures. This mode of construction was introduced in the United States through systems such as that patented by the American, Thadeus Hyatt, in 1878¹⁰ and foreign patents such as the Hennebique system.¹¹ At this date, reinforced concrete was still a new technology and employing a patented method gave added security. The first standard report on reinforced concrete in the U.S. was published in 1916 by a joint committee including ASTM, the Portland Cement Association, and the American Institute of Architects, among others. This report gave only the fundamental principles of the design and did not specify details.¹²

2.2 Concrete as an Architectural Expression

While researchers investigated the physical and structural properties of concrete, practitioners debated the architectural merit of concrete and its appropriate expression. Much of this discussion revolved around the correct form and finish of concrete. Most agreed that concrete should not imitate other building materials but should be formed to reveal its inherent physical qualities. Further, concrete needed an appealing finish to be truly considered an architectural material capable of performing under various aesthetic demands. John Earley took part in this debate and development and achieved some of the most outstanding concrete finishes of the period.

⁹ Jasper O. Draffin, "A Brief History of Lime, Cement, Concrete and Reinforced Concrete": 29.

¹⁰ Jasper O. Draffin, "A Brief History of Lime, Cement, Concrete and Reinforced Concrete": 29.

¹¹ The Hennebique system was successfully advertised by François Hennebique in his magazine *Le Béton Armé* in 1898 and soon gained international recognition. Gwenaél Delhumeau, "Hennebique and Building in Reinforced Concrete around 1900" in *Rassegna*, (v. 14, n. 49/1 (March 1991): 15-24): 15.

An article in *The American Architect* of 1905 compares and rates the various patented systems, all originating from France or Belgium, explaining the relationship of concrete to iron in each system. "Ferro-Concrete in Belgium" in *The American Architect and Building News*, v. 88, n. 1548 (August 19, 1905): 67-71.

¹² Jasper O. Draffin, "A Brief History of Lime, Cement, Concrete and Reinforced Concrete": 31.

2.2.1 Honesty of Form

In the search to transform concrete from an engineering construction material to a material capable of complex architectural expression, the focus was on honesty of form and on creating an appealing finish. The structural, strength, and fireproof qualities of concrete were accepted but its artistic merit was not. At the end of the nineteenth century, architects used reinforced concrete as a structural material often disguising it with cladding. By the early twentieth century, this type of construction was labeled a deception. The argument over the correct form of concrete revolved around the larger discussion of honesty in architecture.

It was urged that buildings constructed of concrete reveal the plastic nature of the material. Concrete should not be molded or formed to imitate other masonry materials. Such attempts were derided: "To mould concrete in blocks so that its face shall have even the mechanical form of stone ashlar or to simulate joints on the surface of a monolithic wall for the same purpose, is only an obvious and quickly resented attempt at deception."¹³ The characteristics of construction and the physical, mechanical, and economical characteristics of reinforced concrete should be studied to discover the essence of the material. Its design should follow the "line of simple and direct expression of the purpose and mode of construction..."¹⁴ Concrete offered the possibility of escaping the masonry vocabulary of stone on stone. Its plastic properties allowed it to be molded in monolithic, organic shapes. To many architects, the search for an honest expression of concrete opened up new possibilities for architecture.¹⁵ Leading English Arts and Crafts Architect, William Lethaby wrote of concrete: "If we could sweep away our fear that it is an inartistic material, and boldly build a railway station, a museum, or a cathedral, wide and simple, amply lighted, and call in our painters to finish the walls, we might be interested in building again almost at once."¹⁶ The new potentials of form offered by concrete fueled interest in finding a contemporary expression in modern architecture. This quotation manifests the interest architects had in concrete as an architectural material but also the doubts they had about its surface finish.

¹³ "The Architectural Treatment of Concrete Surfaces" in *The American Architect*, (V. 54, n. 1978 (November 19, 1913): 193-199): 194.

¹⁴ William Price, "The Possibilities of Concrete Construction from the Standpoint of Utility and Art" in *The American Architect and Building News*, (v. 89, n. 1580 (April 7, 1906): 119-120): 119.

¹⁵ This study will not cover the innovative use of concrete in modern architecture, though that is part of the interest in concrete during this period.

¹⁶ Quoted in N. Pevsner, *Buildings of England, North East Norfolk and Norwich*. (Penguin: Harmondsworth, 1973): 169.

2.2.2 *Appealing Finish*

Concrete was often rejected as a finishing material because of its unpleasing, drab surface. This surface was acceptable for engineering structures and industrial buildings but not for buildings of symbolic importance. A proponent of concrete wrote in 1913 of the current poor methods of concrete construction: “These careless methods, employed above ground, produced results so glaringly ugly as to cause a too common belief that nothing beautiful could be made of concrete....”¹⁷ To correct the idea that concrete was incapable of being aesthetically pleasing, many architects and contractors experimented with treating the surface of concrete structures. The surface treatments that were developed included applied finishes, such as paint and stucco, and integral finishes, such as coloring, tooling, exposing aggregate, and molding, which capitalized on the multi-faceted, plastic character of the concrete.

2.2.2.1 *Paint and Stucco*

Painting concrete demands careful surface preparation. The concrete was neutralized with a zinc sulphate or magnesium fluorosilicate solution before any paint could be applied to avoid chemical reactions between the paint and the substrate.¹⁸ After the surface was neutralized, the concrete was ornamented in a conventional way. Though, the palette of suitable concrete paints was limited until the late 1920s, consisting of only red, yellow, blue, and black.¹⁹

Stuccoing concrete surfaces was similar to standard stucco practice where various finish textures could be achieved. This was a widely used technique because it built on an already established practice and covered many of the casting blemishes. Finishes ranged from a smooth, sand floated finish, achieved by rubbing sand into the finish coat, to a pebble dash finish, obtained by throwing sand and stones into the finish coat. Concrete stuccoes were applied over structural tile or other masonry material.

¹⁷ Wm. Walter Smith, “Ornamental Treatment of Concrete Surfaces” in *The American Architect*, (v. 51, n. 1883 (January 24, 1913): 33-42): 33.

¹⁸ See W.S. Gray, *Concrete Surface Finishes, Renderings and Terrazzo*, London: Concrete Publications, 1935, and W.E. Hart and Raymond Wilson, “The Painting and Coloring of Concrete” in *The American Architect*, (December 20, 1927): 833-838.

¹⁹ L.C. Wason, “Report of Committee on Treatment of Concrete Surfaces” in *Proceedings of the National Association Cement Users*, (v. 7, (December 12-20, 1910): 552-585): 579.

2.2.2.2 Coloring Cement Mix

Coloring of concrete was studied through experimentation with the addition of pigments in the cement mix. Such experiments did not meet with great success as there were few suitable, non-reactive pigments and their inclusion in the concrete mix decreased the strength of the material. Further, the final color of the set concrete was often muddy. Sample panels were required to assure the quality of the color because it was difficult to keep a consistent color between batches. Pigmenting cement greatly improved during the 1930s with the introduction of pre-pigmented Portland cements.²⁰

2.2.2.3 Tooling

Tooled finishes covered a wide variety of techniques such as brushing, scrubbing, spading or working the wet surface of concrete with a facing board similar to the treatment of stucco.²¹ The hardened surface of concrete could be tooled by polishing, sand blasting, chiseling or bush-hammering the surface with a studded hammer in the manner of dressing stone. This required letting the concrete harden for a month or more. Such techniques focused on texturing the wall to give warmth to the cold, smooth surface of concrete.²²

2.2.2.4 Exposing Aggregate

At the turn of the century, the technique of exposing the aggregate of the concrete mix was seen as a newly discovered finishing technique. It was contrasted to the ancient technique of plaster and stucco where the finish was applied to the surface.²³ The aggregate in the cement mix were exposed in three steps: first, removing the casts from the forms while they were still green, second, removing the cement film by mechanically brushing off the film and third, chemically washing the surface with muriatic acid to brighten the color of the aggregate. The exposed aggregate finish could be obtained by integral or applied concrete work: "The entire thickness of wall may be made of these selected aggregates or, by means of facing boards, only an outside layer may be used, backed up by ordinary concrete and naturally thoroughly bonded together with it as a single stone."²⁴ As late as 1935, exposed aggregate finishing was considered a highly

²⁰ "Surface Treatment of Concrete: Practical Hints and Details of Costs" in *Concrete & Constructional Engineering*, (v. 30, n. 1 (January 1935): 74-80): 80.

²¹ See W.S. Gray and W.E. Hart.

²² Wm. Walter Smith, "Ornamental Treatment of Concrete Surfaces": 38.

²³ W.E. Hart and Raymond Wilson, "The Painting and Coloring of Concrete": 833.

²⁴ Wm. Walter Smith, "Ornamental Treatment of Concrete Surfaces": 39.

skilled technique for concrete work. Delicate features could be damaged by the removal of the green cement skin.²⁵ This finishing technique utilized elements of the concrete mix to create the final surface finish.

The process of exposing the aggregate was practiced well before its use at Meridian Hill Park. The literature reveals that small panels were finished through this process in 1907.²⁶ A 1908 article describes a country house finished in the same manner with exposed selected aggregates of trap rock and marble chips.²⁷ Again in 1912, an article mentions concrete work with “displayed selected aggregates”²⁸ and in 1913 a similar technique was utilized at a train station in Montclair, NJ.²⁹ The aesthetic potential of exposed aggregate was acknowledged in another 1913 article: “A wealth of color is everywhere at hand in the various marbles, granites, gravels and burnt clays, from which he may select his crushed aggregates (one of several) and combine them on the mixing board in much the same manner as the artist mixes his paints on his palette.”³⁰

2.3 Conclusion

During the years of the construction of Meridian Hill Park (1915-36) the concrete industry grew from a fledgling to a booming industry, from being primarily applied to engineering structures to wide spread use in high-style architecture. During this period, the concrete industry was establishing reinforced concrete as an economic, durable, and fireproof construction material capable of meeting the aesthetic demands of modern architecture. By 1936, its place in modern architecture was assured. In 1935, an author stated that concrete “deserves, perhaps, to be called the most ‘honest’ of architectural materials since it requires no facing other than the surface of the supporting and enclosing structure.”³¹ John Earley worked through this experimental period of architectural concrete construction with the questions of honesty of material always at hand devising and improving techniques as new discoveries were made and as each design demanded. His experiments and innovations were part of an interesting

²⁵ Arthur McK. Stires, “Concrete: Form, Texture, Color” in *American Architect*, (August 1935): 70-82); 78.

²⁶ J.H. Chubb, “Artistic and Commercially Practical Surface Finishes for Concrete Work” in *Engineering Record*, (April 3, 1907): 415.

²⁷ Albert Moyer, “Concrete of Exposed Selected Aggregates” in *Municipal Engineering*, (v. 34, n. 1 (January 1908): 2-7): 2.

²⁸ Wm. Walter Smith, “Ornamental Treatment of Concrete Surfaces”: 39.

²⁹ “The Architectural Treatment of Concrete Surfaces”: 198.

³⁰ Wm. Walter Smith, “Ornamental Treatment of Concrete Surfaces”: 38.

period in concrete history when concrete construction seemed capable of advancing in many directions.

³¹ Arthur McK. Stires, "Concrete: Form, Texture, Color": 70.

John J. Earley, and the craftsmen at the Earley Studio, continuously applied creative solutions to the problem of creating color, texture, and form in honest and artistic concrete work. Color and texture emerged from the concrete itself as the exposed aggregates were controlled and manipulated through the use of step-graded aggregate in the concrete mix. Complexities of form increased through succeeding work as the Studio gained an increasingly sophisticated understanding of the role of water and structural possibilities of concrete. This lifetime work followed Earley's own belief in honesty and artistry of craftsmanship. The finishes and forms developed directly from a desire to utilize the essential qualities of concrete. Above all, the concrete work attests to the sense of artistry which John Earley brought to each of his projects.

3.1 Biography

John J. Earley (1881-1945) was born in New York to recent Irish immigrants Mary and James Earley, a fourth generation stone carver. He went to parochial school in Washington, DC, when his father's business relocated there, and attended St. John's College. At the age of seventeen he became an apprentice in his father's studio. Here, he met Basil Taylor, a young employee of the studio. John Earley assumed control of the Earley Studio in 1906 after the death of his father. Previously, the studio had produced mainly stone ornamental sculpture following the training of James Earley as a stone carver.¹ John J. Earley and his associate, Basil Taylor, changed the focus of the studio to plaster and stucco work. Earley became interested in experiments being done by the Bureau of Standards in 1911-14. These tests addressed the problems of the failure of Portland cement plaster stuccoes applied over metal lathe. Earley worked with J.C. Pearson, the Bureau's cement chemist, to reduce the appearance of map cracking.² These experiments were contemporary with the work at Meridian Hill Park and directly influenced the construction techniques used there. After the pioneering work at Meridian Hill Park, the work of the Earley Studios progressively became the standard for artistic expression of architectural concrete. Later in life, Earley explained why he became interested in concrete: "my interest in it [concrete] was aroused because it is a permanent material, which at

¹ Frederick W. Cron. *The Man Who Made Concrete Beautiful*, (Fort Collins: Centennial Publications, 1977): 5-7.

² See Bureau of Standards, *Stucco Investigations at the Bureau of Standards December 13, 1926*, Washington, DC: Government Printing Office, 1926.

the same time is a facile or quick medium, wonderfully flexible, adaptable and complete. It is difficult for me to explain what it means to an artist to have a medium in which final effects may be quickly achieved, and in which both form and color may be adequately and permanently preserved.”³ He is remembered for his artistic achievements in concrete.

3.2 *Color and Texture: Step-gradation*

John J. Earley’s work on concrete finishes was part of many experiments at the turn of the century to improve the appearance of concrete. At Meridian Hill Park, Earley experimented with finishing the walls with an exposed aggregate finish using well established processes. The exposed aggregate finish proved an impressive improvement in color and texture and it sparked further experimentation by Earley. Through work with J.C. Pearson at the Bureau of Standards, Earley developed a new technique for grading the aggregate which controlled the appearance of the exposed aggregate and minimized the cement visible on the surface. Earley’s innovation in exposed aggregate finish was not in the technique but in the concrete mix. The earlier techniques of exposing aggregate produced “a rough surface of irregularly distributed colored stones possessing considerable artistic worth.”⁴ It was this *irregular* distribution of aggregate on the surface which Earley’s “step gradation” eliminated. Earley’s experiments developed a technique which created a uniform surface appearance whose color and texture could be controlled. Earley’s accomplishment was his development of a systematic manner of grading the aggregate within the concrete and the high quality standard of the work done by Earley Studios. Earley patented this technique in 1920 as “Step Gradation.” This invention became the basis for the concrete work produced by the Earley Studio.

3.2.1 *Importance of Aggregate Grading*

John Earley approached the problem of improving the surface of exposed aggregate concrete at a time when the current concrete research was focusing on the role of grading aggregate to achieve maximum strength in concrete. The research occurring from 1906-1918 tried to create a stronger concrete by producing a dense mix through careful proportioning. In 1906, Sanford E. Thompson tested the effect of aggregate grading on the strength of concrete.

³ John J. Earley, *The Concrete of the Architect and Sculptor*, (Chicago: Portland Cement Association, 1926): 5.

⁴ Wm. Walter Smith, “Ornamental Treatment of Concrete Surfaces” in *The American Architect*, (V. 51, n. 1883 (January 24, 1913): 33-42): 39.

He stated that “to decrease the proportion of cement without corresponding loss in strength, the aggregate must be specially graded or such materials selected as will increase the density of the set concrete.”⁵ Work such as that of L.N. Edwards and R.B. Young in 1918 focused on the surface area and volume attained by packing certain size aggregates, but not for appearance of the concrete.⁶ In 1918, H. Colin Campbell, noted that the proportioning of the aggregate was an important consideration when the surface was to be treated: “In preparing for the tooled surface it is necessary that particular attention be paid to selecting the aggregates and still greater attention to proportioning the concrete mixtures so that there will be sufficient cement to fill the voids of air spaces in the bulk of aggregates and thus firmly bond all particles into one solid mass.”⁷ His concern here was that the concrete withstand the tooling process, not that the concrete mix itself would provide a better finish.

Though Earley was probably influenced by the studies concerning the role of aggregate grading, Earley approached the problem from the angle of trying to achieve a better finish rather than a stronger concrete. While it appears that Earley knew of these studies, he was not particularly interested in them: “Such work [on aggregate grading] as had been done with aggregate was related to strength and not to appearance. It failed to attract me, I now suppose, because I already had in mind the idea of a mosaic and was anxious to preserve in our new material some of its well known characteristics.”⁸ According to John Earley, the contemporary literature indicated aggregate could positively affect the strength and density of concrete but did not recognize the aesthetic potential of the aggregate. Two methods of aggregate grading were studied at this period: one where the aggregate was graded through many sizes and one where the aggregates were graded into fine, medium, and coarse aggregate.⁹

Studies of aggregate grading in concrete by M. Feret in France interested Earley and J.C. Pearson at the Bureau of Standards. In 1892 and 1897, René Feret concluded that compressive

⁵ Sanford E. Thompson, “Proportioning Concrete” in *American Architect and Building News*, (v. 90 (1906): 59-61): 59.

⁶ Edward E. Bauer, *Plain Concrete*, (New York: McGraw-Hill, 1928): 93.

⁷ H. Colin Campbell, “Concrete as a Medium of Artistic Expression” in *The American Architect* (V. 64, n. 2226 (August 21, 1918): 217-223).

⁸ John J. Earley, “On the Work of the Committee on Architectural Concrete of the Exposed Aggregate Type and the Thomas Alva Edison Memorial Tower” in *Journal of the American Concrete Institute*, (V. 34 Proceedings (May-June 1938): 589-601): 600.

⁹ John J. Earley, “Exposed Aggregate Concrete” in *Journal of the American Concrete Institute- Proceedings*, (V. 5, n. 4 (March-April 1934): 251-278): 252.

strength was a function of the volume of cement to the volume of the water and air voids.¹⁰ Feret experimented with various combinations and proportions of aggregate of three sizes, fine, medium and coarse, finding that the best results occurred when the intermediate sizes were omitted.¹¹ Pearson and Earley took these experiments a step further by exploring the relationship of fine and coarse aggregate of specified mean diameters to produce the best aggregate grading for an evenly distributed exposed aggregate finish.¹²

3.2.2 Pearson and Earley Experimentation

J.C. Pearson of the Bureau of Standards and John J. Earley first collaborated in 1914 on a study of plaster shrinkage when placed against metal lathes. Together, in 1915, they approached the problem of achieving a more regular and controlled appearance of an exposed aggregate concrete finish for Meridian Hill Park. After reviewing the literature on aggregate grading, Pearson and Earley applied the understanding of the behavior of various sized particles in combination to one another to the problem of producing a better surface finish. Unlike the earlier studies, they were primarily concerned with the aesthetic potential of the material and not its strength. The experiments were based on the goal of achieving a surface with the maximum amount of aggregate possible: "If the aggregate is to be the source of color, the concrete must be so designed and manipulated as to deposit in the surface the greatest possibly amount of aggregate..."¹³ Pearson and Earley did experiments with small concrete mixes of graded aggregates viewed under a microscope: "Not the least important part of the laboratory work was the microscopic examination of the structures of these little concretes, which yielded many valuable suggestions for the gradation in size of particles, and for the proper proportions of the various sizes, to yield the desired effects in the treated surfaces."¹⁴ These tests succeeded in creating a surface whose color was dependent on that of the aggregate: "Possibly due in part to the higher reflecting power of the surface of the exposed aggregates, the color of the concrete

¹⁰ See Jasper O. Draffin, "A Brief History of Lime, Cement, Concrete and Reinforced Concrete" in *A Selection of Historic American Papers on Concrete 1876-1926*, Publication SP-52, ed. Howard Newlon, Jr., (Detroit: American Concrete Institute, (1976): 3-40): 7.

¹¹ John J. Earley, "On the Work of the Committee on Architectural Concrete of the Exposed Aggregate Type and the Thomas Alva Edison Memorial Tower": 600.

¹² John J. Earley, "On the Work of the Committee on Architectural Concrete of the Exposed Aggregate Type and the Thomas Alva Edison Memorial Tower": 600.

¹³ J.C. Pearson and J.J. Earley, "New Developments in Surface Treated Concrete and Stucco" in *Proceedings of the American Concrete Institute, V. 16*, (Detroit: American Concrete Institute, 1920: 70-87.): 76.

¹⁴ J.C. Pearson and J.J. Earley, "New Developments in Surface Treated Concrete and Stucco": 79.

surfaces thus produced was determined almost wholly by the color of the aggregates, and only very slightly affected by the cement itself.¹⁵ The step-graded mix gave a finished exposed aggregate surface with closely packed aggregate faces bound by thin ribbons of cement, in some cases, barely visible.

3.2.3 *Earley's Step-Gradation Patent*

In 1921, Earley patented "new and useful Improvements in Methods of Producing a Predetermined Color Effect in Concrete and Stucco."¹⁶ This method was stated to primarily apply to stucco but could be applied to "concrete floors, ornamental urns, pillars, arches, balustrades, building details, etc."¹⁷ The four objects of the invention were stated as:

1. to reproduce in concrete a surface colored after the 'impressionistic school'
2. to so control the amount of large aggregate and cementing material that the desired true color will result with the minimum amount of interference of false tints
3. to obtain the desired texture on the finished product by the grading of the aggregate
4. to devise a method of stuccoing which will be uniform at all times¹⁸

Contrary to a straight line gradation of aggregate, Earley patented a mix where aggregate was divided into groups according to size and recombined according to a definite ratio of size of the grains to volume of each size. He named this new technique "step gradation". According to Earley the patent improves on straight line aggregate graded mixes for its better form, color and texture:

It has better form because under this method it can be successfully molded into more complicated shapes than the ordinary material and therefore it is better able to express architectural and artistic design. It has better color and texture because it receives its color and texture from the large aggregate, which is an element which may be carefully selected for color and carefully graded to a definite size of grain for texture.¹⁹

He specified that upon hardening "the larger aggregate will be found to lie in substantially a plane surface about 1/16" beneath the surface and may be exposed by brushing away the surface with a wire brush." This surface could then be treated with "a weak acid to better bring out the natural color" of the aggregate.²⁰ He lists examples where this work can be seen:

Entrance to Meridian Hill Park, Washington, D.C.;

¹⁵ J.C. Pearson and J.J. Earley, "New Developments in Surface Treated Concrete and Stucco": 74.

¹⁶ U.S. Patent 1,376,748 (May 3, 1921): Line 5-9.

¹⁷ U.S. Patent 1,376,748 (May 3, 1921): Line 13-15.

¹⁸ U.S. Patent 1,376,748 (May 3, 1921): Line 20-32.

¹⁹ U.S. Patent 1,376,748 (May 3, 1921): Line 82-92.

²⁰ U.S. Patent 1,376,748 (May 3, 1921): Line 72-79.

House front-2017 Q street, Washington, D.C.;
Field house, East Potomac Park, Washington, D.C.;
Interior wall, Café St. Marks, Washington, D.C.:
Cumberland Opera House, Cumberland, Maryland.²¹

In Earley's own words, he explains the rationale for the experiments in grading the aggregate and the benefits acquired by the step gradation method:

We, therefore, designed a two-step gradation which proved itself to be just what we wanted. It gave to concrete of the type in which we were interested the best structural qualities and characteristics of appearance adaptable to our theme and quite different from the appearance of concrete made with aggregate graded by other methods. Furthermore, our two-step method of gradation gave to concrete better workability than did the other methods. It prevented segregation and bridging and gave better flow. It permitted us to fill perfectly the most complicated molds.²²

The aggregate gradation was the an important innovative technique used in the concrete work made by the Earley Studio. Aggregate gradation offered the artistic control desired by John Earley in his search for an expression of form, texture and color in concrete. Cement and water worked within the matrix of aggregate but were subordinate to it. Earley wrote:

The importance of the aggregate is the principle which has been developed by all our investigations into the causes which control the appearance of concrete. It is by constructing a skeleton of aggregate that volume-changes, segregations and settlement are prevented. It is by causing the aggregates to occupy a very great part of the surface that predetermined color and texture are obtained. It is the aggregate which takes the form and gives the color and texture. The cement is a binary material which gives the necessary permanence, it also contributes to the appearance. The water is a carrier which places the material with the least amount of work.²³

From the experiments carried out at Meridian Hill Park, Earley and the Earley Studio had begun a new theory of concrete based on the gradation and characteristics of the aggregate. Cement was necessary to bind them together and the water was used and manipulated for optimum workability and set.

²¹ U.S. Patent 1,376,748 (May 3, 1921): Line 89-98. Earley went on to file patents for joints (U.S. Patent No. 1,355,756, John J. Earley, "Flexible Joints", 1920) and molds (U.S. Patent No. 1,412,392, John J. Earley, "Molds", 1922).

²² John J. Earley, "Exposed Aggregate Concrete", 1934: 252.

²³ J.J. Earley, "What Concrete Means to the Craftsmen who are Entrusted with Interpreting Architectural Design" in *Substance, Form and Color through Concrete*, (New York: The Atlas Portland Cement Company, 1925: 15-22): 17.

3.2.4 Achievements in Color & Texture

Development of the step gradation method began with the desire for a more controlled palette on the exposed aggregate surface. Earley noted that the traditional exposed aggregate techniques did in fact brighten up the surface of the concrete but in an irregular way. The step-gradation technique allowed for the surface appearance to be controlled to produce desired color and texture. While the step-graded concrete was developed at Meridian Hill Park, it was used in other contemporary projects including the “Fountain of Time” and the East Potomac Park Field House, mentioned in the patent. The “Fountain of Time”, completed in 1922, depicts a mass of human figures in a large free-standing, poured in place, concrete sculpture in Chicago. The finishes were integral to the concrete so that any section of the concrete would yield the same exposed aggregate surface. The Field House was constructed in 1917 at the same time Earley was working at Meridian Hill Park. The finishes there were similar to those found at Meridian Hill Park but were not integral to the entire thickness of the walls since they were a combination of pre-cast elements and field applied stucco.²⁴

From this early date, Earley discussed the possibilities of color and texture in concrete as if it were an artistic medium. He showed a sophisticated sense of color and texture when viewed from varying distances. In the works mentioned above, the aggregate was a Potomac River Gravel which imparted a natural color to the concrete. Earley noted that at the “Fountain of Time” the “general hue of the concrete is yellow red of bright value and weak chroma (YR7/2) as noted by the Munsell System. This is called a 100 ft. concrete because the particles on the surface blend to a uniform color and texture at that distance.”²⁵ Texture of the concrete was as important as the color of the concrete: “Every concrete surface should be so designed that at great distance the particles of aggregate, which are spots of color, will resolve out into a pleasingly uniform hue and so that at intermediate distance, the texture of particles and the texture of color will produce an appearance harmoniously related to the general scale of the structure. The surface must also be designed so that on close inspection it is entertaining.”²⁶ The size and color of the aggregate produced various visual sensations from different distances: “We have designed surfaces to fill the most exacting requirements and to meet the greatest differences

²⁴ *National Register Nomination, East and West Potomac Parks Washington, DC, 99% Draft*, July 31, 1998, Robinson & Associates, Inc. Files: Section 7, page 48.

²⁵ John J. Earley, “Building the Fountain of Time” in *Journal of the American Concrete Institute*, (V. 19 (1923): 185-190): 189-190.

²⁶ John J. Earley, “On the Work of the Committee on Architectural Concrete of the Exposed Aggregate Type and the Thomas Alva Edison Memorial Tower”: 595.

in scale, surfaces which lose their texture and resolve to uniform hue at twenty-five feet, surfaces which hold their texture at five hundred feet.”²⁷

The limits of color and texture of the concrete were soon challenged by the work at the Church of the Sacred Heart in Washington, DC in 1924. The church interior called for brightly colored, complex designs in the manner of Byzantine mosaics to be executed in a durable material. This goal was achieved by coloring the concrete through the aggregate whose size and texture were carefully controlled to give certain effects at various distances. The detailed designs were executed through specialized molds: “Technical control was exercised by means of raised contour lines in the molds. They permitted the use in one casting of many aggregates of as many colors, separated them and kept each in its own place without losing anything of unity in the mass of concrete.”²⁸ At Sacred Heart, the molds were made in plaster and then pressed into a brown coat of lean porous plaster applied to the wall. This left the ridges in the wall which guided the application of different colored stucco directly to the wall surface. The aggregate was then exposed as usual.²⁹ In 1925, the American Concrete Institute gave Earley an award for the concrete work at Sacred Heart.³⁰

3.3 *Form: Water Control*

John Earley and the Earley Studio achieved greater complexity in the concrete form through the understanding of the role of water in concrete and the innovations of prefabricated panels. The idea that water could be added and removed from the mix as needed, that it was not a fixed factor, allowed for more complex forms to be cast and finished. As the Studio became skillful in controlling the water content, more complex forms were produced, culminating in the intricate, pierced panels used at the Bahai’i temple in Wilmette, IL.

3.3.1 *Removal of Excess Water*

Earley experimented with the control of water in the workability and setting of concrete at Meridian Hill Park. While casting the balustrade for the upper areas of the Main 16th Street Entrance area, it was discovered that withdrawing excess water from the forms would give the

²⁷ J.J. Earley, “What Concrete Means to the Craftsmen who are Entrusted with Interpreting Architectural Design”: 21.

²⁸ John J. Earley, “Exposed Aggregate Concrete”, 1934: 253.

²⁹ Cron: 24.

³⁰ “John J. Earley Obituary” in *Journal of the American Concrete Institute*, V. 42 (January 1946): 8-9.

concrete the early strength that was needed to expose the aggregate for the finish.

Experimentation with the balusters at Meridian Hill Park led to a greater understanding of the role of water in the placing and curing of concrete. The large “Fountain of Time” sculpture was able to be cast as one piece with an exposed aggregate finish by constructing a absorptive core. A layer of porous, lean mortar in the core withdrew the excess water needed for workability while leaving the water needed for hydration of the cement. This technique allowed “the concrete to be placed in one consistency and to set in another.”³¹

Earley held to Abrams’ assertion that the water-cement ratio needed for concrete to set at maximum strength was fixed. In practice, the water-cement ratio needed to be exceeded to create a workable concrete for certain types of concrete and certain molds: “The other water relation is a water to surface relation which includes both the surface of the aggregate and the cement and which has to do with the mobility of the mass and not with its strength.”³² The time between pouring and set of the concrete allowed for the excess water needed for increased workability to be withdrawn from the concrete for maximum strength: “As we have about twelve hours in which to work and as we can easily control the free water: let us deliberately add enough water to concrete to produce an optimum consistency for placing, and when the concrete is in the forms let us remove enough of the water to produce the best consistency for the strength and other good qualities of the concrete.”³³ Control of water accounted in part for the quick set and early strength of the concrete made at the Earley Studio which could accommodate complex forms and allow for finishing within 24 hours.

3.3.2 *Achievements in Form*

The ornamentation of the Baha’i Temple in Wilmette, Illinois involved the application of prefabricated panels to structural concrete that had been previously placed. The project required innovations and rethinking of previous work to fulfill the demands of the project. Water in the concrete was controlled to a precise degree. The aggregate, crushed to a nearly uniform size, was chosen for a sparkling white appearance, for its ease in filling complicated forms and surrounding the reinforcement, and for its physical properties such as its surface area.³⁴ The

³¹ John J. Earley, “Exposed Aggregate Concrete”, 1934: 252.

³² John J. Earley, “Time as a Factor in Making Concrete” in *Proceedings of the American Concrete Institute*, (V. 23 (1927): 473-478): 477.

³³ John J. Earley, “Architectural Concrete” in *Proceedings of the American Concrete Institute*, (V. 22 (1926): 513-534): 533.

³⁴ John J. Earley, “Exposed Aggregate Concrete”, 1934: 254.



entire exterior and interior were finished with delicate traceries of interwoven designs, pierced with opening to give them a lace-like appearance. These forms demanded an extremely workable mix but the conditions required a very durable material. The construction of the dome involved the structural expertise of the Studio and of Basil Taylor in particular. An entire one-ninth scale dome was completed at the Studio plant to work out the curves of each of the slabs.³⁵ The unique structural solutions of the Baha'i Temple came out of the collaborative environment of the Earley Studio where craftsmen, engineers, and artists met.³⁶

3.4 Honesty in Concrete: Color, Texture and Form

The search for a concrete that was both beautiful and honest to the properties of the material developed throughout John J. Earley's lifetime. The exposed aggregate finish developed from the desire to give the wall panel an appealing finish which was characteristic of the material. Removing an exterior film of wet cement to reveal the aggregate of the concrete mix solved both requirements of aesthetic and honest expression. Earley wrote that "it was this decision to employ finishes characteristic of the nature of reinforced concrete that gave the interest to succeeding studies."³⁷ This created a concrete where "any section through it would have the character desired for the surface."³⁸ The exterior finish was integral to the entire structure.

Finishes that relied on revealing the aggregate of the concrete mix limited the color and form of the material. Colors were limited to those aggregate that could economically be used in the entire structure eliminating the more precious, vibrantly colored aggregate. The form was limited by the physical requirements of the finish. Forms needed to be stripped off while the concrete was still relatively green. More complicated structural forms often could not support their own weight if forms were removed when they were still green. Earley wrote of the dilemma in the Earley Studio:

Some years ago we almost despaired of ever being able to apply an acceptable architectural finish to structural concrete. At that time our choice was restricted between a stucco finish of the exposed aggregate type and the application of studio methods to the

³⁵ See J.J. Earley, "The Project of Ornamenting the Baha'i Temple Dome" in *American Concrete Institute*, V. 29 (1933): 403-12.

³⁶ The history of the Earley Studio remains to be written. Oral histories of ex-employees have begun to be collected currently. This is an integral part of the Earley legacy which requires further research.

³⁷ John J. Earley, "Some Problems in Devising a New Finish for Concrete" in *Journal of the American Concrete Institute*. (V. 16 (1918): 127-137): 128.

³⁸ John J. Earley, "Exposed Aggregate Concrete", 1934: 251-252.

entire mass of structural concrete. Some satisfactory work has been done by the stucco method but enough unsatisfactory work has accompanied it to create a prejudice against stucco. On the other hand the application of studio methods and studio wages to the whole of a structural concrete building done in the field is outside of the limits of economic possibility.³⁹

As a compromise, the Earley Studio worked with the technique of applying thin pre-cast panels to structural concrete. The Main 16th Street Entrance at Meridian Hill Park is constructed of pre-cast panels applied to the structural core of concrete. This allowed pre-cast panels to be made and finished in controllable forms in the studio while using a considerably smaller amount of facing aggregate.⁴⁰

Applying pre-cast panels to previously placed structural concrete brought some criticism to the Earley Studio. The technique of applying panels did not adhere to Earley's belief in honesty in concrete. Earley would both question and validate this technique. In the 1920s, Earley began promoting a separation of finished concrete from structural concrete by drawing comparisons between ancient architecture: "I recommend to architects a complete separation of finish from structure. I am convinced that this is the best manner of using architectural concrete."⁴¹ This argument was not particularly convincing and the question of the honesty of form in concrete continued to be worked through in Earley's projects.

The work on the Department of Justice ceilings in 1924 offered Earley a solution to the problem of honesty in using pre-cast panels in construction. The 60 foot span of one ceiling would not allow the concrete to be finished in place. At the time it would have been necessary to remove the forms to finish the ceiling, the concrete would not have yet achieved enough strength to hold their own weight and the ceiling would collapse. Rather than pre-cast thin slabs as had been done previously, the Earley Studio devised a new formwork system which used the thin slabs as formwork for the structural concrete. Pre-cast thin slabs were anchored in place, supported from the ground, and used as formwork themselves into which the structural concrete was cast in place: "...we devised a system of forming by which thin pre-cast slabs of concrete mosaics were used as forms for structural elements and normal forming was eliminated."⁴² This

³⁹ John J. Earley, "On the Work of the Committee on Architectural Concrete of the Exposed Aggregate Type and the Thomas Alva Edison Memorial Tower": 597-9.

⁴⁰ Other concrete work in the 1920s obtained an aggregate finish by facing concrete blocks with an aggregate rich stucco or pressing the aggregate into the surface of green concrete before it has set. See Harrison E. Howe, *The New Stone Age*, (New York: The Century Co., 1921): 130-131.

⁴¹ John J. Earley, "Architectural Concrete", 1926: 526.

⁴² John J. Earley, "Exposed Aggregate Concrete", 1934: 253.



project innovated the use of pre-cast slabs, finished in the Earley Studio, as formwork behind which the concrete was poured. Earley wrote of the search for honesty in concrete later in his career:

Some years ago I rebelled against the thesis developed in a committee study in the American Concrete Institute that the finish of a concrete structure, however fine it may be, must be integral with the structure. I maintained that a finish entirely distinct and separate from the structure was proper. We came to an impasse because, as I see it now, we were not able to produce a monolithic reinforced concrete building with high esthetic value and I could not decorate the building without a separate finish... In the years that followed experience proved I was mistaken at a time when I had no solution to offer for the problem presented. I became convinced that the day of applied finishes had passed and set myself to find a solution for the problem.⁴³

Slabs became integral to the structure by becoming “forms for the structural concrete. It is poured into them, it is one with them, they are part of the designed thickness of the wall or the floor. They are not a veneer.”⁴⁴ Though the Earley Studio continued to apply panels to structural concrete the work at the Department of Justice presented a way of expressing the inherent construction and physical qualities of the material. This technique opened up new possibilities of prefabricated construction.⁴⁵

3.5 Earley's Aesthetic Sensibility

John J. Earley approached concrete from an artistic point of view drawing on the arts of painting, mosaic, and stucco to achieve artistic results in concrete. The technique of pointillism used by the Impressionists guided the aesthetics of the step-graded aggregate revealed during the finishing process. The art of the mosaic directed the theory and practice of color in concrete. The ancient art of stucco added texture complexity and traditional finishing techniques as well as validated the art of applied finishes. Earley's approach brought innovative ways of thinking to the concrete industry which stepped outside of the traditional strength considerations.

⁴³ John J. Earley, “The Characteristics of Concrete for Architectural Use” in *Journal of the American Concrete Institute*, (V. 35 Proceedings (April 1939): 385-389): 388-389.

⁴⁴ John J. Earley, “The Characteristics of Concrete for Architectural Use”, 1939: 388-389.

⁴⁵ John J. Earley and Basil Taylor later patented this construction technique in 1936 as the Earley Process and promoted it as a way of manufacturing prefabricated housing. The Polychrome Houses of Colesville Pike, MD, are directly derived from the work done at the Department of Justice. Also, the Dextone Company of New Haven, Connecticut used Earley's patent to manufacture Mo-Sai panels for the concrete construction industry on a wider scale. See John J. Earley, “Mosaic Ceilings, U.S. Department of Justice Building” in *Proceedings American Concrete Institute*, (V. 31 (1935): 557-564): 557 and Sidney Freedman, “Architectural Pre-Cast Concrete” in *Twentieth-Century Building Materials: History and Conservation*, edited by Thomas C. Jester, (New York: McGraw-Hill, 1995:108-113): 110.



Earley thought of himself first and foremost as a craftsman and artist. His official title was “Architectural Sculptor”. Though, Earley went on to be president of the American Concrete Institute, he continued to state that his concrete work developed from an artistic and not a scientific study. He wrote: “I am a craftsman and all that I could ever do was to record sensible experiences and the conclusions drawn from them and to describe the work which resulted from those conclusions.”⁴⁶ He validated the work of the craftsman who perfects a technique through empirical means stating that “history teaches us that the judgment of craftsmen on materials and on methods for handling them have been eminently sound, their intuitions have been well founded and science subsequently retracing their paths have approved with notable regularity.”⁴⁷ Understanding Earley in the role of the craftsman leads to a closer look at the art forms that inspired and improved the concrete work of the Earley Studio.

From the beginning of the development of the exposed aggregate technique, Earley compared the control of variously colored aggregate to that of the juxtaposition of points of color in pointillism. In the 1921 patent for step-graded concrete, Earley wrote that this technique produces a surface colored “after the ‘impressionistic school’.”⁴⁸ Earley easily assimilated the optical science of pointillism where pure spots of color resolve to a uniform hue at a certain distance to exposed aggregate concrete: “An examination of ... paintings of the impressionist school suggests a technique in coloring which is peculiarly adaptable to the coloring of concrete by means of the aggregate.”⁴⁹ Earley wrote: “By considering the particles of aggregate as spots of color in juxtaposition, all the knowledge and much of the technique of the impressionist, or the pointillist school of painting, was immediately applicable to concrete.”⁵⁰ The juxtaposition of colors in pointillist paintings created a richness of color which Earley believed could easily translate into concrete work: “The wonderful clarity of color, the vibrant quality of surface, which distinguishes the paintings of this school, are found also in concrete.”⁵¹ The science of pointillist coloring became a guide for the selection and gradation of aggregate in colored concrete work.

⁴⁶ John J. Earley, “On the Work of the Committee on Architectural Concrete of the Exposed Aggregate Type and the Thomas Alva Edison Memorial Tower”: 589.

⁴⁷ John J. Earley, “On the Work of the Committee on Architectural Concrete of the Exposed Aggregate Type and the Thomas Alva Edison Memorial Tower”: 601.

⁴⁸ U.S. Patent 1,376,748 (May 3, 1921): Line 20-32.

⁴⁹ J.C. Pearson and J.J. Earley, “New Developments in Surface Treated Concrete and Stucco”: 76.

⁵⁰ J.J. Earley, “What Concrete Means to the Craftsmen who are Entrusted with Interpreting Architectural Design”: 19.

During the beginning of Earley's investigation into concrete, he wrote that he was little interested in the scientific studies which focused on obtaining a maximum strength concrete. "because I already had in mind the idea of a mosaic and was anxious to preserve in our new material some of its well known characteristics."⁵² Instead, he turned to the traditional arts in his search for an aesthetically pleasing concrete. Mosaic work is like concrete in that "both materials are made by cementing together small pieces of stone."⁵³ In mosaic work the points of color formed by the aggregate impart not only color but texture and radiance to the surface of the concrete. The surface of exposed aggregate concrete is similar to the mosaic surface in that it "is made up of a myriad of tiny, irregular stone chips averaging about ¼ in. in maximum dimension, and closely grouped. Interstices are slightly tilted in various directions, resulting in a richly textured surface which, however, is held firmly in plane by the flat surface of the mold."⁵⁴ The aggregate's "small size and jagged shape results in their catching and refracting light from all directions, giving the surface a subdued 'sparkle' which is highly distinctive."⁵⁵ John Earley became well known for this concrete mosaic technique.

The Thomas Alva Edison Memorial project is an example of the Earley Studio's attention to the detail of color and texture of the surface. The Memorial consists of a tower tapering to its top which is surmounted by a large glass light bulb. The tower was constructed of pre-cast panels attached to a structural frame of iron. From the base to the top of the tower, the concrete moves progressively from black to white at the summit. The deep black of the base was made from the aggregates of black and red crushed ceramic and black glass. The black glass gives the surface brilliance while the black ceramic gives a matte blackness to counterbalance the lightening influence of the reflected "specular lighting" of the glass fragments. The red ceramic aggregates give interest to the surface when seen from near at hand.⁵⁶

John J. Earley carried elements of the art of stucco to his work in concrete. He and Basil Taylor had turned the focus of the studio to stucco after the death of Earley's father. Stucco and concrete have similar plastic qualities, ingredients, and application methods. Earley argued that

⁵¹ J.J. Earley, "What Concrete Means to the Craftsmen who are Entrusted with Interpreting Architectural Design": 20

⁵² John J. Earley, "On the Work of the Committee on Architectural Concrete of the Exposed Aggregate Type and the Thomas Alva Edison Memorial Tower": 600.

⁵³ John J. Earley, "Mosaic Ceilings, U.S. Department of Justice Building" in *Journal of the American Concrete Institute*, (V. 31 (1935): 557-564): 559.

⁵⁴ "Architectural Concrete Slabs" in *Architectural Forum*. (February 1940: 101-106): 103.

⁵⁵ "Architectural Concrete Slabs": 102.



“it can be suggested to those who wish to achieve the best technique for making portland cement stucco and concrete that a careful study be made of ancient and modern methods for making stucco whether with mud, lime or cement.”⁵⁷ Many of his projects utilized the Earley Studio skill with stucco finishes (see Appendix B). For example, the applied finishes at the Church of the Sacred Heart required the art of a plasterer to execute.

While John Earley was looking to these other arts to both promote and improve the aesthetic quality of concrete, he recognized the merit of concrete as an artistic medium in itself. It was extremely durable, economic and permitted rapid execution of forms. In 1925, Earley placed the facility and permanence of concrete above the aesthetic possibilities for treating the surface in categorizing the attractive artistic qualities of the medium.⁵⁸ He saw concrete as a modern artistic medium which could solve modern building design problems. He likened his use of concrete to Luca della Robbia’s development of terracotta during the Renaissance. In both instances, he felt, new technology had been developed to create an economic, durable, and ultimately artistic medium to express the architectural ornamentation of its own era.⁵⁹ He wrote: “It is deceiving to see the material [architectural concrete] as a form of structural concrete elevated to the level of an artistic medium when on the contrary it is an artistic medium extended to more general use.”⁶⁰

3.6 *John J. Earley’s Legacy*

During the period of Earley’s work in concrete from 1915-1945, contemporaries acknowledged his contributions to the concrete industry. They credited him with elevating the status of the material and the industry. In 1924, he was introduced at an American Concrete Institute conference with the following: “The speaker has always felt... that its members [of the ACI] do not really appreciate how much of a pioneer he is in this very important field of the artistic treatment of concrete, although it was before this Institute that his work was first exploited... the speaker believes that in that future, because of its great merit, this work will be

⁵⁶ John J. Earley, “On the Work of the Committee on Architectural Concrete of the Exposed Aggregate Type and the Thomas Alva Edison Memorial Tower”: 594-5.

⁵⁷ John J. Earley, “Time as a Factor in Making Concrete”, 1927: 477.

⁵⁸ J.J. Earley, “What Concrete Means to the Craftsmen who are Entrusted with Interpreting Architectural Design”: 20.

⁵⁹ John J. Earley, *The Concrete of the Architect and Sculptor*, (Chicago: Portland Cement Association, 1926): 7.

⁶⁰ John J. Earley, “On the Work of the Committee on Architectural Concrete of the Exposed Aggregate Type and the Thomas Alva Edison Memorial Tower”: 591.

referred to as Earley Concrete.⁶¹ It is in the evolution of concrete finishing, which coincided with a general acceptance of the aesthetics of concrete, where Earley's work is paramount. His work is often cited in literature of the day both in the United States and abroad.⁶²

John J. Earley died on November 25, 1945.⁶³ His obituary in the *Journal of the American Concrete Institute* stated that he is remembered for developing concrete as an artistic medium. His contributions to the field of concrete were described as unique. He was tireless in perfecting the artistic qualities of concrete through experiment and fine craftsmanship.⁶⁴ He was remembered for being a craftsman who understood the physical properties of the material: "[a]lways dominated by the artistic approach and with a keen sense of drama, he could bring himself and endless patience to the study of the engineering approach to the integrity [*sic*] of a material."⁶⁵ He is most noted for such varied concrete works the Church of the Sacred Heart in Washington, DC, the Baha'i Temple in Wilmette, IL, and the "Fountain of Time" sculpture in Chicago, IL. In 1984, the Executive Vice President of the American Concrete Institute wrote that John J. Earley "pioneered the use of concrete in architecture, established the fundamental criteria for concrete to suit esthetic and durability requirements and contributed to the embellishment of various structures of national importance."⁶⁶

The solutions of finding an architectural concrete with acceptable color, texture and form began at Meridian Hill Park. This work began with the development of an integral exposed aggregate finish at Meridian Hill Park and led to more elaborate and perfected design solutions such as the sculpture the "Fountain of Time". The search for a vibrantly colored concrete finish culminated in the work at the Church of the Sacred Heart in Washington, DC. The concrete work at the Baha'i Temple in Wilmette, Illinois took this technique to another level of

⁶¹ "Introduction" in *Journal of the American Concrete Institute*, V. 20 (1924): 157.

⁶² See Harrison E. Howe, *The New Stone Age*, (New York: The Century Co., 1921), W.E. Hart and Raymond Wilson, "The Painting and Coloring of Concrete" in *The American Architect* (December 20, 1927: 833-838): 833, Edward E. Bauer, *Plain Concrete*, (New York: McGraw-Hill, 1928): 131, and H.L. Childe, *Concrete Surface Finishes, Renderings and Terrazzo*, (London: Concrete Publications Limited, 1943): 28. NOTE: Childe's book makes reference to Earley's Parthenon concrete work, figure 58, on page 35.

⁶³ Earley suffered a stroke while inspecting a parking garage project in Washington, DC, and died two weeks later. See Cron, 60.

⁶⁴ "John J. Earley Obituary" in *Journal of the American Concrete Institute*, Proceedings V. 42 (January 1946): 8-9.

⁶⁵ "John J. Earley Obituary": 8-9.

⁶⁶ *Letter from George F. Leyh, Executive Vice President American Concrete Institute, to Mr. Manus J. Fish, Regional Director National Capitol Region, National Park Service, November 29, 1984, NPS Design Services (NCR), Meridian Hill File 1.*

sophistication. Colored, thin slab pre-cast panels were used in an innovative way as the actual formwork in the Department of Justice Ceilings in Washington, DC.

The Earley Studio and the craft carried on by its employees are perhaps the least appreciated part of the Earley legacy today. The concrete work is a testimony to the skill of those employed to execute the artistic visions of Earley. This work produced by the Earley Studio is a reflection of the artistic ability of both Earley and the Earley Studio. Earley's own enthusiasm for the concrete work must have spread to his employees who took pride in the work as the quality of the concrete suggests. Earley wrote in 1925 that "[c]oncrete is so wonderfully responsive that it has wound a spell around me and around the men in my studio. When the work is taken from the moulds each morning and colors are exposed, there is something so spectacular, so magical about it, that our enthusiasm never abates."⁶⁷ One contemporary noted that the work of the Earley Studio exhibited an "[a]rtistry of a high order, and a specialized technical skill in concrete."⁶⁸ Another noted that "[t]here seems to be something infectious about working in this medium [exposed aggregate concrete] and it is very noticeable that contractors and workers who have become experienced in architectural concrete work have developed a pride of craftsmanship which promises well for the future."⁶⁹ The dedication of the employees to the techniques used by the studio extended well beyond the life of John Earley. The Earley Studio remained in business until 1966. Even then the art was carried to other concrete plants through the employees. A group of those skilled in the art of creating the Earley mosaics formed a working society to preserve the technique which was in existence until 1989. The history of the employees of the Earley Studios, their skill, training, and dedication, remains to be thoroughly documented. A

⁶⁷ J.J. Earley, "What Concrete Means to the Craftsmen who are Entrusted with Interpreting Architectural Design": 18.

⁶⁸ W.E. Hart and Raymond Wilson, "The Painting and Coloring of Concrete" in *The American Architect* (December 20, 1927): 833-838): 833.

⁶⁹ Arthur McK. Stires, "Concrete: Form, Texture, Color" in *American Architect*, (August 1935): 70-82): 82.

Further mention of the skill and dedication of the employees of the Earley Studio: "The men on the job seem to take a keen interest and pride in the work they are doing, and to be willing to carry forward any number of experiments in order to improve the quality or the interest of their work."

"The preparation of this concrete work comes down to the factor of the man on the job,--of the intelligent foreman who understands the principles of the work, and of the mechanics and laborers who are careful in the execution. The material has to be carefully graded and accurately mixed, with a definite proportion maintained for corresponding work from start to finish of the job, and with due advance precautions to make certain that the gravel is gotten for the entire job from one place, so that the note of color will be consistent throughout." See Horace W. Peaslee, "Notes on the Concrete Work of Meridian Hill Park, Washington" in *Landscape Architecture*. (V. 21, n. 1 (October 1930): 31-38): 36.



complete understanding of the work of John Earley depends on further study of the craftsmen at the studio.

John J. Earley's work at Meridian Hill Park represents the experimentation, development and dissemination of the art of creating color, texture and form in step-graded, reinforced, exposed aggregate concrete. Earley first approached the problem of creating aesthetically pleasing concrete work with the goal of achieving an artistic expression of color, texture and form. Each of these three goals were achieved at different stages of experimentation and development. During the initial experimentation stage Earley created an exposed aggregate concrete wall that greatly improved the coloring after an initial mock-up proved unsatisfactory. Earley then developed improved color and texture through the use of a step-graded concrete mix and more complex castings through the control of water in the concrete. This knowledge was then disseminated to other concrete contractors who worked on the much of the concrete at the park.

4.1 Experimentation: Exposed Aggregate Concrete

In 1915, John J. Earley was commissioned to create a mock-up of a wall panel unit subject to the approval of the Commission of Fine Arts to be placed at Meridian Hill Park. The Commission's dissatisfaction with the color and texture of the initial mock-up initiated an experimentation with the finish. This experimentation led to the use of an exposed aggregate finish that greatly improved the color and texture of the concrete. Wall panels along the West Wall of the park from the northwest corner to the Lower 16th Street Entrance date from this period of construction. This work was developed further in later construction at Meridian Hill Park.

4.1.1 Mock-up 1915

The Earley Studio was awarded the contract for the work at Meridian Hill Park because of its reputation for plaster and stucco work. Previously, the studio had remodeled the interior of the White House under Theodore Roosevelt's first term and finished the main lobby of the Willard Hotel in Washington, DC.¹ The contract for Meridian Hill Park stipulated that a full-scale mock-up, complete in all details except for reinforcement, must be approved by the

¹ Frederick W. Cron, *The Man Who Made Concrete Beautiful*, (Fort Collins: Centennial Publications, 1977): 7.

Commission of Fine Arts before work could begin. The aesthetic of the wall panel were important to the Commission which was intimately involved in the design decisions made at Meridian Hill Park.

Earley made several mock-ups for inspection by the Commission of Fine Arts. The Commission refused the first mock-up of smooth cast concrete because of its uninteresting surface.² Horace Peaslee later commented that “[i]n the first stage of the construction... the intent was to obtain interest in the surface by expedients of form alone, paneling the wall sections and rustivating the posts. An effort was made to rib the rustication in the manner of the heavy cutting of certain Italian garden work. The balusters, urns, etc., were of cast cement, smooth, cold, and uninteresting.”³ While the form replicated Italian masonry, the concrete failed to capture the correct color and texture. The Commission desired that the walls should closely resemble the Mediterranean tuff or pebble mosaics found in Italian villa gardens. Cass Gilbert is said to have been responsible for sparking Earley’s imagination to create a similar texture in concrete.⁴ Certainly, the Commission of Fine Arts reviewed the wall and made critical remarks on its form and finish.

It is clear from Earley’s writings that the challenge of producing an aesthetic concrete finish was agreeable to his sense of artistry in architecture. He wrote in 1918: “An analysis of the problem of appearance indicates three principal factors; namely, form, color, and texture, all of which must be developed before reinforced concrete can be accepted, by architects, as a fitting medium for the expression of academic design.”⁵ From this early date, John Earley was preoccupied with the creation of a concrete capable of artistically expressing form, color, and texture.

The second mock-up addressed the problems of color and texture exhibited in the first wall unit. The form of the mold shown in the construction drawings and historic photos is nearly identical to the first mock-up and to those seen in the park today. As described by Peaslee above, the wall units are paneled with rusticated posts or piers. The wall panel consisted of a base, an inner panel, a border around the panel, and a coping with a drip running underneath (see fig. 5).

² Cron: 9.

³ Horace W. Peaslee, “Notes on the Concrete Work of Meridian Hill Park, Washington” in *Landscape Architecture*, (V. 21, n. 1 (October 1930): 31-38): 31.

⁴ William M. Avery, “Earley’s Mosaic Concrete Opens Limitless Vistas in Products Field” in *Pit and Quarry*, (V. 37, n. 3 (1944): 131-134): 131.

⁵ John J. Earley, “Some Problems in Devising a New Finish for Concrete” in *Journal of the American Concrete Institute*, (V. 16 (1918): 127-137): 127.

This form had been discussed in the minutest detail by the members of the Commission. While the form remained essentially the same, the second mock-up attempted to use textured finishes to make the wall more interesting. Of this experiment, Earley wrote:

An effort was made to relieve the monotony of appearance by finishing various details in different texture. The piers were built of rusticated blocks the surface of which was grooved vertically with straight, symmetrical, V-shaped grooves about 3/8 in. on centers and 1/4 in. deep. The coping and border of the wall panels were sand floated. The panels themselves were pebble dash in which the pebbles were as nearly as possible one size, having passed a 1/4 in. screen and having been retained on a 1/8-in. screen.⁶

Experiments with this technique can be seen in historic photos of the mock-up made along 16th Street (see fig. 6). The surface of the base and the rusticated posts have vertical lines with three or four cuts to the inch. The false joints in the posts were left smooth. The pebble dash finish on the surface of the inner panel was applied in two coats. The first coat of one part cement to three parts sand was applied under pressure directly to the broken stone core of the wall to a 5/8 inch thickness. This was scored, set, and sprayed before the second pebble dash finish was applied to a 3/8 inch thickness. The inner border at eight, ten and twelve inches wide around the inner panel and the coping were finished smooth with a facing cement of two parts cement and three parts sand.⁷ The exact construction methods devised for the second mock-up are specified in a 1915 document.

Earley himself criticized the second mock-up for its poor color and particularly for its failure to express the character of concrete. He wrote that “[t]he color was unsatisfactory. It was the cold gray cement color that has always been so objectionable. Every particle of sand was coated with cement and had no color value of its own.”⁸ The second mock-up was also objectionable because of its inability to reveal the physical characteristics of concrete. In a caption to a detailed photograph of this mock-up (see fig. 7) Earley noted that the “textures are conventional and not characteristic of concrete.”⁹ This mock-up was “a plastered wall, nothing more. The construction might just as well have been of brick, terra cotta, or metal lath on channel studs so far as the appearance revealed. The wall was without scale. It did not give the appearance of strength and size equal to its task as a retaining wall.”¹⁰ In the succeeding stage of

⁶ John J. Earley, “Some Problems in Devising a New Finish for Concrete”: 128.

⁷ *Meridian Hill 1915 Specification*, National Archives, RG42, Entry 97, Box No. 24, File 240.

⁸ John J. Earley, “Some Problems in Devising a New Finish for Concrete”: 127.

⁹ *Ibid.*: 129.

¹⁰ *Ibid.*: 127.

experimentation, Earley strove to create a wall unit with a more pleasing color and texture that revealed the characteristics of the material.

4.1.2 Construction of West Wall along 16th Street 1915-1918

It is unclear how exposed aggregate concrete came to be used at Meridian Hill Park between 1915-1918. The process of exposing aggregate was practiced on earlier concrete work and it is unclear how much was known to Earley and those involved in the design of the park.¹¹ The technique of exposing the aggregate exhibited the inherent physical properties of concrete while achieving a vast improvement in both color and texture. Exposed aggregate concrete opened up new possibilities in color and texture to Earley and his studio. From these early experiments Earley moved to the development of a technique for controlling and improving the surface qualities of concrete.

The use of an exposed aggregate finish at Meridian Hill Park was most likely part of a general experimentation in concrete by the Earley Studio. According to Earley the finish was suggested as a solution to the problem of finishing the concrete at Meridian Hill Park: "It was then suggested that the forms be removed while the concrete was yet green and the surfaces brushed with steel brushes until the aggregate was exposed."¹² The process is similar to one described in a 1913 article by Wm. Walter Smith:

The forms may be removed while the concrete is yet 'green' and the face may be brushed or scrubbed Such treatment removes the thin exterior covering of cement and brings the coarse color aggregate slightly in relief. Likewise, at the proper age, the surface may be tooled. After the film of cement has been removed by either of these methods, to brighten up with colors, the walls should be painted with one or more applications of a wash composed of one part commercial hydrochloric (muriatic) acid mixed with five to ten parts of clear water, with an interval of a few minutes between the applications. When suitable effects have been obtained, usually within a half-hour, thoroughly scrub the walls with a fiber brush to remove the acid and loose particles.¹³

Another article dating from 1913 indicates that a similar process was used at a train station in Montclair, NJ, where detail work was finished by exposing the aggregate.¹⁴

¹¹ Research for this thesis did not uncover where the idea of using an exposed aggregate finish originated.

¹² John J. Earley, "Some Problems in Devising a New Finish for Concrete": 128.

¹³ Wm. Walter Smith, "Ornamental Treatment of Concrete Surfaces" in *The American Architect*, (V. 51, n. 1883 (January 24, 1913): 33-42): 39.

¹⁴ "The Architectural Treatment of Concrete Surfaces" in *The American Architect*, (V. 54, n. 1978 (November 19, 1913): 193-199): 198-199.

Exposed aggregate finishes had been obtained by both integral and applied concrete work. These finishes could be achieved either way: “The entire thickness of wall may be made of these selected aggregates or, by means of facing boards, only an outside layer may be used, backed up by ordinary concrete and naturally thoroughly bonded together with it as a single stone.”¹⁵ Earley consciously chose to expose the integral aggregate of the concrete in this original experiment to satisfy his desire to create an honest and artistic expression in concrete. He wrote: “Permit me to emphasize in an especial manner, that it was this decision to employ finishes characteristic of the nature of reinforced concrete that gave the interest to succeeding studies and resulted in the development of surface treatments as applied at Meridian Hill Park.”¹⁶ In contrast to the earlier mock-ups, this wall harnessed the qualities of the material, by emphasizing the texture and color of the aggregate, for both structural and finishing purposes. In contrast to the earlier experiments Earley wrote: “The wall was no longer a plastered one, but was reinforced concrete and nothing else, and it seemed big and strong enough to suit all the demands that would be made upon it.”¹⁷ In subsequent work at Meridian Hill Park, Earley utilized a facing concrete and pre-cast elements.

4.1.2.1 Detail description of concrete

The park is delimited by walls on all sides with gates located at the northwest, northeast, mid-east, mid-west, lower east, southwest, and southeast areas of the park. The West Wall consists of 46 wall units, including 40 wall panels, six curved panels and the Main 16th Street Entrance, the 16th Street Fountain Niche, and the Lower 16th Street Entrance. Wall panels to the south of the Fountain Niche were constructed in 1915 by the Earley Studio (see Appendix A: 1915 Map and Figure 8). A concrete gutter and catch basin system runs behind the top of the wall. Catch basins are located behind the posts (see fig. 8a).

John Earley described the construction details of these first experimental walls in a 1918 article entitled “Some Problems in Devising a New Finish for Concrete.”¹⁸ Later in 1930, Horace Peaslee wrote an article on the experiments in concrete work made at Meridian Hill

¹⁵ Wm. Walter Smith, “Ornamental Treatment of Concrete Surfaces”: 39.

¹⁶ John J. Earley, “Some Problems in Devising a New Finish for Concrete”: 128.

¹⁷ *Ibid.*: 128.

¹⁸ *Ibid.*: 127-137.

Park.¹⁹ From these articles and the historic physical evidence the construction techniques used on these wall panels can be detailed.

4.1.2.2 Mix

The concrete for the footings and the wall units was a 1:2:4 mix which was almost a universal standard for concrete construction at this period. The cement was an Atlas White Portland cement which was the type preferred by Earley throughout his career.²⁰ The sand used in the mix was a river sand finer than ¼ inch and was known as concrete or torpedo sand. Aggregate consisted of pebbles known as Potomac River Gravel ranging from 1 ¼ inch to ¼ inch with the greatest proportion between ¾-¼ inch in size. Water was added to the mix so that “its consistency was soft, so soft that it would flow readily.”²¹

4.1.2.3 Forms & Molds

The forms of the wall units were plaster waterproofed with shellac. The plaster forms fit inside standard wooden forms that supported the weight of the concrete (see fig. 9). Formwork for concrete work at this period varied from basic wood or metal lined forms for large pours to casts and molds of plaster for more detailed work. They were cleaned and coated with some impermeable liquid before pouring such as petroleum or paraffin based oils. One general method for plaster casts included “sizing them with one or two coats of shellac and painting them with a mixture of cup-grease thinned with kerosene to which crystallized stearic acid is sometimes added.”²² Fine, crisp details such as the drip under the coping and the recessed groove on the panel were achieved by detachable wooden strips.²³ These strips were loosely attached to the interior of the plaster mold and were grooved on the back to allow for expansion. After the pour, the wooden strips remained in the concrete form protecting the fine details. The strips were released as the wood dried and shrank.²⁴

¹⁹ Peaslee, “Notes on the Concrete Work of Meridian Hill Park, Washington”: 31.

²⁰ Cron noted that Earley developed a good working relationship with that Atlas Portland Cement Company and almost exclusively used the white Portland cement produced at the Northampton, PA, plant. See Cron, footnote on page 14.

²¹ John J. Earley, “Some Problems in Devising a New Finish for Concrete”: 130.

²² Arthur McK. Stires, “Concrete: Form, Texture, Color” in *American Architect*, (August 1935): 70-82); 74.

²³ John J. Earley, “Some Problems in Devising a New Finish for Concrete”: 128.

4.1.2.4 Pouring

The wall footings were placed in unbroken sections for each wall panel with the joints at the lower side of the piers. The wall panel and the south post were cast as an integral form in one pour. An examination of the walls today reveals a range in texture of the exposed aggregate that indicates the use of two types of mixes in each pour (see fig. 10). The rusticated posts, coping, inner panel, and base all have an exposed aggregate finish while the inner border has a fine sand finish that has been tooth chiseled. This inner border appears to be a cement and sand mix rather than the 1:2:4 mix mentioned in the Earley article. Comparison of this border with the unexposed areas of the grooves in the rusticated posts, where large aggregate are visible on the surface, points to a different mix used for the inner border area (see fig. 11). Pouring of these walls required dividers, probably of some sort of sheet metal, to separate the different concrete mixes (see figs. 12-16). In the first fill the large aggregate mix was poured to the level of the base of the wall panel. Secondly, a divider was placed at the junction of the wall panel and the post. The fine cement and sand mix was poured on the wall panel side to the level of the inner panel. On the post side, the large aggregate mix was poured. Third, more dividers were placed within the form on either side of the inner panel. The fine mix was used to fill either side of the inner panel while the aggregate mix was used on the panel and the post to the level of the upper edge of the inner panel. The dividers on either side of the panel were then removed and again the fine mix was poured on the wall panel side and the aggregate mix was poured on the post side to the level of the coping. Finally, the last divider between the panel and the post was removed and the coping and post were completed with the coarse aggregate mix.

Concrete was poured at numerous points in a large pour. Ornamental concrete required special attention to pouring so the concrete would not splash up and prematurely harden on the mold before the pour had reached that level. Canvas was frequently used to cover the face of the mold during pouring and lifting as the canvas as pouring progressed.²⁵ Pours were stopped at horizontal elements in the form to minimize visible lines. Between pours, the excess water would be struck off, and a new mortar concrete placed at each lift to ensure bonding between pours.²⁶

²⁴ W.F. Lockhardt, "Architectural Concrete and its Use" in *The Architectural Record*, (January 1936): 57-62): 62.

²⁵ Arthur McK. Stires, "Concrete: Form, Texture, Color": 75.

²⁶ W.F. Lockhardt, "Architectural Concrete and its Use": 57-62.

Ornamental concrete features, such as the console piece, were dry pressed castings. The castings were made with a cement mix of one part cement to 1 ½ parts coarse sand with only enough water so that the cement held its shape when packed into the mold. The forms could then be removed immediately to reveal a crisply molded casting.²⁷ The surface was left untreated.²⁸ The console piece is no longer in place above the West Wall but a similar console casting can be found on the east and west sides of the Exedra Area (see figs. 17 & 18).

4.1.2.5 Reinforcement

Reinforcement for this period of construction is not specifically mentioned by either Earley or Peaslee though it was probably similar to that detailed in the 1915 specifications. The 1915 document specified that the reinforcement meet the standard 1911 ASTM specifications for steel. They were primarily square, cold-twisted rods. Footings were transversely reinforced with ½ inch rods 6 inches on center, framed on two ¾ inch rods placed three inches above the bottom of the concrete and running the full length of each unit. Two feet long, one inch diameter dowel pins were imbedded half in the footing and half in the wall panel. Piers were vertically reinforced with four ¾ inch steel bars projecting 4 inches into the coping. The wall panels had ½ inch rods six inches on center running horizontally through panel and pier, wired to four ¾ inch vertical rods and kept 4 inches from the surface. Alternate horizontal rods were bent in opposite directions and wired to three vertical rods in each pier (see fig. 8a).²⁹

4.1.2.6 Finishing

After 24 to 48 hours the forms were pulled when the surface of the concrete was still green. The surfaces of the inner panel, the face of the coping and the rusticated posts were scrubbed with a steel brush to expose the aggregate, care being taken to create an even exposure. The border around the panel was tooth chiseled while the rusticated grooves were left unfinished.³⁰ The walls were then hosed with water. According to Peaslee, the surfaces were washed with muriatic acid to remove any excess film though Earley does not mention this step.³¹ The walls were carefully monitored while they dried and were wetted if they appeared to be

²⁷ John J. Earley, "Some Problems in Devising a New Finish for Concrete": 130.

²⁸ Wm. Walter Smith, "Ornamental Treatment of Concrete Surfaces": 35-36.

²⁹ *Meridian Hill 1915 Specification*, National Archives, RG42, Entry 97, Box No. 24, File 240.

³⁰ John J. Earley, "Some Problems in Devising a New Finish for Concrete": 128.

³¹ Peaslee, "Notes on the Concrete Work of Meridian Hill Park, Washington": 31.

drying too rapidly.³² The top of the wall coping and the top of the base received a troweled surface.

4.1.2.7 Construction

Construction of the West Wall panels progressed as every other post and panel unit was poured in place. This allowed for the ends to be coated with five ply felt and tar to form an expansion joint. This ensured that when the walls were poured to fill the gaps the adjacent wall panels had sufficient strength to withstand the work performed on the new panel.³³

Construction of the drainage system progressed with the wall. A 15 inch wide concrete gutter was laid approximately 9 to 12 inches below the top of the wall on a 6 inch cinder frost bed. Concrete catch basins were placed at 90 foot intervals and set behind piers. The runoff was carried by four inch terracotta sewer pipes to a 6 inch sewer pipe laid behind the wall footings. From there it connected to the street sewer on the east side of 16th Street (see fig. 8a).³⁴

4.1.3 Improvement in Color and Texture:

The color and texture achieved by revealing the aggregate sparked an exploration of the artistic potential of concrete which influenced the career of Earley and the Earley Studio. Earley described the effect the exposed aggregate had on the surface of the concrete at Meridian Hill Park:

A change took place in the color. The surface, which had been wholly of a cement gray, was broken in frequent spots by clean pebbles in their natural color which varied from white, to yellow, to light brown... These spots relieved the gray of the cement to such an extent that they imparted to the whole structure a cream color which was a great improvement and a decided step forward.³⁵

In this second stage of experimentation the color of the aggregate enlivened the dull gray of the cement. The exposed aggregate appeared in uneven pockets across the face of the concrete. Though it was a great improvement to the initial mock-ups, these wall panels and posts did not achieve the artistic finish desired by both Earley and Horace Peaslee, principal architect at the

³² John J. Earley, "Some Problems in Devising a New Finish for Concrete": 130.

³³ *Ibid.*: 128.

³⁴ *Meridian Hill 1915 Specification*, National Archives, RG42, Entry 97, Box No. 24, File 240.

³⁵ John J. Earley, "Some Problems in Devising a New Finish for Concrete": 128.

park.³⁶ Peaslee noted that “[t]he earlier stages of the work showed lumps of coarse aggregate in certain sections of the panels, and sparse cement areas in others, giving decided irregularity, but even at that not an unpleasant effect.”³⁷ In a 1930 article on the concrete work at Meridian Hill Park, Peaslee captioned a photo of one of the West Wall panels in this manner: “Section showing early experimental work. Note the irregular distribution of the aggregate in coping and panel, and the use of the tooled border for contrast.”³⁸ In the next stage, Earley developed a the step gradation method for grading the aggregate in the concrete mix to achieve amore uniform distribution on the surface.

4.2 Development: Improvement of Color, Texture and Form through Step Graded Mixes and Water Control 1918-1921

As a direct effort to improve the concrete finishes at Meridian Hill Park, Earley and the Earley Studio developed techniques to achieve a more artistic finish through step grading of aggregate and to execute more complex castings through control of water in the mix. Step graded aggregate incorporated the potential of an exposed aggregate finish with improvement in the distribution of the aggregate by proportioning the mix to create more complex textures. Better castings were completed by the new understanding that water could both increase workability and flow as well as create high strength concrete. The construction of the concrete involved the use of pre-cast units later constructed on site or applied to the structural concrete. The testing and development of these techniques allowed the finishes to be replicated by other contractors and, in this way, disseminated the discoveries made in concrete at Meridian Hill Park.

4.2.1 Step Gradation

John Earley approached the problem of creating an appropriate concrete for Meridian Hill Park with the considerations of the finish as his first priority. According to Earley, few others placed the final surface finish in such a place of prestige, focusing more on the strength and durability of concrete: “The evidence showed that appearance had been an afterthought, a secondary matter, a desirable but rather impossible thing which should receive all the

³⁶ For more information on the design of the park by Horace Peaslee see Thomas W. Dolan, *Meridian Hill Park, Washington, DC*, Graduate Thesis, School of Architecture, University of Virginia, May 1983.

³⁷ Peaslee, “Notes on the Concrete Work of Meridian Hill Park, Washington”: 31.

consideration possible after the structural problems had been solved.³⁹ After discovering the potentials of exposing the aggregate, Earley turned to the development of a finish by experimenting with the concrete mix as a whole rather than treating the surface later. Exposing the aggregates after casting would therefore reveal the inherent qualities of the material carefully controlled from the very beginning.

As discussed in the previous chapter, Earley worked with J.C. Pearson at the Bureau of Standards to develop a step graded aggregate mix that would reduce the cement visible on the surface of the concrete by proportioning the aggregate to fit as closely together as possible.⁴⁰ The studies were carried out to achieve a certain aesthetic which was clearly defined by Earley from the beginning. In 1918, he wrote:

When the aggregate is exposed on concrete surfaces the planes and lines should not be irregular and lumpy showing many stones in one place and few in another, but should rather be uniform and true conforming perfectly to the contours of architectural detail. The surfaces should have many uniform particles lying closely together, as the scales on a fish, true and even of surface, yet presenting many irregular planes to the play of light and shade.⁴¹

Pearson and Earley worked out the optimum shape and diameter of the grains to gain the best packing of aggregate. By experimenting with different sizes of aggregate and sand, cement and water, Earley and Pearson solved both the problems of color and texture simultaneously.⁴²

The invention of step graded mixes was only the first step in the development a technique that grew from the earlier experimental work and continued to be perfected. The development of the step graded aggregate mix at Meridian Hill Park was a direct evolution from the previous work:

The technical progress made in the execution of this work and the great improvement shown in the results were largely due to a careful study and severe criticism of the first operation. So radical were the changes in methods and materials that I feel that I must pause here to make sure the criticism I am about to make of the first operation stands in no need of apology. It is a thoroughly satisfactory concrete retaining wall, rather better than was expected at the start, and while the second operation shows marked improvement, it is only a reasonable progress and must not detract from the merit of the first.⁴³

³⁸ Peaslee, "Notes on the Concrete Work of Meridian Hill Park, Washington": 34.

³⁹ John J. Earley, "Some Problems in Devising a New Finish for Concrete": 127.

⁴⁰ Pearson & Earley article have two close up photos of finishes showing improvement in the appearance by the reduction of cement visible on the surface. See J.C. Pearson and J.J. Earley, "New Developments in Surface Treated Concrete and Stucco" in *Proceedings of the American Concrete Institute. V. 16.* (Detroit: American Concrete Institute, 1920: 70-87.): 83.

⁴¹ John J. Earley, "Some Problems in Devising a New Finish for Concrete": 135.

⁴² *Ibid.*: 135.

⁴³ *Ibid.*: 130.

This theme of a progressive development of the technique of exposing step graded aggregate, built on earlier experimentation, is stressed by both Earley and Pearson in a 1920 article with photographic examples that are “arranged in nearly chronological order and show the gradual improvement that is being made as experience accumulates.”⁴⁴ The progressive development of the technique shows that the skill of the craftsman remained essential to the achievement of an artistic finish. While proportioning the aggregate was the most important innovation in achieving a better finish, the surface appearance of the concrete at Meridian Hill Park still depended on the skills of those mixing and placing the concrete: “The frequency with which the spots appeared on the surface was principally influenced by the composition and the consistency of the concrete, by the care with which it was placed; by the uniformity with which it was mixed; both as regards the proportioning of the ingredients and the length of time it was allowed to remain in the mixer.”⁴⁵ It was a combination of the discoveries in step grading and the skill of the craftsmen in the studio and on site that achieved the many surface textures which Horace Peaslee declared was the outstanding feature of Meridian Hill Park.⁴⁶

4.2.2 *Water Control*

The development of the step graded concrete improved the color and texture of the coarse aggregate of the walls but did not solve the problems involved in casting the more complex elements. According to Peaslee, there was a period when it was not clear if similar textures could be obtained on finer architectural elements such as balustrades and banisters.⁴⁷ Earley overcame this obstacle by the controlled use of water. From earlier experimentation at the Meridian Hill Park, Earley noted that the amount of water affected the color and texture of the concrete by its effect on the arrangement of the aggregate.⁴⁸ He further explored the role of water when trying to cast the forms of the balusters found on the upper overlook area of the Main 16th Street Entrance (see fig. 19). A certain amount of water was needed to obtain a workable mix that would successfully fill the mold but this often led to balusters that shrank during casting and left cracks. Earley and the Earley Studio discovered that the excess water needed for

⁴⁴ J.C. Pearson and J.J. Earley, “New Developments in Surface Treated Concrete and Stucco”: 80.

⁴⁵ John J. Earley, “Some Problems in Devising a New Finish for Concrete”: 134.

⁴⁶ Peaslee, “Notes on the Concrete Work of Meridian Hill Park, Washington”: 31.

⁴⁷ *Ibid.*: 32.

⁴⁸ John J. Earley, “Some Problems in Devising a New Finish for Concrete”: 135.

workability could be withdrawn through capillary action during the set. It is interesting to read Earley's own description of this experimentation at Meridian Hill Park:

The first time we ever used the capillary system to pull the water out of the concrete was many years ago, when we were doing some balusters at Meridian Hill Park in Washington. Those balusters were designed by Cass Gilbert... It was a beautiful baluster, but it was an exceedingly difficult form to cast because the bowl is large and the base is large, but the necking at the top and at the bottom is very thin. In that way he gets a vigor in the baluster and a decoration at these thin points. When we were casting these balusters we put five balusters in the molds every day and took them out and threw them on the dump the next morning. We cast a great many that way. It cost us \$1500.00 to make the first baluster. The reason was that shrinkage in the concrete left an incipient crack around the neck of every baluster. We could have pointed them up and sent them out, but it wouldn't have been sporty. Finally, we decided that the movement was due to the water in the concrete. We filled those balusters and piled the concrete up on top of them and shrunk them down; then we took a piece of newspaper and spread that across the top of this wet concrete. Of course the newspaper acts like a piece of blotting paper and starts pulling the water and it was not very long before the newspaper was wet all through, so in order to continue to give volume to the newspaper we piled a very fine sand on top (the refuse from our crushing system) and that pulled the water up out of the balusters so that the concrete was stiff as I described it to you. Those castings came out all right- not like beads on the reinforcement.⁴⁹

The removal of excess water was found to actually increase the strength of the concrete. In 1927, a Portland Cement Association publication, *Concrete in Architecture*, discussed Earley's control of water and stated that the removal of excess water "increases the density, strength and impermeability-and consequently the durability-of the concrete and diminishes the shrinkage or tendency of the concrete to draw away from the molds during the process of hardening."⁵⁰ Through this control, Earley was capable of filling complex molds and creating a concrete that could produce almost any form demanded.

4.2.3 Construction of the Main 16th Street Entrance 1918-21

The Main 16th Street entrance was constructed between 1917-1918 (see fig. 20). The entrance has a recessed sitting area defined by wall panels with benches that curve in from the 16th Street sidewalk to the barrel vaulted entrance to the staircase. The entrance has a granite base and is flanked by massive grooved pilasters that rise to a neo-classical entablature with a heavy cornice. The Main 16th Street Entrance is on a simple rectangular plan with steps leading

⁴⁹ John J. Earley, "Exposed Aggregate Concrete" in *Journal of the American Concrete Institute-Proceedings*, (V. 5, n. 4 (March-April 1934): 251-278): 276.

⁵⁰ *Concrete in Architecture*, (Chicago: Portland Cement Association, 1927): 56.

up into the structure under a barrel vault from the street on the west. The interior contains a molded bench on the north side under a half circle, iron grated window and a grotto niche to the east (see fig. 21). The grotto niche is a round arched recess decorated with concrete stalactites and a stylized mask. A round platform curves out at the base of the niche. To the south, steps lead out of the structure under a round arch to the upper park. The south stairs have two tiers of steps and are delimited on the east and west with paneled walls topped with balustrades (see fig. 22). The top of the structure functions as an overlook area with a balustrade to the west and molded concrete benches to the north and south (see fig. 23). Planting areas were planned for the upper areas to the west and north of the south steps. A planting pocket was designed on the northern side of the overlook area. South of the main entrance is the Upper 16th Street Retaining Wall completed in 1919 (see figs. 24 & 25). The wall is approximately 50 feet high and was cast in four sections with separately cast balustrades set in place along the top.

4.2.3.1 Mix

Step graded concrete required that the standard 1:2:4 mix be abandoned during this phase of construction.⁵¹ The mix is not specified but the ratios probably ranged from 1:1:3 to 1:1 ½:4.⁵² The cement used was white Portland cement and the fine sand was similar to the earlier type. The exposed aggregate finish required that the forms be stripped while they were still green so Earley added hydrated lime to achieve an early strength though the exact amount used is unspecified.⁵³ The majority of the aggregate is a Potomac River Gravel from a local Washington sand and gravel company whose cooperation with the variously graded aggregate used at Meridian Hill Park greatly contributed to the project.⁵⁴ There is use of black trap rock in the paving of the steps and the overlook area. The aggregate was screened according to the sizes demanded and combined in proportions to make a dense uniform mix so that voids constituted less than twenty percent of the volume.⁵⁵ Earley did not use additives in his concrete to accelerate or retard the setting. Earley stated in a 1918 discussion that he had mixed the cement with boiling water to accelerate the setting.⁵⁶

⁵¹ John J. Earley, "Some Problems in Devising a New Finish for Concrete": 134.

⁵² Peaslee, "Notes on the Concrete Work of Meridian Hill Park, Washington": 32.

⁵³ See *Meridian Hill Park Specifications (Draft)*, 1923, National Archives RG42. Entry 310, Box No. 2.

⁵⁴ John J. Earley, "Some Problems in Devising a New Finish for Concrete": 134.

⁵⁵ *Concrete in Architecture*: 56.

⁵⁶ John J. Earley, "Some Problems in Devising a New Finish for Concrete": 136.

Earley specified the order of mixing the concrete. First, water followed by cement, and then sand was mixed to a consistency of thick soup. To this was added the aggregate. The goal was to keep the water content as low as possible to make the mix workable.⁵⁷ The exact amount of water used at this stage is never specified. The only rule was that the consistency be such that the mix would easily fill the forms. During the time of the construction of Meridian Hill Park, proportioning of concrete was often done empirically on site rather than determined in specifications. Previously proportioning of dry materials and water was left to those on site. Empirical proportioning provides the qualities and quantities of cement and aggregate but does not give an exact amount of water. Rather, a desired consistency is specified as a quality control. If this was not strictly supervised, a wide variety of strengths could result.⁵⁸ In 1928, the trend in proportioning was to do so by observation to achieve the best workability with the largest amount of coarse aggregate possible.⁵⁹ As a reference, in 1927, Earley used four gallons of water for each 94lb. bag of cement used in the mix.⁶⁰ Excess water was then removed through capillary action by placing an absorbent material over the form.

4.2.3.2 *Forms & Molds*

The forms and molds used in this period were both wooden and plaster. Detailed casts that were not repetitive were done in plaster piece molds, waterproofed with shellac. Wooden molds lined with metal were used to cast repetitive and large scale elements.⁶¹

4.2.3.3 *Pouring*

The concrete work dating from this period was both poured in place and pre-cast.⁶² The walls of the entrance area, the northern wing wall, the Upper 16th Street Retaining Wall, the walls flanking the south steps, and the steps and paving were all poured in place. Mixed textures were achieved by the use of medium and coarse aggregate mixes in the walls to the entrance area and the walls flanking the south steps. The elements that are pre-cast include the applied facade panels of the Main 16th Street Entrance, the interior surfaces of the entrance, the balustrade

⁵⁷ *Ibid.*: 136-7.

⁵⁸ Edward E. Bauer, *Plain Concrete*, (New York: McGraw-Hill, 1928): 83.

⁵⁹ Bauer: 92.

⁶⁰ *Concrete in Architecture*: 56.

⁶¹ John J. Earley, "Some Problems in Devising a New Finish for Concrete": 136.

⁶² Peaslee, "Notes on the Concrete Work of Meridian Hill Park, Washington": 36.

elements along the Upper 16th Street Retaining Wall, as well as the balusters, handrails, seats and planting boxes in the overlook area.⁶³

4.2.3.4 *Finishing*

The process of finishing the concrete by exposing the aggregate did not change during this period of construction. New challenges were met because of the requirement that the forms be stripped while the surface was still green. Earley encountered problems when casting the balusters because the step of stripping the forms created suction forces between the mold and the still wet concrete leaving pockmarks on the casts. This problem was solved by the removal of excess water. Exposing the aggregate on the handrails also proved difficult as the entire length of 14-15 feet had to be finished on all sides. The concrete had to achieve an early set so that it was strong enough to be handled and finished. This was done by experimenting with the order of mixing the ingredients as mentioned earlier.⁶⁴

4.2.3.5 *Expansion Joints*

New expansion joints were required for the balustrade elements of the upper overlook area and the top of the Upper 16th Street Retaining Wall. For example, for every 24 feet of the handrail along the retaining wall two ¼ inch joints were left open without any pointing at all. Where large masses of concrete met, Earley used ½ inch thick bituminous expansion felt manufactured by Barrett Mfg. Co.⁶⁵

4.3 *Dissemination: Work of Other Concrete Contractors at Meridian Hill Park 1923-28*

Other Washington, DC, based contractors constructed much of the concrete work at Meridian Hill Park based on the experimentation and development of new techniques by Earley and the Earley Studio. Quite possibly these firms produced new techniques to solve the design problems they encountered. According to Horace Peaslee, one of the achievements of Meridian Hill Park was the dissemination of these techniques to other concrete contractors. In 1930, he wrote that "...although this work was originated with the experimentation of one Washington contractor, the knowledge of the process has spread so that a number of men are available for

⁶³ J.C. Pearson and J.J. Earley, "New Developments in Surface Treated Concrete and Stucco": 72, 81.

⁶⁴ Cron: 11-12.

⁶⁵ John J. Earley, "Some Problems in Devising a New Finish for Concrete": 137.

bidding and each seems to be able to improve upon the preceding work.”⁶⁶ Few documents survive to attest to the skill and ingenuity of these contractors in placing the concrete work at Meridian Hill Park.

It appears that Earley was called in to work on the West Wall Fountain Niche in 1924.⁶⁷ It is unclear which contractor constructed the North Wall and the East Wall to north of the Chapin Street Entrance or whether this was completed by the Earley Studio. Fred Drew Company was possibly awarded the contract to complete the East Wall but was definitely credited for the construction of the South Wall and the remaining panels of the West Wall. Their involvement with the construction of the park was such that Horace Peaslee wrote in 1935: “... I find that Mr. [Fred] Drew who has done most of the work at Meridian Hill...”⁶⁸ Fred Drew is photographed next to Horace Peaslee in a 1932 newspaper article where he is credited with building the cascades at the park.⁶⁹ Another Washington, DC, contractor, Chas. H Tompkins, Co., reportedly worked at Meridian Hill Park under seven different contracts from 1916 to 1929 though its exact role is unclear.⁷⁰ Probably they worked with the Earley Studio and Fred Drew Co. on site. In 1979, the Vice-President of Tompkins Co. wrote that “Chas. H. Tompkins Co., developed techniques of construction along with the development of the concrete design by John J. Earley so all parties to the construction effort understood the problems and could work together to effect successful solutions.”⁷¹ A complete history of the concrete work at Meridian Hill Park must try to incorporate the role of these contractors and their concrete construction techniques.

4.3.1 Construction Techniques used on the remainder of Meridian Hill Park

Information on the construction discussed is valid from the period 1923-1928 which produced the North, East, and South Walls as well as the remaining panels of the West Wall (see

⁶⁶ Peaslee, “Notes on the Concrete Work of Meridian Hill Park, Washington”: 32.

⁶⁷ *Letter from Horace Peaslee to Mr. Marsh, Superintendent*, September 24, 1924, National Archives, RG 42, Entry 310, Box No. 1, Folder 1 (May 1922-June 1927).

⁶⁸ *Letter from Horace W. Peaslee to Mr. C. Marshall Finnan, Superintendent National Capitol Parks*, February 20, 1935, National Archives, RG42, Entry 310, Box No. 1, Folder 2.

⁶⁹ “Meridian Hill Cascades Inspected” in *The Washington Star*, Saturday, August 20, 1932, National Park Service National Capitol Region, Rock Creek Park Cultural Resource Management Archives, Meridian Hill Files.

⁷⁰ James W. Mann, “Meridian Hill Park—Circa 1916” in *Concrete International*, (October 1979): 84-86): 84.

⁷¹ *Ibid.*: 86.

Appendix A).⁷² The North Wall is composed of six wall units including four wall panels, two decorative niches and an iron grille fence (see fig. 26). The East Wall contains 44 wall units, 40 of which are wall panels, two are curved entrance walls, and two are balustrade units (see fig. 27). The low South Wall is made of eleven wall units with nine composed of a base wall topped with a balustrade and two topped with solid panels. Four urns decorate the top of the balusters (see fig. 29).

The 16th Street Fountain Niche is located where two wall units with molded concrete benches curve in from the street. The round arched recess of the niche is flanked by rounded, grooved pilasters that rise to a decorative entablature and heavy cornice. “MERIDIAN HILL” is written above the arch. The niche contains a fountain basin with three scalloped spouts along the rim from which water spills over into a curved basin decorated with scroll designs. The Lower 16th Street Entrance is defined by walls panels topped with balustrades that curve in from 16th Street to the entrance steps (see fig. 31). The wide steps are flanked by crisply detailed walls with sharp panels and copings. Atop these walls are two urns decked with garland that is decorated with colored pebbles. The Main 15th Street Entrance has two wall panels that curve in from 15th Street to meet two low balustrades that flank the entry steps (see fig. 28). Two urns mark the north and south ends of the balustrades while two obelisks stand on either side of the steps. The Service Entrance is a narrow entrance flanked by grooved concrete aggregate piers topped with tall urns and two small wall panels on the park side. The Southeast and Southwest Entrances have asphalt ramps that spiral into the south corners of the park (see fig. 30). The outside of the spiral ramp is a low wall. The inside of the spiral is defined by a curved balustrade topped wall decorated with two obelisks with spheres at the apices.

4.3.1.1 Mix

The cement used at the park was a White Portland cement mixed with sand and aggregate in ratios ranging from 1:1:3 to 1:1 ½:4, according to Peaslee.⁷³ The specifications for the East Wall specifically called for a 1:2:4 mix with hydrated lime equaling 10% of the cement by volume.⁷⁴ The sand used in the foundation concrete was composed of hard, sharp grains while the surface concrete was a fine white sand both being free from clay, decayed rock, mica,

⁷² Its applicability to the construction of the features between 1928-1936 is unknown and falls outside the scope of this study.

⁷³ Peaslee, “Notes on the Concrete Work of Meridian Hill Park, Washington”: 32.

leaves and other foreign matter.⁷⁵ The aggregate was graded according to size defined as coarse, medium and fine. The coarse aggregate ranged in size from ½ to 1 ¼ inch. Medium aggregate ranged between ½ to 3/16 inch. Fine aggregate was defined as anything below 3/16 inch.⁷⁶ The aggregate was Potomac River Gravel. The different sized aggregates were used in step-graded mixes to obtain differently grained textures on the surface when the aggregate was exposed. Machine mixers, such as the one bag mixers used by the Tompkins Co., combined the cement, sand and aggregate with enough water to achieve a uniform consistency for optimum workability.⁷⁷ Cement was ordered by the barrel weighing 376 lbs. and shipped in bags containing 94 lbs. Prior to 1927, cement was shipped in cloth bags. After this date, cement began to be shipped in wall-paper bags.⁷⁸ The extraction of excess water during the setting period may only have been performed on the finer concrete details and is not mentioned in the work done by the other contractors.

4.3.1.2 Forms & Molds

The forms used for the wall panels were wooden frame forms lined with metal for waterproofing. Decorative work was cast in plaster molds that were waterproofed with shellac or oil.⁷⁹ In addition, forms were coated with a material to retard the setting of the concrete in warm weather to allow for the removal of the green cement skin.⁸⁰ Anecdotal evidence points to every day substances being used for such purposes: ““We learned to coat the form surface with sugar syrup just prior to placing the concrete. That delayed setting up of the surface. As soon as concrete set up enough, we stripped the forms and scrubbed the surface the same day it was

2. ⁷⁴ *Meridian Hill Park Specifications (Draft)*, 1923, National Archives RG42, Entry 310, Box No.

⁷⁵ *Ibid.*

⁷⁶ Peaslee, “Notes on the Concrete Work of Meridian Hill Park, Washington”: 32.

⁷⁷ *Letter from James W. Mann, Vice President Chas. H. Tompkins Co. to Paul Goeldner, Chief, Historic Resource Services, National Park Service*, May 20, 1981, NPS Design Services Meridian Hill 1 Files.

⁷⁸ Bauer: 29.

⁷⁹ Peaslee, “Notes on the Concrete Work of Meridian Hill Park, Washington”: 36. No mention is made of the use of Earley’s plaster molds patented in 1922 which lined the plaster molds with foil or waterproof fabric to create a non-absorptive reusable mold, see U.S. Patent No. 1,412,392, John J. Earley, “Molds”, 1922.

⁸⁰ Peaslee, “Notes on the Concrete Work of Meridian Hill Park, Washington”: 36.

placed. We even cast the obelisks in place.”⁸¹ This practice indicates that later contractors continued to experiment with the construction techniques at Meridian Hill Park.

4.3.1.3 Pouring

The 1923 specifications make a distinction between structural and surface concrete. Surface concrete is defined as “all visible surfaces of the completed work whether separately precast or integral with the structural concrete.” In either case the structural concrete must be integrally cast with the surface concrete as noted in the specifications: “Special attention is called to the fact that all cores must be cast integral with the scrubbed surface concrete.”⁸² Most of the concrete work at Meridian Hill Park between 1923-1928 was poured in place with large units cast in one pour. Pre-cast units were used in the Main 16th Street Entrance and the 16th Street Fountain Niche.⁸³ Large architectural elements were constructed by pouring the surface concrete over reinforcing rebars projecting from a structural concrete backwall such as the Main 16th Street Entrance and the niche area of the 16th Street Fountain Niche. The same technique was later used in the construction of the vertical surfaces of the Grand Terrace and is illustrated in historic photographs (see fig. 32).

Along the North Wall, the 1922 concrete features, such as the East and West Niches, were poured in place and exhibit various textures achieved by exposed aggregates of different sizes. These textures required that one pour incorporate several mixes with differently graded aggregate. This was achieved by the use of metal dividers as described for the initial experimental wall panels of the West Wall. Simply described this technique used metal dividers “with one mix placed on one side and a different mix on the other side. As the pour progressed, the divider was raised.”⁸⁴ In this way differently grained textures were achieved by exposing the aggregate of different sizes. The inner border areas of the 1915 and 1922 wall panels have a fine, tooled surface achieved by a second mix. In contrast, the later wall panels were constructed with only one mix and the surfaces selectively exposed (see figs. 10 & 11). Pours did not take

⁸¹ Quoted in James W. Mann, “Meridian Hill Park—Circa 1916”: 86. Sucrose will retard the setting of concrete in low concentrations, suggesting that they act by adsorption on surfaces of hydration products. See H.F.W. Taylor, *Cement Chemistry*, (London: Academic Press, 1990): 345-349.

⁸² *Meridian Hill Park Specifications (Draft)*, 1923.

⁸³ Pre-cast elements were also used for the East and West Fountains in the overlook area of the Grand Terrace and the free standing benches throughout the park.

⁸⁴ *Letter from James W. Mann, Vice President Chas. H. Tompkins Co. to Paul Goeldner, Chief, Historic Resource Services, National Park Service, May 20, 1981, NPS Design Services Meridian Hill I Files.*

place below 38°F. The released concrete casts were kept wet for ten days after pouring to protect them from drying out too rapidly.⁸⁵

4.3.1.4 Reinforcement

All castings were reinforced with steel which met the ASTM standards of the period. The reinforcement was kept *at least* one and one-half inches from the surface. Each casting was specified to be reinforced with steel rods equal in area to one-half per cent of the cross section of the casting.⁸⁶ The footings were reinforced with four ½ inch square rods running the length of the form with ½ inch square rods transversely wired. The wall panels had ½ inch vertical rods, 12 inches on center, extending from the bottom of the footings into the coping that were wired to 3/8 inch horizontal rods and kept 4 inches from the surface. The coping was reinforced with three ½ inch rods running the length of the form that were wired to ½ inch transverse rods and tied to the wall panel reinforcement. The posts had the same reinforcement as the wall and the coping and carried the reinforcement into the bottom of the anchor block.⁸⁷ This amount of reinforcement, Peaslee noted in his 1930 article on Meridian Hill Park, may have been considered excessive at the time.⁸⁸

4.3.1.5 Finishing

The varied textures of the concrete inherent in the different gradations of aggregate in the mixes were exposed in the same manner as had been previously used. Several different textures were specified for the concrete work at Meridian Hill Park with attention called to the fact that “large and small aggregate shall be so apportioned that no sparse cement areas shall be left exposed.”⁸⁹ A trowelled surface was used for the top of the wall coping and drip, for the back of the post joints and for the top of the base of the wall panel. The inner panel border continued to be tooled to match the earlier work. A fine aggregate surface was used for balusters and paneled piers, obelisks, vases, and urns. A medium aggregate surface was used for molded copings, balusters and panels. A coarse aggregate surface was used on pier, panel centers, and the base of wall panels. Finally, a crushed stone aggregate surface was used for the walks within

⁸⁵ *Meridian Hill Park Specifications (Draft)*, 1923.

⁸⁶ *Ibid.*

⁸⁷ *Ibid.*

⁸⁸ Peaslee, “Notes on the Concrete Work of Meridian Hill Park, Washington”: 36.

⁸⁹ *Meridian Hill Park Specifications (Draft)*, 1923.

the park walls.⁹⁰ The specifications for Meridian Hill Park remained somewhat general rather than specific referring to previous work as the basis for new work. Changes could be made upon these models but the appearance would be judged upon a comparison. Methods did not need to be followed to the letter as long as the final product compared favorably to previous work.⁹¹ In this way, earlier work set standards for form and finish and guided work under later contracts.

4.3.1.6 Drainage

A drainage system was constructed along the length of the East Wall and throughout the rest of the park. The system resembled that placed in 1915 and is in fact referenced in the 1923 specifications. An extra note is added to instruct that the gutter be firmly tied to the back of the walls with anchors.⁹²

4.3.1.7 Expansion Joints and Waterproofing

The design of expansion joints became more sophisticated as the concrete work progressed at Meridian Hill Park. Joints at the juncture of the wall panel and the northern posts made during the experimental stage of construction soon failed. The rusticated posts fractured, as Peaslee believed, because the grooves into which the tongue of the panel fit were not sufficiently strong. Later joints narrowed the tongue and reinforced the groove and far fewer failures are evident.⁹³ The joints and the back side of retaining walls were waterproofed with a bituminous material. Later expansion joints used copper plates and bituminous waterproofing materials. The waterproofing for the joints was a “refined coal tar or asphalt mixed with 25- asbestos fibre by volume... which will remain plastic at 32°, will not run at temperature of 120°

⁹⁰ As quoted in James W. Mann, “Meridian Hill Park—Circa 1916”: 85 :

Texture 1.—A trowelled surface used for wall coping top and drip, for back of post joints and for top of base ...

Texture 2.—A tooled surface shall be used for panel border ...

Texture 3.—A fine aggregate surface shall be used for ... balusters and panelled piers, for obelisks and vases ...

Texture 4. —A coarse aggregate surface shall be used for the panel centers and for bases of walls ...

Texture 5. —A crushed stone aggregate surface shall be used for walks within the park walls...

Further textures are detailed by Peaslee, “Notes on the Concrete Work of Meridian Hill Park, Washington”: 32.

⁹¹ Peaslee, “Notes on the Concrete Work of Meridian Hill Park, Washington”: 31.

⁹² *Meridian Hill Park Specifications (Draft)*, 1923.

⁹³ Peaslee, “Notes on the Concrete Work of Meridian Hill Park, Washington”: 36.

F., will adhere to concrete and reheel after a fracture.”⁹⁴ The backs of retaining walls were mopped with the tar below grade. All structural concrete was waterproofed using the “integral method”: by mixing a thin mixture of hydrated lime in quantity of ten per cent by volume of cement in water and adding this to the mixing water for the structural concrete.⁹⁵

4.4 Legacy of Concrete Work at Meridian Hill Park

According to accounts by Horace Peaslee and John J. Earley the work on the walls at Meridian Hill Park was performed as an experiment in a new construction technology. Earley brought his unique artistic ability to the problem of constructing the walls at Meridian Hill Park while Peaslee demonstrated a dedication to creating, reworking and continually improving the work. In 1930, Peaslee defended the experimental work at the park against allegations that he had wasted time and money at Meridian Hill Park. He championed the work: “Not only has the park esthetic and recreational value, but it has served as an experimental laboratory for the development of new concrete processes, the value of which to park and garden work throughout the country is being continually demonstrated.”⁹⁶ The experimentation was necessary for the later development and improvement of the innovative techniques: “Casual observation shows the immense progress that has been made in both wall and walk construction since the beginning of the work. There is no comparison between the first walls and those of later development...”⁹⁷ The dissemination of the new techniques originating at Meridian Hill Park was considered an important achievement of the work at the park contributing to concrete construction on a larger scale.

The concrete work evidences the thought processes of Earley and the Earley Studio when confronted with the aesthetic demands of the project. Meridian Hill Park is often cited as the first project where Earley experimented with the techniques that he was to perfect and adapt to many other architectural demands throughout his career. In 1931, the concrete work at Meridian Hill Park was already recognized as unique:

‘Meridian Hill Park has probably some of the most beautiful concrete work in existence,’ says Maj. D.H. Gillette, U.S. Army, who has direct charge of this work. [...]Much of it has been cast with great care in plaster moulds, which are very beautifully and accurately

⁹⁴ *Meridian Hill Park Specifications (Draft)*, 1923.

⁹⁵ *Ibid.*

⁹⁶ *Letter from Horace Peaslee to Colonel U.S. Grant III*, December 19, 1930, National Archives RG42 Entry 310 Box. No. 1 Folder 3.

⁹⁷ *Ibid.*

done. In the park are textures and shapes which are very rarely seen in concrete. It is a classic as to texture, color and finish.⁹⁸

In 1984, the Executive Vice President of the American Concrete Institute noted its significance: “The ornamental concrete work in Meridian Hill Park has historical value because it is one of the earliest and finest examples of architectural concrete in North America, executed under the aegis of a unique Master of the Art.”⁹⁹ Today, the concrete work is further valued for the insights it allows into the creative process of John Earley. An understanding of the historical context, debates, experimentation and construction techniques used at Meridian Hill Park is required to interpret the conditions of the concrete work as it stands today.

⁹⁸ “Falls to be Added in Meridian Park” in *The Washington Star*, April 14, 1931.

⁹⁹ *Letter from George F. Leyh, Executive Vice President American Concrete Institute, to Mr. Manus J. Fish, Regional Director National Capitol Region, National Park Service, November 29, 1984, NPS Design Services (NCR), Meridian Hill File 1.*

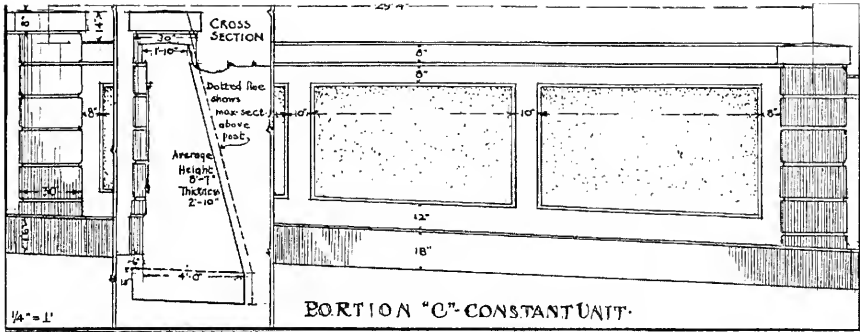


Figure 5: Specifications for 1915 Wall Panel
Meridian Hill Park, 1915 Specifications,
National Archives RG42, Entry 97, Box No. 24, File 240

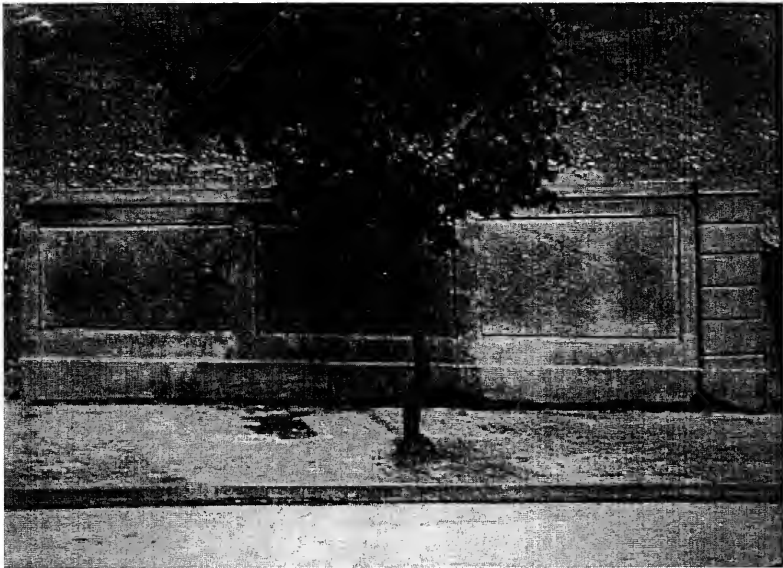


Figure 6: 1915 Mock-up
Rock Creek Park. Cultural Resource Management Archives

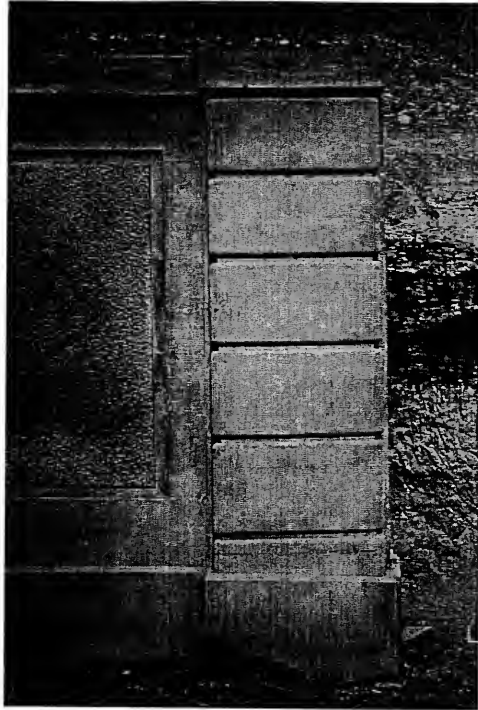


Figure 7: 1915 Mock-up, Detail of Textures
Rock Creek Park, Cultural Resource Management Archives



Figure 8: West Wall Construction, c. 1915-17
Rock Creek Park, Cultural Resource Management Archives



Figure 9: Detail of Form Work
Rock Creek Park, Cultural Resource Management Archives



Figure 10: Detail of Coarse and Fine Textures, 1915 Construction

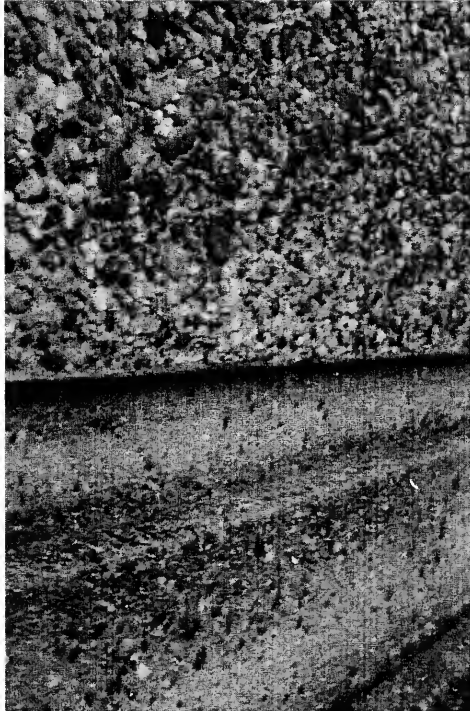


Figure 11: Detail of Coarse and Fine Textures, 1925-27 Construction

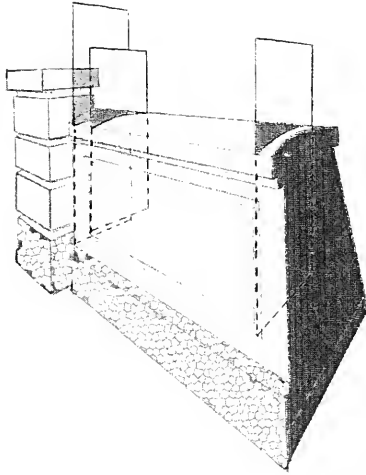


Figure 12: Pour Chronology 1

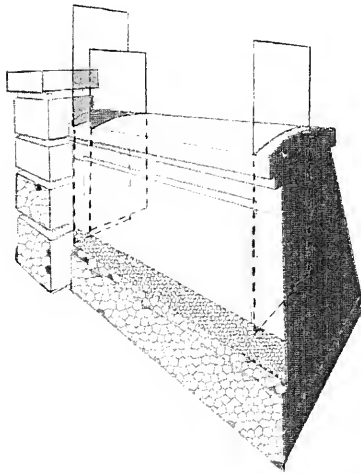


Figure 13: Pour Chronology 2

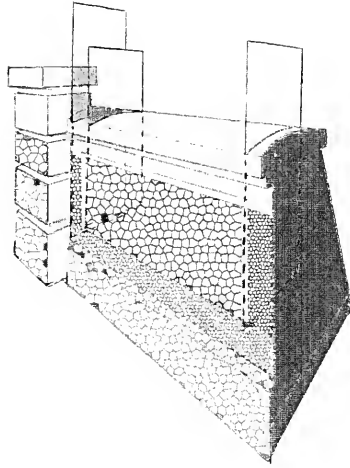


Figure 14: Pour Chronology 3

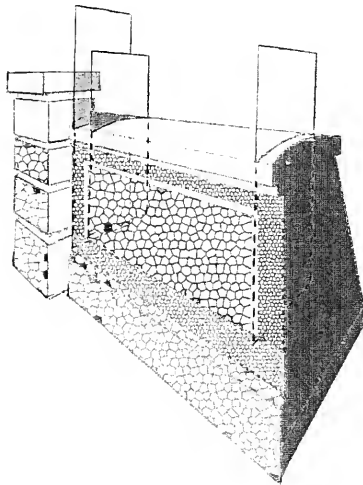


Figure 15: Pour Chronology 4

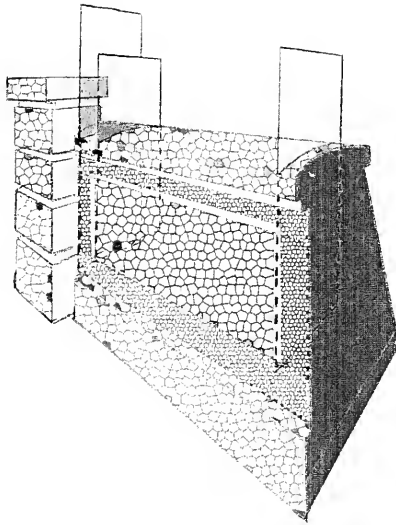


Figure 16: Pour Chronology 5

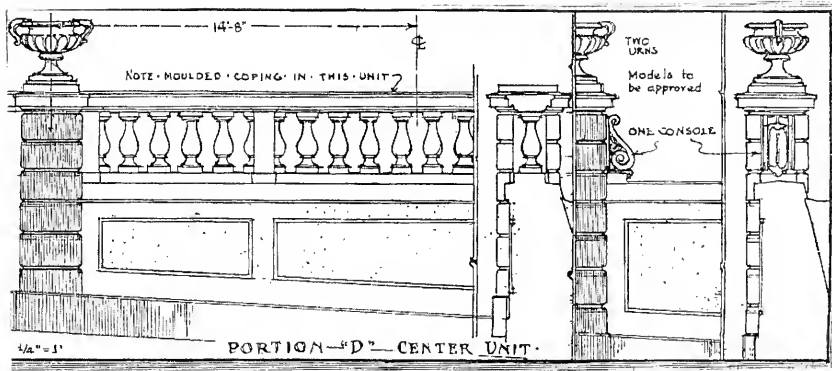


Figure 17: 1915 Specifications for Console
National Archives RG42, Entry 97, Bo No. 24, File 240



Figure 18: Missing Console from West Wall

7-14-1



Figure 19: Baluster Mock-up, n.d (c. 1915-18)
Rock Creek Park, Cultural Resource Management Archives



Figure 20: Main 16th Street Entrance, c. 1918
Rock Creek Park, Cultural Resource Management Archives



Figure 21: Interior of Main 16th Street Entrance



Figure 22: Main 16th Street Entrance, South Stairs



Figure 23: Main 16th Street Entrance Overlook Area,
Molded Benches, n.d (c. 1918-19)
Rock Creek Park, Cultural Resource Management Archives

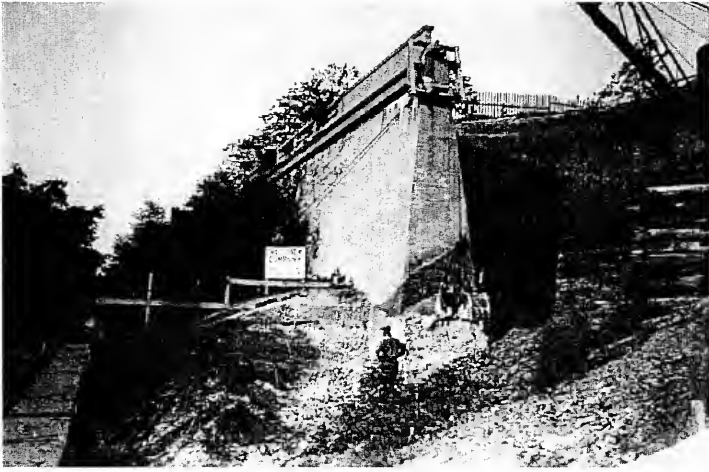


Figure 24: Upper 16th Street Retaining Wall Construction, c. 1929
Rock Creek Park, Cultural Resource Management Archives



Figure 25: Upper 16th Street Retaining Wall Footing, c. 1929
Rock Creek Park, Cultural Resource Management Archives

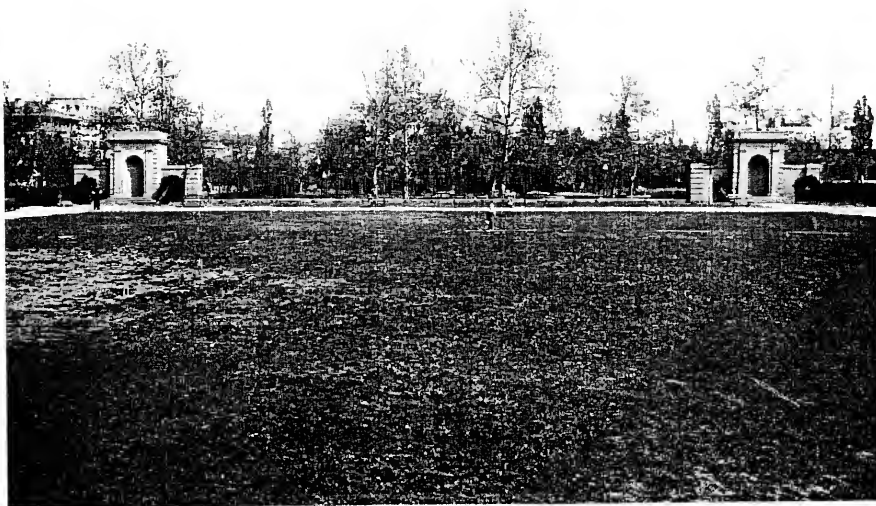


Figure 26: North Wall, looking north from Upper Mall, n.d.
Rock Creek Park, Cultural Resource Archives

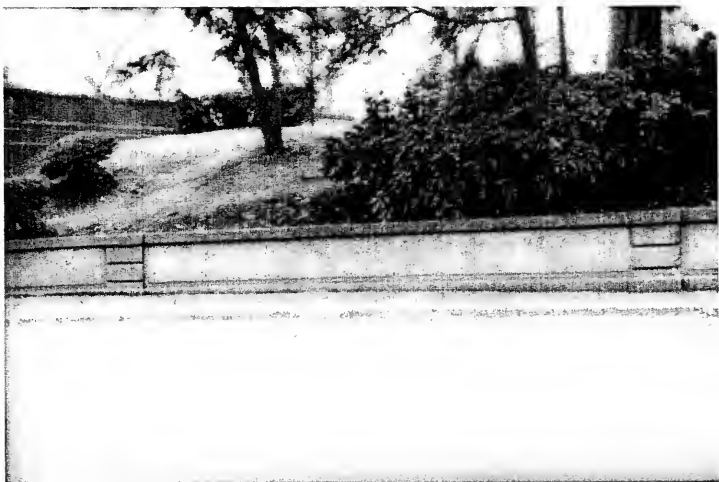


Figure 27: Typical low East Wall Panel



Figure 28: Main 15th Street Entrance

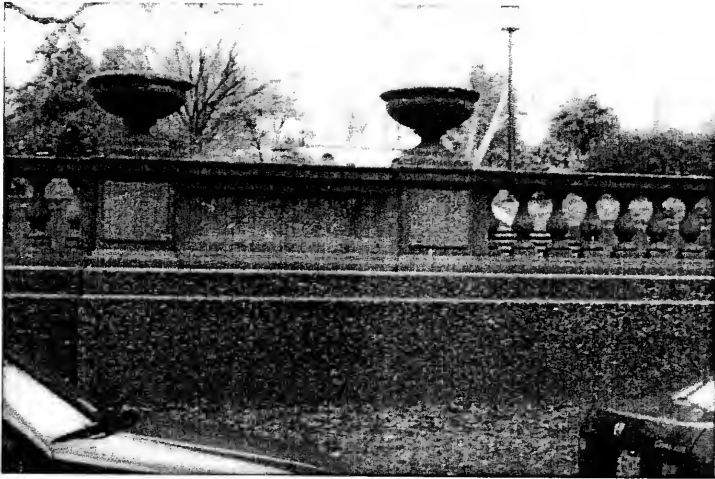


Figure 29: Typical Urn and Baluster Design of the South Wall

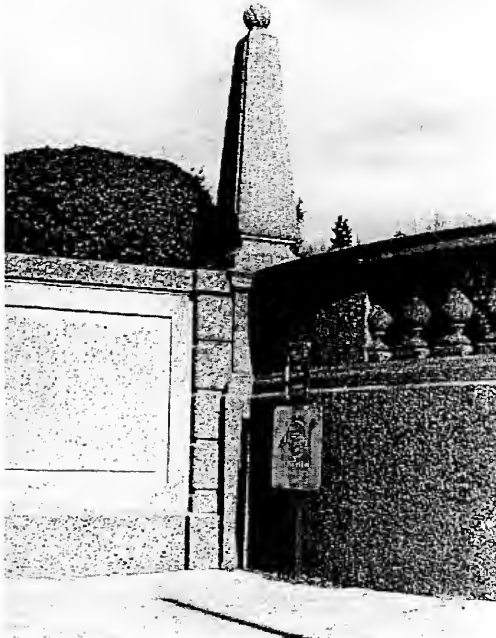


Figure 30: Southwest Entrance, entrance to spiral ramp



Figure 31: 16th Street Fountain Niche Construction, 1936
Rock Creek Park, Cultural Resource Management Archives

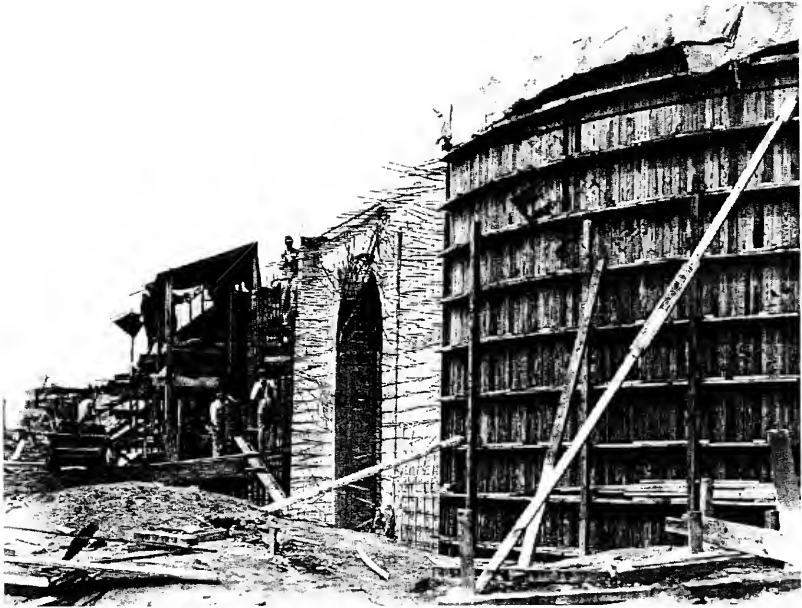


Figure 32: Example of Structural Backwall Construction Technique,
Great Terrace Construction, c. 1930
Rock Creek Park, Cultural Resource Management Archives

The concrete work at Meridian Hill Park is currently in good condition considering its age and construction at a time when concrete was not fully understood. The deterioration mechanism found at the park will be understood within the context of the chemical and physical properties of the material and the intrinsic and extrinsic deterioration mechanisms of concrete. A summary of the conditions found at the park will demonstrate what mechanisms are currently acting on the concrete work. This is followed by an examination of the composition and characterization of the concrete and deterioration products to better understand the concrete work. Each of these components must be discussed to understand the physical and chemical properties of the concrete perimeter walls at Meridian Hill Park and their current condition.

5.1 Chemical and Physical Properties of Concrete

Reinforced concrete is a system composed of cement matrix that has hardened around an interior matrix of coarse and fine aggregate and metal reinforcement. Its compressive strength is acquired from the hydration of the cement which forms a binding paste around the aggregates. Metal reinforcement gives concrete tensile strength. The alkalinity of sound concrete protects the reinforcement from corrosion by stabilizing an oxide film over the steel. Corrosion will be inhibited as long as the passivity layer over the reinforcement is not impaired.

Portland cement is produced by burning a mixture of limestone and clay, or similar reactive materials, at a high temperature of about 1450°C. The partially fused material, known as clinker, is then finely ground with a few per cent of gypsum which controls the rate of set.¹ The clinker is composed of various percentages of lime (CaO), silica (SiO₂), alumina (Al₂O₃), and iron oxide (Fe₂O₃) which upon burning form four major phases called the alite, belite, aluminat and ferrite phases.² Alite (Ca₃SiO₅) is the most important phase responsible for the strength of concrete comprising 50-70% of the clinker. Several types of special cements were

¹ H.F.W. Taylor, *Cement Chemistry*, (London: Academic Press, 1990): 1.

² Mineral Composition of Clinker- 1928 and 1990:

Mineral	% Composition (Bauer, 1928: 31)	% Composition (Taylor, 1990: 1)
CaO	60-64	67
SiO ₂	19-25	22
Al ₂ O ₃	5-9	5

produced as of 1928 such as aluminate, high early strength, waterproof and white cements.³ Of particular interest is the composition of white Portland cement which was the special type used by John J. Earley and the Earley Studio. This cement has the same chemical composition as regular Portland cement except that the iron oxide content is much lower at ½ to 1 per cent. White Portland cement is more finely ground than regular Portland cement and has a lower specific gravity.⁴

When the ground clinker is mixed with water it undergoes a further exothermic chemical reaction called hydration. Among other products, calcium hydroxide and calcium silica hydrates are formed during this process. During hydration, alite (Ca_3SiO_5) and belite (Ca_2SiO_4) react to form the gel of calcium silicate hydrates which bind the cement paste and the crystalline calcium hydroxide.⁵ Their formation parallels the gradual increase of strength of the concrete. The hydration of alite is almost complete within 28 days and gives early strength. Belite will hydrate much more slowly and continue to strengthen the concrete after one year. Setting occurs within a few hours as the concrete stiffens without developing a significant compressive strength. This strength develops during a longer period of time as the concrete hardens.⁶

The physical properties of cement matrix vary throughout the concrete. The microstructure of the hardened paste close to the aggregate and on the surface is more porous, permeable and lower in strength than the bulk cement paste.⁷ The pore system within the paste originates from the original water content, the hydrated gel, and incomplete compaction. The extra water that does not react in hydration creates a system of connecting voids in the cement paste that communicate to the surface of the concrete. The pores within the calcium silicate

Fe_2O_3	0-4	3
Magnesia	5 maximum	not mentioned
SO_3	2 maximum	not mentioned

Below 1300°C, the reaction of the products formed from the decomposition of calcite (CaCO_3) and clay minerals give lime and belite, aluminate and ferrite phases. Clinker forms at temperatures from 1300-1450°C when the aluminate and ferrite melt and the belite and lime react to form alite (Taylor, 60). Alite (Ca_3SiO_5) is the most important phase responsible for the strength of concrete comprising 50-70% of the clinker. It is modified in composition and crystal structure with Mg^{2+} , Al^{3+} , and Fe^{3+} . Belite (Ca_2SiO_4) is the second most abundant phase at 15-30%. The aluminate phase ($\text{Ca}_3\text{Al}_2\text{O}_6$) can cause rapid setting unless gypsum is added to the mix. Finally there is the ferrite phase ($\text{Ca}_2\text{AlFeO}_4$) which is modified by the variation in the Al/Fe ratio and the other ions present in the mix (Taylor, 1-3).

³ Edward E. Bauer, *Plain Concrete*, (New York: McGraw-Hill, 1928): 21.

⁴ Bauer: 44.

⁵ M.S. Eglinton, *Concrete and Its Chemical Behaviour*, (London: Thomas Telford, 1987): 7.

⁶ Taylor: 123.

⁷ Taylor: 377.

hydrate gel are considerably finer than the capillary pores. Incomplete compaction of the concrete creates large, irregular voids within the paste.⁸ In the 1930's, a further pore system of fine, discrete pores was created through air entrainment. Air entrained concrete significantly improves the ability of concrete to withstand freeze/thaw deterioration. A suitable surfactant, such as a saponified Vinsol resin, is added to the concrete mix which entraps air within bubbles in the cement paste.⁹ A system of fine, isolated pores is created which increase the voids where pore water can expand. The pressures created under these circumstances are decreased.¹⁰ Air entrainment has been proven to improve workability and durability.

5.2 *Deterioration Mechanisms*

The deterioration of concrete can be attributed to various mechanisms working simultaneously that originate from the chemistry of the concrete, structural defects, and external agents. The deterioration mechanisms of concrete are always found in combinations, often aggravating other problems within the concrete. The properties of each of the parts of the concrete mix will affect the condition of the hardened concrete. From the period of construction, the concrete continually undergoes chemical changes within itself. Deterioration can come from deleterious reactions between the concrete ingredients and from defects in the structure. External agents such as the freeze/thaw cycles of weathering, the ingress of salts, and the carbonation of the concrete can cause damage through various processes.

5.2.1 *Deterioration within Concrete Ingredients & Structure*

Certain types of fine grained siliceous aggregates will react with the cement paste in an alkali-silica reaction. Reactive aggregates include sufficiently strained quartz and fine grained quartz, known as flint or chert, which may contain inclusions of chalcedony, a fibrous quartz, and structurally unstable quartz minerals such as opal, tridymite and cristobalite.¹¹ The fine grained aggregate have a large surface area to react with sodium in the cement. If soluble sodium is present in significant quantities to give a critical sodium hydroxide concentration in the pore water than a harmful reaction can take place. The reaction of the sodium and the aggregate in the

⁸ T.P. Lees, "Deterioration mechanism" in *Durability of Concrete Structures: Investigation, Repair, Protection*, ed. Geoff Mays (New York: E. & F.N. Spon, 1992): 13-14.

⁹ John C. Ropke, *Concrete Problems, Causes and Cures*, (New York: McGraw-Hill, 1982): 14.

¹⁰ Taylor: 351.

¹¹ Taylor: 390.

proper ratios can produce an expansive, sodium rich silicate gel that takes in large amounts of water and increases in volume. If the concrete is not sufficiently porous, the gel will cause internal stress of the matrix and form cracks. When the gel dries, cracks will be opened up within the matrix.¹² Fine map cracking on the surface of the concrete can indicate that a significant alkali-silica reaction has occurred on the interior of the concrete.

Deterioration from structural defects takes many forms and can originate at any stage in construction. Detailing of insufficient expansion joints may cause stress cracks, bulging or complete failure. Poor mixing or pouring of concrete can cause incomplete packing, cracking, and uneven settlement of the mix. These can lead to accelerated corrosion of reinforcement. Overloading the structure can also lead to deterioration of the concrete.

5.2.2 Deterioration from External Agents

Many of the external agents that cause concrete deterioration are dependent upon the presence of water. Therefore, the permeability and density of the concrete and the waterproofing of the structure are important factors in withstanding attack from external agents. The weathering effect of freeze/thaw cycles on the concrete is particularly damaging. Water carrying salts can physically and chemically disrupt the fabric of the concrete as well as deposit efflorescence on the surface. Corrosion of reinforcement can occur through the carbonation of the concrete and the reaction with chloride ions.

5.2.2.1 Freeze/Thaw Cycles

Deterioration from freeze/thaw cycles is dependent on the permeability and porosity of the concrete. Damage will not occur unless there is a sufficient amount of water in the capillary pores where freezing can occur. The entire volume of the concrete does not need to be saturated to damage the concrete as surface layers can spall and delaminate due to freezing pressure. Liquid in the fine gel pores will not freeze. During freezing, unfrozen water from the capillary pores is forced into the finer gel pores. The unfrozen water being forced into the gel pores has a high concentration of salts because ice has formed from pure water. This movement of a concentrate solution into the gel pores creates an osmotic pressure as less concentrated solution moves toward the concentrated solution to create an equilibrium.¹³ Several other models have

¹² Lees: 23.

¹³ *Ibid* : 30-31.

been advanced to explain the origination of the pressures which cause disruption of the material.¹⁴ These pressures may be strong enough to disrupt the cement paste. Air entrained concrete reduces these pressures, whatever their cause, by allowing expansion within the small, discrete voids. This improvement did not appear until the mid 1930s and much of the failure of earlier concrete was caused by freeze/thaw deterioration.

5.2.2.2 Salt Crystallization & Efflorescence

Solutions of salts or carbon dioxide percolating through concrete can cause leaching and deterioration of the concrete. The type of damage depends on the rate of evaporation of the solution when it reaches the surface of the concrete. If the evaporation is rapid, salts can be deposited within the pore system on the interior of the concrete. Here, the pressures caused by crystallization and hydration of salts in the presence of a saturated solution can disrupt the paste.¹⁵ If the rate of evaporation is fairly slow, efflorescence will appear on the surface of the concrete. Damage occurs on surfaces where drying takes place.

The formation of efflorescence requires that water laden with certain elements move through or flow over the concrete. These deposits come from elements that were carried in the water and the source of these elements shed information on the condition of the concrete. The rate of their formation depends on the quality of the concrete, the rate water is moving through the concrete and evaporating from the surface, temperature and the concentration of solutes carried in the water.¹⁶ Calcium carbonate forms on the surface of concrete when carbon dioxide in solution percolates through the concrete dissolving the carbonates in the cement paste and then depositing them on the surface. A solution of water and carbon dioxide is formed under pressure in the pores and fine cracks of concrete where the solubility of carbon dioxide increases.¹⁷ When the acidic solution carrying dissolved carbonates reaches the surface of the concrete, the pressure and, therefore, the solubility of carbon dioxide in water decreases and the carbonates are precipitated on the surface as the water slowly evaporates.¹⁸ This can lead to unsightly masses on affected surfaces.

¹⁴ See Taylor: 402-403.

¹⁵ Lees: 32.

¹⁶ Taylor: 404.

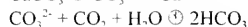
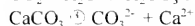
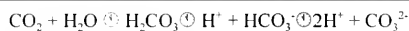
¹⁷ CaCO_3 can be dissolved as well as CH ($\text{CaO} \cdot \text{H}_2\text{O}$) and Ca^{2+} and OH^- from the C-S-H ($\text{CaO} \cdot \text{SiO}_2 \cdot \text{H}_2\text{O}$) phase. The hydrated calcium aluminate phases can also be dissolved. See Taylor, 404.

¹⁸ The chemical process is as follows:

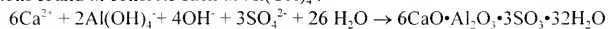
Solutions containing sulfates originating from ground water or contaminated aggregates can attack concrete and cause expansion, cracking and disintegration. Sulfates will attack the calcium hydroxide and hydrated silicates of the cement to form ettringite in an expansive reaction.¹⁹ The reaction also releases displaced hydroxide ions into the concrete possibly aggravating any alkali-silica reactions. Gypsum in solution can also damage concrete by reacting to form ettringite though not by attacking the calcium hydroxide or silicate hydrates of the cement paste.²⁰ Sulfates from air pollution and water react with the calcium carbonate of the concrete to form gypsum crusts (calcium sulfate, $\text{Ca}_2\text{SO}_4 \cdot \text{H}_2\text{O}$) on surfaces.²¹ Dust and fly ash become trapped in the crusts making turning them into black crusts. These crusts often foster biological growth.

5.2.2.3 Corrosion of Reinforcement

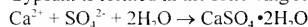
Corrosion of the metal reinforcement in concrete is inhibited by the high pH of the material which forms an oxide film over the steel and prevents further attack. Sufficient concrete covering of the reinforcement will further inhibit corrosion. The protective alkalinity of the concrete can be disrupted by the lowering of pH values by carbonation or by reaction with chlorides. Corrosion is an electrochemical process where areas of the metal become positively and negatively charged. At the anode, iron is dissolved and iron oxide is deposited. Electrons travel from anode to cathode within the metal and hydroxide ions travel from cathode to anode through the solution it is in contact with. A continual source of oxygen and water must be maintained. If there is a high pH and no chloride ions are present, the deposited oxide will form a continuous protective film over the reinforcement. If the pH is lowered, the oxide is deposited in an incoherent form and corrosion accelerates.²²



¹⁹ The formation of ettringite from sulphate ions in solution, dissolution of calcium hydroxide, and other ions found in concrete such as $\text{Al}(\text{OH})_4^-$:



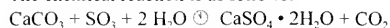
Gypsum is formed in the following reaction:



See Taylor: 397.

²⁰ Taylor: 399.

²¹ The chemical reaction is as follows:



²² H.F.W. Taylor, *Cement Chemistry*, (London: Academic Press, 1990): 387.

Carbonation is the reaction of carbon dioxide with the cement paste to form calcium carbonate. Carbon dioxide in the pores of the cement paste produces carbonates⁻ which reacts with calcium ions to produce CaCO₃. The hydroxide and calcium ions in the reaction are provided by the dissolution of calcium hydroxide and the decomposition of the hydrated silicate and aluminate phases.²³ The carbonated layer of concrete becomes a framework of silica, alumina, and iron oxide filled with calcium carbonate.²⁴ This reaction significantly lowers the pH of the concrete. If the zone of carbonation reaches the reinforcement, it can disrupt the protective oxide layer and induce corrosion.

The risk of chloride induced corrosion of reinforcement depends on the ease at which chloride ions can move through the concrete. Chloride ions originate from the decomposition of minerals in the cement paste, from contaminated aggregates, from mixing water, and from external sources. Diffusion of chloride ions will take place through the water in the pore system and will move more rapidly with cycles of drying and saturation. Chloride ions in contact with the reinforcement can break down the passive oxide layer even at high pH levels. The exposed areas become anodes and the unaffected areas become cathodes causing pitting of the metal and a localized decrease in pH.²⁵

5.3 Condition Summary of Perimeter Walls at Meridian Hill Park

Concrete is a complex composite material which undergoes chemical and physical changes over its service life. Many of these mechanisms have only been understood within the last fifty years. Earlier concrete practices aggravated deterioration problems revealing their misunderstandings of the material. These practices include the addition of chlorides to concrete mixes in cold weather and the use of contaminated or unstable aggregates. Many of these

²³ Carbonation reaction:
 $\text{CO}_2 + 2 \text{OH}^- \rightarrow \text{CO}_3^{2-} + \text{H}_2\text{O}$
 $\text{Ca}^{2+} + \text{CO}_3^{2-} \rightarrow \text{CaCO}_3$
 $\text{Ca}(\text{OH})_2 \rightarrow \text{Ca}^{2+} + 2 \text{OH}^-$
See Taylor, 384-385.

²⁴ T.P. Lees, "Deterioration mechanism" in *Durability of Concrete Structures: Investigation, Repair, Protection*, ed. Geoff Mays (New York: E. & F.N. Spon, 1992): 34.

²⁵ T.P. Lees, "Deterioration mechanism" in *Durability of Concrete Structures: Investigation, Repair, Protection*, ed. Geoff Mays (New York: E. & F.N. Spon, 1992): 35.

practices have doomed concrete to an untimely demise. Further, historic concrete suffers from general weathering of exposed surfaces such as erosion, spalling and cracking.²⁶

Meridian Hill Park shows many of the common signs of weathering; however, the concrete work is in remarkably good condition. A survey of the perimeter walls shows relatively few areas of active deterioration. The state of the concrete work can be ascertained by a review of the conditions found at Meridian Hill Park and an analysis of the material evidence. The relatively good condition of the concrete raises the unique question of what was done right rather than what has gone wrong.

5.3.1 *History of Conditions at Meridian Hill Park*

Documentary evidence traces the past weathering history and conditions at Meridian Hill Park. As early as 1926, records note the need for structural repairs to the concrete work at Meridian Hill Park. The noses of the steps at the Main 16th Street Entrance were reportedly vandalized immediately after they were open to the public and required repair.²⁷ The paving south of the planting pocket on the north side of the overlook area above the Main 16th Street Entrance was found to be disintegrating and causing discoloration of the concrete ceiling below only eight years after construction. A pier to the left of the south recessed seat in this overlook area was reportedly broken and the balustrade immediately south was either settling or bulging.²⁸ The planting areas immediately beneath this balustrade required additional water in the planting pockets: "... it is not generally known that about 6" to 8" below the surface of these soil pockets, a layer of solid cement prevents proper moisture being supplied naturally and in consequence artificial watering is necessary-an expensive process."²⁹ Watering may have accelerated the problems found in this area so soon after construction.

²⁶ Carolyn L. Searls and Sven E. Thomsen, "Deterioration and restoration of historic concrete structures" in *Structural Repair and Maintenance of Historic Buildings*, ed. C.A. Brebbia (Southampton: Computational Mechanics Publications, 1989): 397-405.

²⁷ *Letter from Horace W. Peaslee to Major U.S. Grant, III*, June 8, 1926, NPS Design Services (NCR), Meridian Hill File 1.

²⁸ *Letter from Irving W. Payne, Chief, Landscape Architecture Section, to Chief, Design and Construction Division*, June 21, 1926, NPS Design Services (NCR), Meridian Hill File 1, and *Letter from Horace W. Peaslee to Major U.S. Grant, III*, June 8, 1926, NPS Design Services (NCR), Meridian Hill File 1.

²⁹ *Letter from Irving W. Payne, Chief, Landscape Architecture Section, to Chief, Design and Construction Division*, June 21, 1926, NPS Design Services (NCR), Meridian Hill File 1.

In 1926, Peaslee reported a more serious problem in the design of the wall panels of the perimeter walls. Faulty design of the expansion joint was believed to be causing the fracture of the posts along the Sixteenth Street wall.³⁰ In 1930, Peaslee wrote of this condition:

The question of expansion joints is one that must be carefully considered in order to obtain permanently satisfactory work. In the initial stages it was found that where wall panels were jointed into piers, the transverse thickness of the rusticated pier receiving in its groove the tongue of the panel was not sufficient to resist transverse fracture, and a number of rustications have broken. In subsequent work, care has been taken to limit the width of the tongue and to strengthen the sides of this groove so that these fractures have been successfully avoided.³¹

It was important to Peaslee that these fractures be repaired not only for their unsightly appearance, but for their damage to the reputation of concrete. Peaslee reported that some of the earlier pier construction which had developed flaws was later replaced.³²

In 1927, Peaslee noted defects in the concrete due to poor workmanship and inadequate supervision. He reported an unacceptable segregation of large and small aggregate in an east wall panel:

I was concerned to see in the panels of the W Street wall a most disagreeable stratification of large and small aggregates in a single panel. The top section of the wall second from the Belmont Street entrance is a case in point. If I had detailed superintendence of the work I would have condemned this panel immediately upon removal of the forms, and if it were the first of the lot, would have forestalled its repetition.³³

This is an exceptional report during the construction of Meridian Hill Park. The workmanship is more often extolled than denounced.

In 1954, Horace Peaslee reported the spalling and settling of walls and walks at Meridian Hill Park. Pavement along the upper park edge of the Upper 16th Street Retaining wall were up ended and several seats without foundations along the upper park had sunk.³⁴ In general, Peaslee felt the concrete had held up well over the thirty years since construction though he

³⁰ *Letter from Horace W. Peaslee to Major U.S. Grant, III*, June 8, 1926, NPS Design Services (NCR), Meridian Hill File 1.

³¹ Horace W. Peaslee, "Notes on the Concrete Work of Meridian Hill Park, Washington" in *Landscape Architecture*, (V. 21, n. 1 (October 1930): 31-38): 36.

³² *Letter from Horace Peaslee to Colonel U.S. Grant, III*, December 19, 1930, National Archives RG42, Entry 310, Box. No. 1, Folder 3.

³³ *Letter from Horace Peaslee to Col. U.S. Grant, III, Director of Public Buildings and Public Parks*, November 22, 1927, National Archives RG42 Entry 310 Box No. 1 Folder 2.

³⁴ *Memorandum from Horace W. Peaselee re: Fine Arts Inspection of Meridian Hill Park, April 8, 1954*, April 9, 1954, NPS Design Services (NCR), Meridian Hill File 1.

remarked on some areas of deterioration. He noted settlement in the East Descent from the upper terrace and spalling here on a corner of a pilaster. He reported reinforcement too close to the surface at the junction of the ascents from the lower garden and the east cascade walk. He mentioned that along 16th Street the “original cast cement balustrade and urn panel, should be replaced with scrubbed concrete work. Three balusters broken off: One urn disintegrating and in danger of falling on passerby.”³⁵ Also, at the Lower 16th Street entrance the surface of the concrete work was spalling.³⁶

Ten years later in 1964, condition photos show severe delamination, failure and poor repair of pavement, and settlement of the concrete in the overlook area of the Great Terrace (see fig. 33). A photo of the Upper 16th Street Retaining Wall shows efflorescence under the drip edge and loss of areas of concrete (see fig. 34).

In 1981, the bulging of the Upper 16th Street Retaining Wall caused serious safety concerns. A report on the problem concluded that inadequate drainage was causing the collection of runoff in the backfill. They recommended that the tie back system be reinstalled to insure the structural stability of the wall.³⁷ Testing of the soil behind the Upper 16th Street Retaining Wall revealed that the soil had a high clay content which poorly supported itself and was capable of retaining large amounts of water. The extra weight was causing the wall to buckle while the soil carried acid ground water to the walls.³⁸ Failure of tie-backs under the Upper 16th Street Retaining Wall was noted in 1982.

In 1982 the National Park Service completed the first comprehensive restoration work on the walls and walks at the park. This work included restoration of the tie-back system along the upper retaining wall along 16th Street. The project also involved patching deteriorated concrete and cleaning of the concrete. Deteriorated concrete was cut out of the wall and patched. Exposed reinforcement was cleaned and painted with epoxy paint. The concrete surfaces were cleaned with pressurized water.³⁹ In 1990 the National Park Service created a new

³⁵ *Ibid.*

³⁶ *Ibid.*

³⁷ ROCR, Pkg. 413, Meridian Hill Park, Restore Aggregate Walls and Walks, April 1, 1981, ROCR Park Cultural Resource Management Archives, Meridian Hill File.

³⁸ *Subsurface Investigation for Evaluation of Stability of Retaining Walls at Meridian Hill Park*, Pkg. No. 413, March 20, 1981, ROCR Park Cultural Resource Management Archives, Meridian Hill Files.

³⁹ Project Manual, Rock Creek Park Meridian Hill, IFB 3471-82B Restoration of Walls and Walks Package No. 413, May 11, 1982.

comprehensive rehabilitation plan for the park though it was not executed. The park was most recently surveyed and assessed during a 1997 Cultural Landscape study.⁴⁰

5.3.2 *Current Conditions at Meridian Hill Park*

Physical conditions visible on the perimeter walls at Meridian Hill Park indicate various processes that have acted or are currently acting on the concrete. These include surface erosion, cracks, spalling, settlement, efflorescence and biological growth. The majority of these conditions are related to water movement and structural stresses. In a few places, the concrete is in a severe state of deterioration.

5.3.2.1 *Erosion*

Concrete surfaces which are under continual exposure to the flow of water show erosion of the cement paste. A comparison of the surface of a protected surface from the interior of the Main 16th Street Entrance with that of a weathered surface from the top of a post at the Lower 16th Street Entrance reveals the amount of cement paste which has eroded (see figs. 35 & 36). The weathered surface shows highly exposed sand and fine aggregates with large gaps between the aggregate and the matrix. While this type of erosion does not indicate a serious structural problem, it does affect the appearance of the concrete and may lead to loss of aggregate on severely eroded surfaces. The broad surface of the coping at the Main 16th Street Entrance shows an erosion of the cement paste leaving a surface of highly exposed aggregate. These aggregate hold water on the surface and no longer allow it to run off. The presence of moss in this area indicates that this is a chronic condition and could lead to more serious deterioration.

5.3.2.2 *Cracking*

Cracks are the most common deterioration condition found at Meridian Hill Park. They range from microcracks to significant openings in the walls and occur because of a variety of deterioration mechanisms. Microcracks appear on the surfaces of walls where the coarse aggregate have been exposed. This is evident on the 1915 panels of the West Wall. These fine

⁴⁰ Further information on the history of conditions at Meridian Hill can be found in the in-house surveys of the park that are filed at the Rock Creek Park Cultural Resource Management Archives in Washington, DC. Also, the knowledge of those directly responsible for the maintenance of the park would also add invaluable information on the cyclic conditions and chronic problems found at the site.

cracks fan out from the edge of one aggregate to another and may have been caused by shrinkage of the cement paste or weathering.

Larger cracks can be seen on the posts, particularly in the base area, and within the inner panel border in the West Wall panels (see fig. 37). The cracks may evidence various mechanisms at work. Cracks on the posts are particularly noticeable as large efflorescence has formed around the opening (see fig. 38). The large amount of efflorescence indicates that a fairly significant and steady amount of water is percolating through the concrete at these points. The presence of these cracks on almost all of the West Wall posts indicates a possible failure of the drainage system in combination with structural stresses and inadequate concrete waterproofing. Construction drawings show that catch basins were placed behind the posts and are a source of continual drainage. A failure in this system could be responsible for directing a significant and steady flow of water through the posts. Waterproofing on the backside of these posts may have failed as is shown in certain areas where the tar has slowly crept out through the joints over time. History has shown that these posts are subject to stresses from the adjacent wall panels. It is also possible that stresses placed on the retaining wall from the soil behind it are being communicated to these posts. Another possible cause of the cracks is water infiltration through capillary rise from the ground. This may account for the same cracks at the base of the post of the northernmost West Wall panel and the posts of the North Wall which have neither a catch basin nor act as retaining walls. All of the above cracking in the presence of water will be aggravated by deterioration from freeze/thaw cycles as well.

The cracks within the inner border panels may be caused by water infiltration and corrosion of reinforcement. One of the typical cracks seen in the West Wall panels is a long crack running the length of the top section of the inner border panel (see fig. 39). The location of this crack could indicate a failure of the drainage system located one foot below the top of the wall panel. According to the 1915 specifications the reinforcement is running the length of the wall panel at this level. It is possible that a failure of the drainage system caused corrosion of the reinforcement which in turn crack through to the surface. The northernmost West Wall panel shows horizontal cracks at regular intervals through the inner border panel which may correspond to the interior reinforcement (see fig. 40). This crack pattern is found only in the inner border panel of the West Wall where a second, fine aggregate mix was used indicating that this section of the wall is more susceptible to cracking than the coarse aggregate sections.

5.3.2.3 *Spalling and Delamination*

A few areas of the perimeter walls are actively spalling and delaminating. These areas are primarily, though not exclusively, located at free standing posts. Water from rain and rising damp, heavy use, and poor construction techniques and freeze/thaw cycles may all be responsible for the severe spalling and loss of concrete in these places. The post to the south of the northernmost East Wall panel is in the worst condition of any found at Meridian Hill Park (see fig. 41). The problems here are aggravated by the deterioration of the top of the post which allows water to flow freely down the face of the post. This entrance is in daily use as a vehicular entrance to the upper mall area and may be damaged from this use. Delamination is occurring at the base of the south post marking this entrance which may be suffering from similar problems (see fig. 42). Similar conditions, though less severe, can be seen at the extreme northeast post and the posts flanking the Northwest Entrance in the West Wall (see figs. 43 & 44).

The low concrete wall underneath the iron grille along the North Wall is actively spalling on its upper surface showing failure of the smooth drip surface (see fig. 45). Series of horizontal cracks demonstrate poor construction of the three foot high wall. The top of East Wall Panel 1 is also actively spalling. Further spalling can be seen along the coping of the south post at the top of the steps at the Lower 16th Street Entrance (see fig. 46). Deterioration on all of these surfaces may be exacerbated by vandalism in the park and freeze/thaw cycles as they are all saturated with water.

In other areas, spalling of the concrete can be attributed to the corrosion of the reinforcement. Some areas are no longer actively spalling though the past damage is evident. For example, damage is no longer occurring in the area of exposed reinforcement on the west baluster in the Main 16th Street Entrance overlook area (see fig. 47). Exposed reinforcement on an East Wall panel just south of the Service Entrance is not causing active deterioration and the inadequate cover is probably the fault of poor workmanship (see fig. 48). There are a few active areas on the perimeter walls. The area of spalling already discussed along the low wall of the North Wall may also be attributed to the corrosion of the reinforcement (see fig. 45). A very recent occurrence of spalling from corrosion of reinforcement is located on the interior vaulting of the Main 16th Street Entrance (see fig. 49). Large, flat pieces of concrete have fallen from the vaulting along the spring line. The interior of these pieces retain remnants of iron oxide corrosion products. The areas of spalling from corrosion are relatively few at Meridian Hill Park and the uncovered reinforcement does not appear to be dangerously corroding. This may be due

to the repair work carried out at the park when exposed reinforcement was cleaned and painted with epoxy paint.

5.3.2.4 *Loss*

Significant loss of concrete from prominent decorative elements evidences deterioration and vandalism problems at the park. Most of these losses have occurred in the past. For example, the console element at the top of the West Wall north of the Lower 16th Street Entrance is no longer in place (see fig. 50). This decoration was independently cast and cemented in place and may have been removed. Another wholesale loss is the missing sphere from an obelisk at the Southeast Entrance (see fig. 51). A few large pieces of the balusters along the South Wall and the upper balusters of the Main 16th Street Entrance have also been lost (see fig. 52 & 53). The base of the Grotto Niche on the interior of the Main 16th Street Entrance shows losses at the curbing. These elements may have been lost through vandalism or failure of the concrete.

5.3.2.5 *Efflorescence and Biological Growth*

Efflorescence is one of the most common and visible conditions at Meridian Hill Park. It is found in connection with cracks and joints and is associated with water flow over and through the concrete. It is found in two main types: white-gray efflorescence and black crusts. The white-gray efflorescence takes the form of a thin white coating and large masses known as lime blooms. The different formations indicated the rate of water flow over the area and the amount of elements carried by the water. The thinner efflorescence is found around the edges of cracks in posts and wall panels, under drip edges (see fig. 54), and at the joints in the pre-cast panels of the Main 16th Street Entrances (see fig. 55). Water appears to be flowing less frequently over these areas in comparison with the locations of the lime blooms. Large white-gray masses take the form of undulating deposits and small stalactites along the expansion joints and joints between the posts and the wall panels. The joints of the West and North Walls and the expansion joints of the Upper 16th Street Retaining Wall appear particularly susceptible to these formations (see fig. 56). The rate of water flow is rapid, channeled down and through the construction joints.

Black crusts appear in areas where water is present but not flowing over the concrete surface (see fig. 57). They are commonly found on the inner border region of wall panels and are particularly evident on the West and East Walls. Large crusts are found only on the upper

regions of the inner border panel on the West Wall often in association with the horizontal cracks found in the same area. Thinner crusts are found on the East Wall panels in the same area and along the lower regions of the inner border on the West Wall panels (see fig. 58). Thin black layers can be seen coating all of the exposed aggregate of the perimeter walls (see fig. 59). These black crusts and discoloration may be associated with air pollution as the West and East Walls run close to heavily trafficked streets where these conditions are most marked.

Biological growth, primarily in the form of moss, is found on areas where water sits on the concrete surfaces. Growths are found on the coping of the wall panels, the large coping of the Main 16th Street Entrance and the seats of benches molded into the walls at the Main and Lower 16th Street Entrances (see fig. 60). These growths indicate the chronic water problems of the concrete walls, though they may not cause any significant deterioration themselves. In the original plans for the park, it was considered desirable that moss and vines grow over the concrete walls (see figs. 61 & 62). In 1915, Cass Gilbert advised against creating a large projecting coping on the wall panels: "The coping on these walls projects too far. It is not really necessary that it should be a 'drip', for after all it is a garden and the sooner it gets the effect of staining of water, dust and weather the better."⁴¹ The concrete work may have been specifically designed to foster this type of growth.

5.4 Material Analysis

Analysis of the condition of the concrete at Meridian Hill Park was performed in lab testing. Samples of concrete from different periods of construction revealed variations of the aggregate. Testing of the efflorescence indicated that the concrete is not currently undergoing any large scale chemical attack. The analyses compliment the condition survey and show how the historic periods of construction are reflected on the interior of the concrete.

Samples of concrete and efflorescence were gathered from the site on January 28, 1999. Samples were gathered from areas of the perimeter walls and associated entrances where the surface concrete was actively spalling or had previously broken off. An effort was made to collect samples from each period of construction. All samples were taken from the walls by picking them off the surface or retrieving broken pieces from cracks. Sampling was therefore limited to failing concrete from the top two inches of the surface. After collection, samples were

placed in double sealed plastic bags, labeled, their orientation and location noted and stored in an environment averaging 60°F (see fig. 63). A representative sampling from each period of construction and for each condition was not achieved. The following analysis of the material is only a preliminary study of the concrete at Meridian Hill Park and is not definitive.

The concrete was directly observed under a stereoscope and thin sections were prepared of selected samples. Thin sections were studied under a polarizing light microscope according to the *ASTM Standard Guide for Petrographic Examination of Hardened Concrete*.⁴² From this study, the condition of the cement paste and the mineralogical type of the aggregate were ascertained. The composition of the paste and aggregate were examined through powder x-ray diffraction (XRD).

Efflorescence collected from the surface of the concrete was examined. Samples of the white-gray thin coating, the large masses, and the black crusts were collected. Their composition and formation type were examined under a stereoscope. Chemical tests identified some of the components of the efflorescence. Powder XRD confirmed their composition.

5.4.1 Concrete Examination

Visual and stereoscopic examination of the concrete samples revealed the variations in aggregate size, pore size and distribution, surface exposure, and condition of cement paste. Petrographic examination of selected concrete samples in thin sections allowed for identification and characterization of the cement paste and the mineralogical type of coarse and fine aggregate. The concrete samples evidence the differences in the periods of construction at Meridian Hill Park as seen in the surface concrete only.

The concrete samples collected from the south post at the sidewalk of the Main 16th Street Entrance date from the earliest 1915 construction period. Samples were gathered from a crack behind the post where the pieces had fallen (see Appendix C: Sample 1-3, Petro. 3). They had cracked from the backside of the post and some were coated with tar. It is unclear how long these fragments had been separate from the structure, but a 1964 condition photo shows the loss of the corner of the post where the pieces were collected. The coarse aggregate ranges in size from 0.5 to 1.25 inches and are rounded with smooth surfaces and fine stress cracks. These

⁴¹ *Letter from Cass Gilbert to Wm. W. Hart*, Jan. 21, 1915. National Archives, RG42, Entry 97, Box No. 24, File 240.

cracks are associated with the formation of the rock and not with stresses from within the concrete. In thin section and under the crossed polars of the polarizing light microscope, the coarse aggregate quartz has a patchwork appearance with grains of various sizes most likely due to deformation as a result of induced geological stress. The coarse aggregate exhibit undulose extinction, distinctive in minerals that have been geologically deformed, which appears as a wavy alteration of the interference colors as the specimen stage is turned.

The fine aggregate are natural, sub-angular and rounded quartz grains ranging from 0.0313 to 0.0625" in diameter. These are evenly distributed and densely packed throughout the surface concrete. In thin section, the fine quartz grains reveal the fractured edges and fine cracks of crushed aggregate. Muscovite flakes also appear under crossed polars as brightly colored flecks exhibiting the perfect cleavage of mica. Mica flakes are present in small quantities though fines were specified to be free from mica.

The matrix of the 1915 concrete sample reveals the large amount of cement paste in between the aggregates. There is some cracking in the matrix around the aggregate and irregular settlement cracks where the aggregate did not settle properly. Otherwise, the aggregate is well bonded to the concrete. The cement paste is fairly dense with some large irregular voids from the poor packing of aggregate. These voids are irregular with ragged edges from settlement. Powder XRD indicates that the concrete is fully carbonated and has the structure of a silica skeleton with crystalline calcium carbonate: composed primarily of quartz (silicon oxide, SiO_2) and calcium carbonate (CaCO_3).

A sample of the 1918 concrete work at the Main 16th Street Entrance was gathered from the inner barrel vault over the west stairs (see Appendix C: Sample 4). The exterior surface shows a non-eroded exposed aggregate finish while the interior section has the remnants of iron oxide corrosion products. The coarse aggregate is much finer than the 1915 concrete, averaging 0.125 to 0.375 inches in diameter. It is sub-angular and rounded with the appearance of natural weathering. The aggregate are graded to equivalent sizes and exhibit more varied colors than the 1915 aggregate. No petrographic examination was undertaken for this sample but the aggregate visually resembles that found at the Lower 16th Street Entrance and should be compared to those results. The fine aggregate is a very fine, quartz sand comprised of angular and sub-angular grains that are evenly distributed through the matrix. The pinkish color of the matrix evidences

⁴² *Standard Guide for Petrographic Examination of Hardened Concrete*, ASTM Designation C856-95.

how the original concrete work may have appeared in 1918 as other exposed concrete surfaces are a mottled brown and gray in color. A thin ribbon of cement bonds the aggregate. There is a system of small pores as well as large, irregular voids found clustered around aggregate. The XRD analysis found the components of a fully carbonated concrete, quartz (silicon oxide, SiO₂) and calcium carbonate (CaCO₃).

Concrete sampled from the 1922 period of construction of the North Wall resembles the 1915 sample (see Appendix C: Sample 5, Petro. 1). The sample came from the area of active spalling under the iron grille. The coarse aggregate ranged in size from 0.25 to 1.5 inches in diameter. Again, a rounded, strained quartz gravel was used. In thin section, the aggregate gave the same appearance of quartz as those found in the 1915 concrete. The fine aggregate is also composed of an angular and rounded quartz grains densely packed throughout the matrix. They show fractures and stress cracks from crushing. Muscovite flakes also appear in the matrix. There is a large amount of cement paste between the coarse aggregate. This matrix has many fractures through the cement paste and around the aggregates. The pore system includes small voids and large irregular voids associated with poor packing. The XRD analysis of the cement paste identified quartz (silicon oxide, SiO₂) and calcium carbonate (CaCO₃).

A sample was also collected from the 1927-28 period of construction. A sample of surface concrete came from an active area of spalling on the coping of the south post located at the top of the steps at the Lower 16th Street Entrance (see Appendix C: Sample 6, Petro. 2 & Sample 7). The surface of the concrete is eroded and the aggregate are more exposed than those seen in the sample protected from the weather. Thin black crusts cover the top of the gravel. The coarse aggregate ranges from 0.25 to 0.625 inches in diameter. The aggregate are sub-angular in shape, graded to a similar size and appear naturally weathered. On the surface they are closely packed together with a thin ribbon of cement past in between. In thin section under crossed polars, the coarse aggregate are identified as chert, a fine grained quartz, with inclusions of chalcedony, a fibrous quartz.⁴³ While these aggregates are associated with alkali-silica reaction, no deterioration has occurred from that type of chemical reaction.

⁴³ Chert is a fine grained, microcrystalline variety of quartz with fine, equant grains. Chalcedony is a general term applied to fibrous quartz varieties. It forms by low temperature crystallization out of an aqueous solution or silica gel and is often found filling cavities within rocks. In thin section, chalcedony has a feathery appearance when cut parallel to fibers. Chalcedony fibers are twisted so the optic axis is brought to a vertical position every 180°. This imparts the repeated waves of extinction along the length of the fibers. See Cornelis Klein and Cornelius S. Hurlbut, Jr., *Manual of Mineralogy*, (New York: John

The fine aggregate is composed of a sub-angular quartz which are revealed on the surface. It ranges from 0.015 to 0.125 inches in diameter. Under a polarizing light microscope, the fine grains exhibit different interference colors than those seen in the other samples. The quartz grains change from orange to black as the specimen stage is rotated every 90°. Muscovite flakes are also present. The cement matrix has cracks throughout the paste and around the aggregates, particularly on the exposed surface. Small pores and medium sized irregular pores comprise the pore system. XRD analysis found the same composition as the other cement pastes: quartz (silicon oxide, SiO₂) and calcium carbonate (CaCO₃).

A comparison of the concrete sampled shows a similarity in aggregate type according to size. The large aggregate of the walls was all rounded gravel of quartz with fine stress cracks. The smaller aggregate of the Lower, and possibly the Main, 16th Street Entrance is predominantly chert that has stronger coloring than the larger aggregate. The consistency of mineral type within similar sized aggregate indicates that the system of aggregate grading produced a mineralogical separation. It is unclear whether the chert aggregates were selected for their colors or whether they were unknowingly selected because of their smaller size. The fine grained form of chert would cause them to naturally weather more than the large quartz gravel. The fine sand aggregate used at Meridian Hill Park is consistently a crushed quartz with some muscovite flakes. The fine aggregate of the 1927-28 sample exhibits different interference colors which indicates a varied composition.

The matrices of the concrete sampled are similar in their comparative denseness and chemical composition. The composition of the cement paste in each of the samples was identical. The presence of silica and calcium carbonate confirm that the top two inches of the concrete are fully carbonated. The voids in the cement paste differed between the concrete sampled. Larger aggregates used in the 1915 and 1922 concrete caused large, ragged, irregular voids from poor packing. In contrast, the 1918 and 1927-28 concrete had medium, smooth edged, elliptical voids from entrapped water. As the concrete sampled came only from the surface, a comparison with the interior concrete cannot be made. It would be interesting for further study to examine how the surface treatment of the exposed aggregate concrete affected the physical and chemical properties of the surface concrete.

Wiley & Sons, Inc., 1999): 528, and William D. Nesse, *Introduction to Optical Mineralogy*, 2nd ed., (New York: Oxford University Press, 1991): 263.

5.4.2 Efflorescence and Black Crusts Testing

The formation of efflorescence or growths on the surface of concrete is an indication of processes occurring within the concrete. In this study, they were particularly important indicators of the condition of the interior concrete as the sampling was limited to pieces from the top 1-1 ½ inches of the concrete surface. Chemical and XRD testing identified the primary composition and trace salts found in the efflorescence (see Appendix C: Eff. 1-5, B.C. 2). The results indicate that the interior concrete is not undergoing significant chemical attack but that there is significant amounts of water percolating through and over the concrete.

Chemical tests revealed the presence of carbonates in the thin powder and thick masses of the white-gray efflorescence.⁴⁴ The carbonates (CO_3^{2-}) originated from the dissolution of the calcium carbonate in the cement paste in the presence of a solution of water and carbon dioxide. The calcium carbonates precipitated out of this solution to form the efflorescence. Powder XRD confirmed that the efflorescence was composed predominantly of calcite (calcium carbonate, CaCO_3) and quartz (silicon oxide, SiO_2).⁴⁵ The quartz grains originate from the cement paste or fine aggregate of the deteriorated concrete. Certain white-gray masses tested positively for nitrites. These were found in two locations on the West Wall and one on the North Wall. Traces of nitrites in the efflorescence indicate biological growth. Nitrites may have formed from nitrates reduced by biological or bacterial growth. The source of these salts may be from the ground water, in the case of the West Wall where nitrites were found in retaining walls, or air pollutants, in the case of the North Wall which is freestanding. Nitrites (NO_2^-) will normally be oxidized to form nitrates (NO_3^-) on the surfaces of objects unless biological or bacterial growth is present.

Chemical tests identified large amounts of sulfates (SO_4^{2-}) present in the black crusts as well as less significant amounts of nitrites and nitrates. Powder XRD confirmed that the crusts were composed primarily of gypsum (calcium sulfate, $\text{Ca}_2\text{SO}_4 \cdot \text{H}_2\text{O}$) and quartz (silicon oxide, SiO_2). The quartz grains were pulled out of the deteriorated concrete. Visual examination of the crusts revealed the presence of organic and inorganic matter trapped in the granular gypsum

⁴⁴ For procedure see Jeanne Marie Teutonico, "Ex. 16 Qualitative Analysis of Water-Soluble Salts and Carbonates" in *A Laboratory Manual for Architectural Conservators*. (Rome: ICCROM, 1988): 58-67.

⁴⁵ Powder XRD (X-Ray Diffraction) measures the crystallographic axes and crystal structure of the powdered material to determine its composition. An x-ray travels in an arc over the surface of the powdered material. Its diffraction from the surface of the material is measured and marked as peaks on a

crusts. The gypsum crust is formed by the reaction of sulfates with calcium carbonate in the cement paste. The sulfates may have originated from the concrete itself, microbiological growth, or air pollutants. The presence of nitrites and nitrates is discussed above. Large crust formations appear near the horizontal cracks in the West Wall panels indicating a strong reaction occurring in these areas.

No other elements were found in sufficient quantities to be read by XRD. The absence of other materials linked to chemical attack of concrete or reinforcement indicates that certain types of attack are not occurring on the interior of the concrete. For example, the mineral ettringite ($6\text{CaO}\cdot\text{Al}_2\text{O}_3\cdot 3\text{SO}_3\cdot 32\text{H}_2\text{O}$) is formed during sulfate attack of concrete. If found in sufficient quantities, ettringite can indicate that sulfate attack is occurring on the interior of the concrete.⁴⁶ If the concrete is undergoing both sulfate attack and carbonation, thaumasite can form which can cause severe softening of concrete.⁴⁷ Further, the lack of substantial quantities of the iron oxides of corrosion products indicates that the reinforcement is not rapidly corroding. The absence of any of these elements in significant quantities indicates that the concrete is in good health.

5.5 Conclusion

Having considered the deterioration mechanisms, it must be emphasized that the concrete work at the park is in very good condition considering its age (see fig. 64). There is very little damage occurring from the corrosion of the reinforcement. The structural defects are few. Weathering of the concrete has cracked and eroded the surface but there is no active aggressive chemical attack. The concrete work retains its structural and aesthetic integrity. The reasons for this can be attributed to the soundness of the materials and the skills of the workmen. The concrete is extremely dense, particularly in areas where step-graded mixes were used. The reinforcement is adequately covered in most places. Finally, the concrete work exhibits a consistency of quality of construction.

chart. A computer program sorts the peaks according to their intensity and position on the chart and lists the most probable minerals present.

⁴⁶ Xavier Deloye, et al. "Stalactites, concrete masses and efflorescences as a guide to diagnosis of chemical damages in structure" in *Materials science and restoration, Proceedings of the international conference, Esslingen, 6-8 Sept. 1983*, (Lausanne: Lack und chemie, 1983): 33-38.

⁴⁷ Taylor: 401.



Figure 33: Spalling and Delamination on Upper Retaining Wall Balustrade, 1964
Note: Mesh cover over balustrade openings
NPS MARS Collection

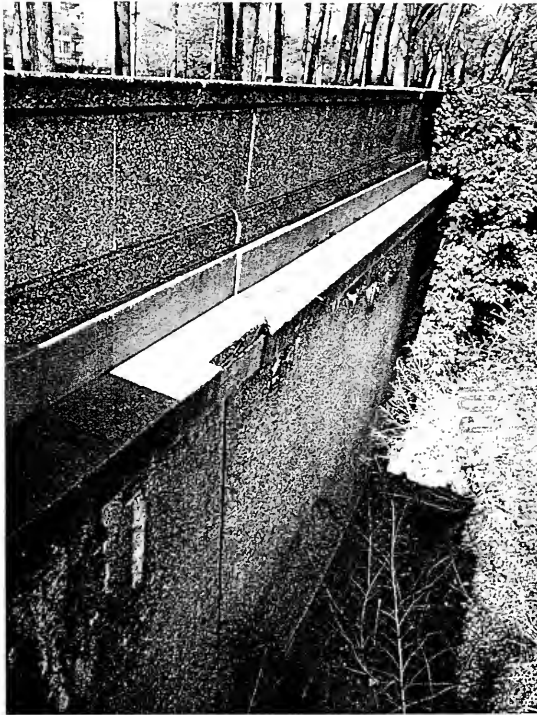


Figure 34: Efflorescence on Upper Main 16th Street Retaining Wall, 1964
NPS MARS Collection

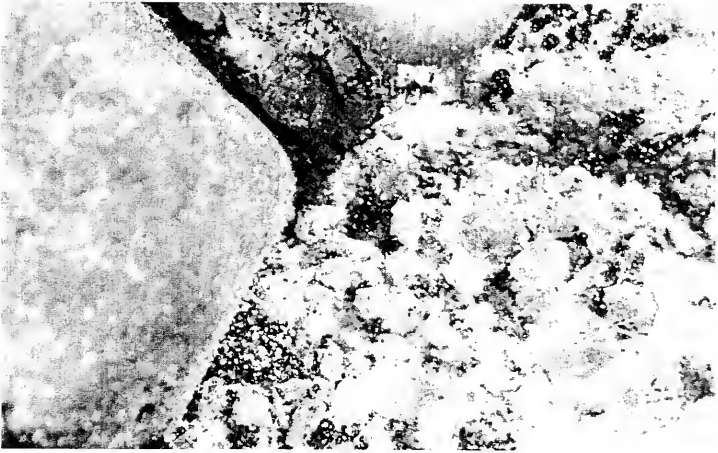


Figure 35: Eroded Surface, Lower 16th Street Entrance



Figure 36: Non-eroded surface, Interior of Main 16th Street Entrance

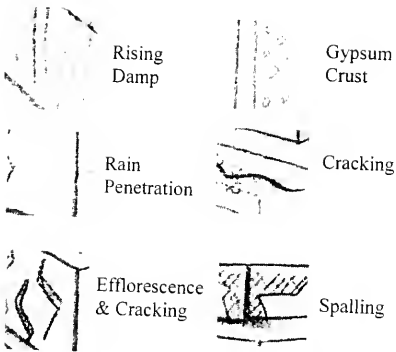
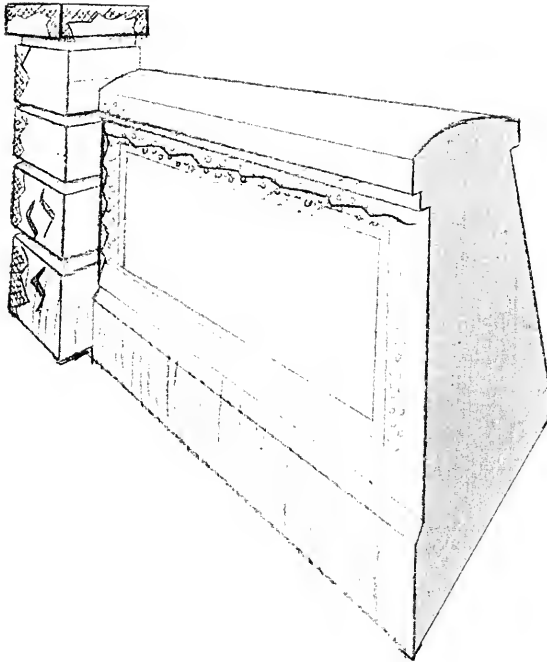


Figure 37: Typical Wall Panel Conditions

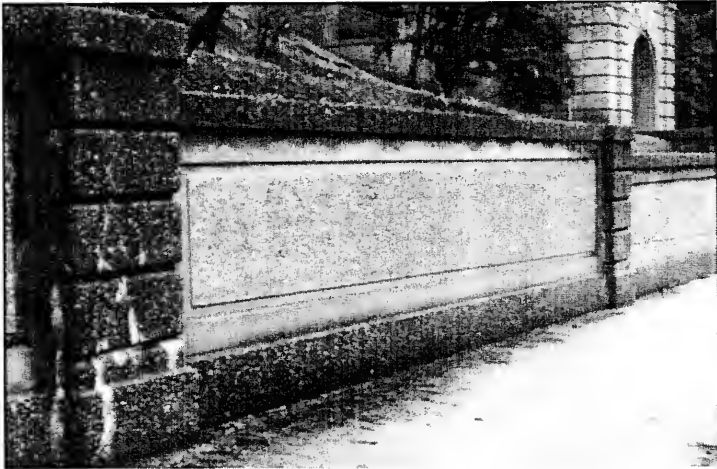


Figure 38: Cracking and Efflorescence on Posts, West Wall

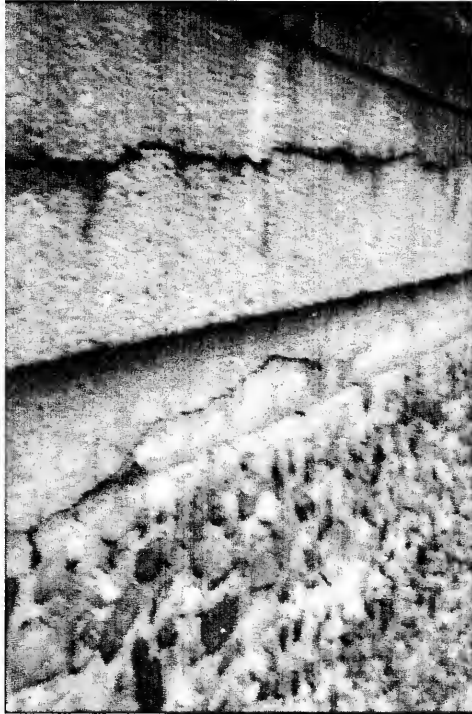


Figure 39: Horizontal Cracking on Inner Border, West Wall

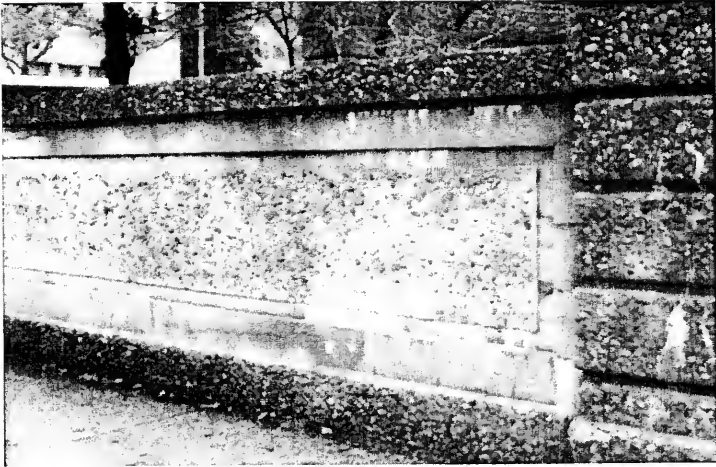


Figure 40: Multiple horizontal cracking in Northernmost West Wall Panel



Figure 41: Spalling and Delamination, North Post of Northeast Entrance



Figure 42: Spalling and Delamination, Base of South Post of Northeast Entrance

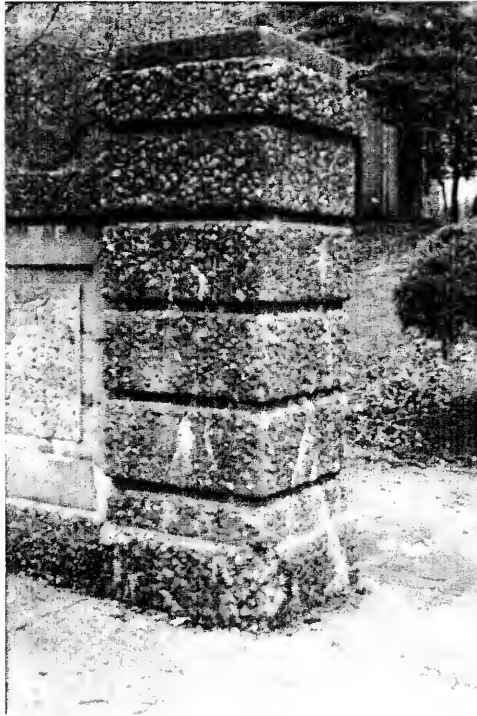


Figure 43: Spalling at base of North Post of Northwest Entrance



Figure 44: Spalling on South Post of Northwest Entrance



Figure 45: Spalling on top of low North Wall and failure of drip edge



Figure 46: Spalling at edge of coping on upper south post of Lower 16th Street Entrance

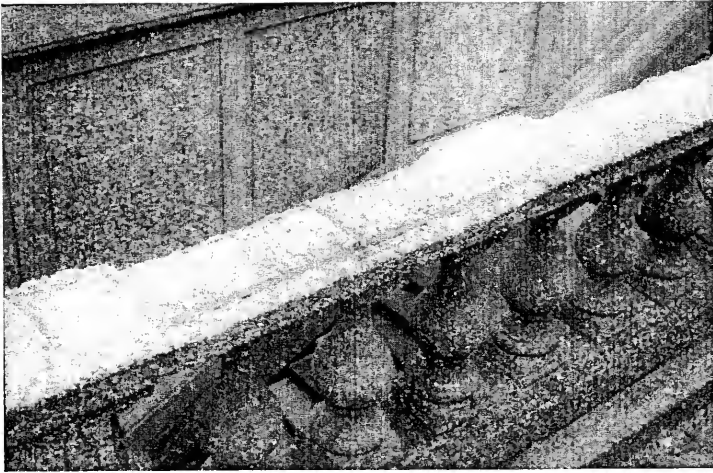


Figure 47: Spalled area on the west balustrade above south stairs of Main 16th Street Entrance

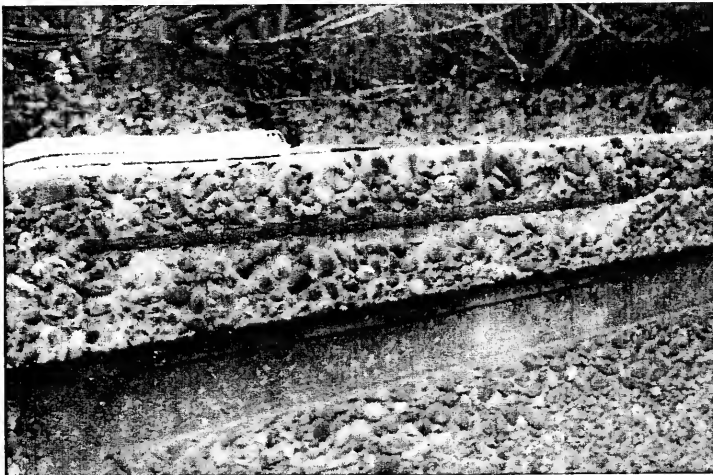


Figure 48: Exposed Reinforcement on East Wall panel 32 from inadequate cover



Figure 49: Corrosion of Reinforcement causing minor Spalling at spring line of vaulting, Interior Main 16th Street Entrance



Figure 50: Missing Console from West Wall



Figure 51: Missing Sphere from Obelisk at Southwest Entrance



Figure 52: Loss of Baluster Base from South Wall



Figure 53: Losses from Cracked Balusters,
West Balustrade above South Steps, Main 16th Street Entrance



Figure 54: Location of Efflorescence on West Wall Panel

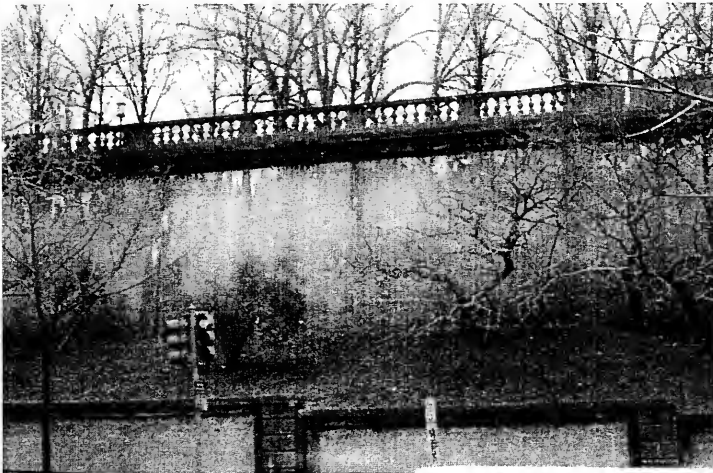


Figure 55: Efflorescence on Upper 16th Street Retaining Wall

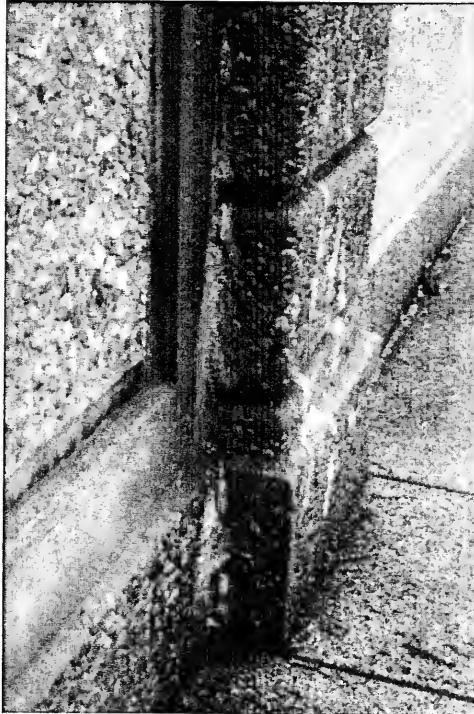


Figure 56: Large Efflorescence at Joint of West Wall Panel



Figure 57: Black Gypsum Crusts on Wall Panel
Note: Absence of crust at joint where water flows

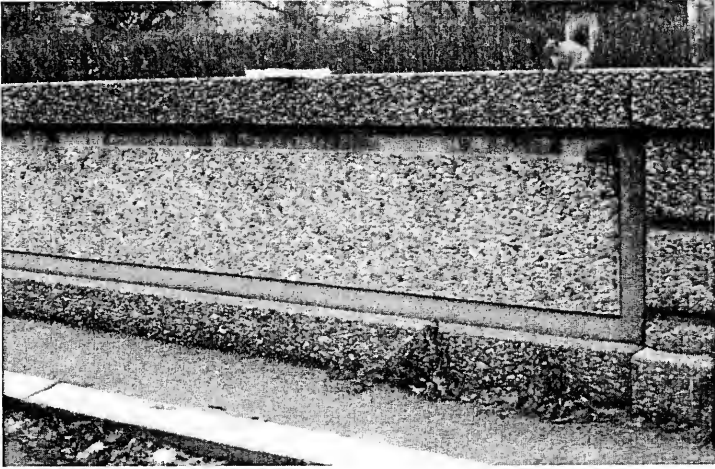


Figure 58: Thin Crusts on East Wall Panel



Figure 59: Thin Black Crust on Exposed Aggregate

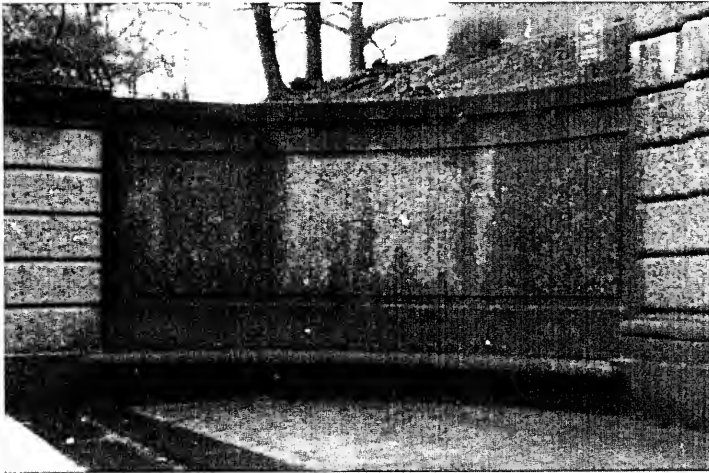


Figure 60: Biological Growth at Main 16th Street Entrance

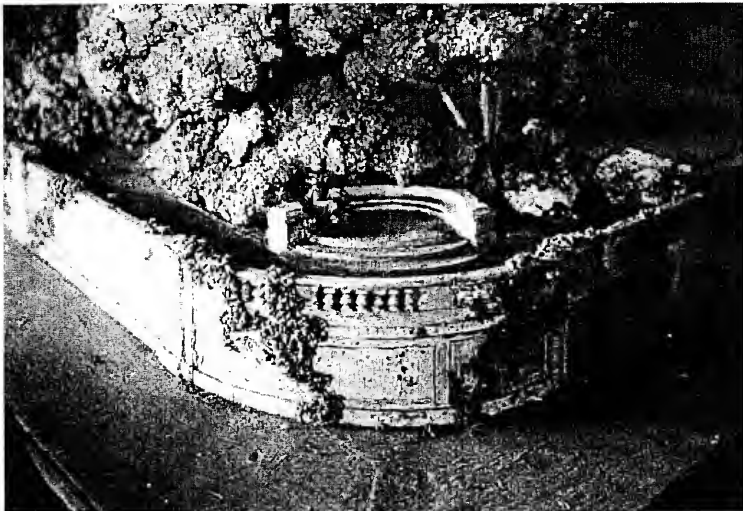


Figure 61: Original Model for Meridian Hill Park showing Vegetation
Rock Creek Park, Cultural Resource Management Archives

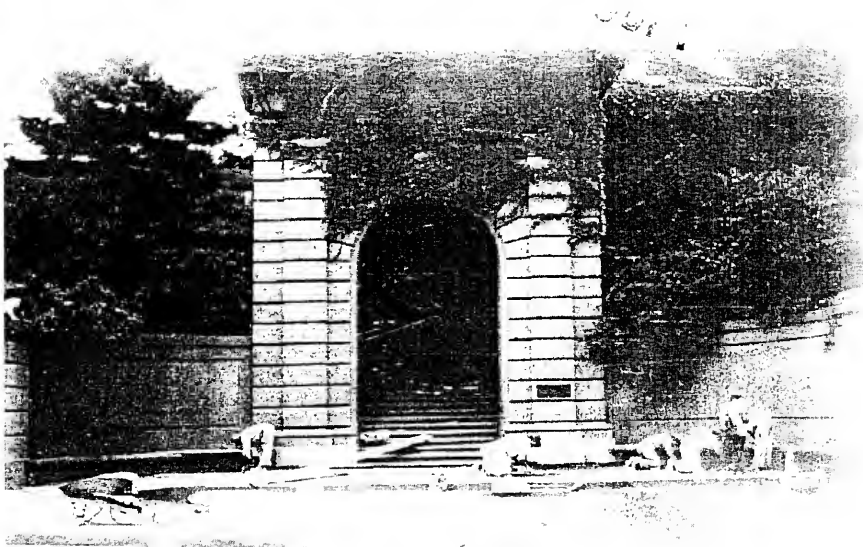


Figure 62: Main 16th Street Entrance with Wisteria Vines, c.
Rock Creek Park, Cultural Resource Management Archives

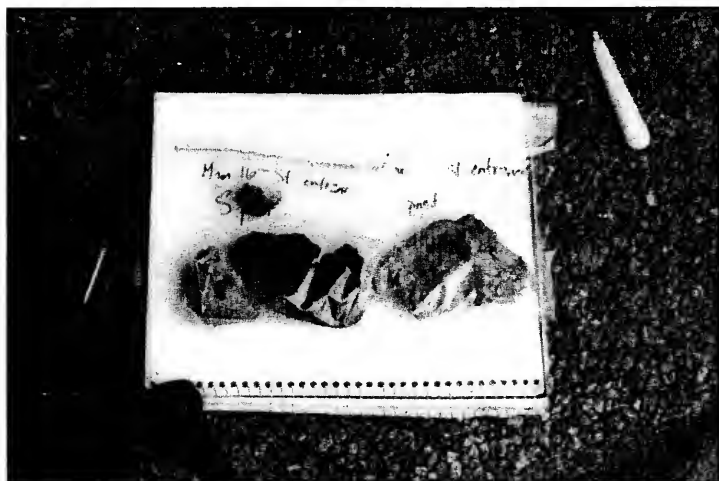


Figure 63: Sample Collection



Figure 64: Current Condition of Concrete Work at Meridian Hill Park

The exposed aggregate, reinforced concrete walls constructed at Meridian Hill Park in Washington, DC, manifest the experiments in mix design, construction, and finishing of concrete which were performed during the period of 1915-1936. The concrete work at the park belongs to an era of exploration of the physical and aesthetic possibilities of concrete as an architectural material. The debate surrounding concrete at this period centered around the search for an honest and artistic expression of the material. John J. Earley participated in this debate and innovated techniques that transformed concrete into an architectural and artistic material. The documentary history of the park confirms that the exposed aggregate concrete work at Meridian Hill Park developed in tandem with experiments done by John J. Earley to produce an aesthetically pleasing, architectural concrete. Meridian Hill Park is the first in a lifetime of experimental work and achievements in concrete by Earley and the Earley Studio.

Meridian Hill Park remains unique today for the quality of the concrete work after 80 years of weathering. Conditions surveyed at the park indicate that few areas are showing active aggressive deterioration. The majority of the concrete work is remarkably sound and the exposed aggregate finishes intact. The crispness of the detailing and the warmth of the textured surfaces attest to the quality of the workmanship and evidence the original aesthetic intent of the concrete work. Some of the deterioration mechanisms do have the capability of causing damage to the concrete work in the future. Most importantly, the problem of water penetration must be addressed as the presence of water instigates many of the deterioration mechanisms at work in the park. These problems must be addressed in future restoration work at the park.

Future restoration of the concrete work at Meridian Hill Park will need to be guided by an understanding of the different periods of construction, the aesthetic of the concrete constructed during each period, and the character of the concrete in each area as well as the specific deterioration problems of the site. The analysis of the physical material revealed information on the character of the mix used during the periods of construction, notably the identification of the aggregate used, but not the specific ratios of the original mix. Further study of the concrete mix must take the history of the construction technology into account. For example, any analysis of the concrete work, especially the detail work, must take into account the removal of excess water performed by the Earley Studio. John J. Earley's concrete work will

have two water: cement ratios, one for workability and one for strength. Standard tests to determine this ratio will not take this into account.

A complete study of the concrete work of the Earley Studio would include an analysis of other works. A comparison of the conditions of Earley's work could indicate deterioration mechanisms and, more importantly, the reasons for the resiliency characteristic of his projects over time. These conditions should be compared and contrasted to that of other concrete work that survives from this period. A review of the role of concrete in architecture after Earley's lifetime could highlight Earley's contribution, perhaps forgotten, to the development of concrete as an architectural material. In this way, a broader understanding could be ascertained of the unique way in which Earley developed and executed his concrete work.

The concrete work at Meridian Hill Park is a testament to the work of a master in concrete and the skill of the workmen. It is also a material record of the experiments made by Earley at the beginning of his distinguished career in concrete. Significant losses of the concrete work disrupt the aesthetic of the park and also destroy evidence of these developments in concrete. For this reason, the concrete work requires sensitive restoration which includes an understanding of the concrete as a structural, an artistic, and a documentary material.

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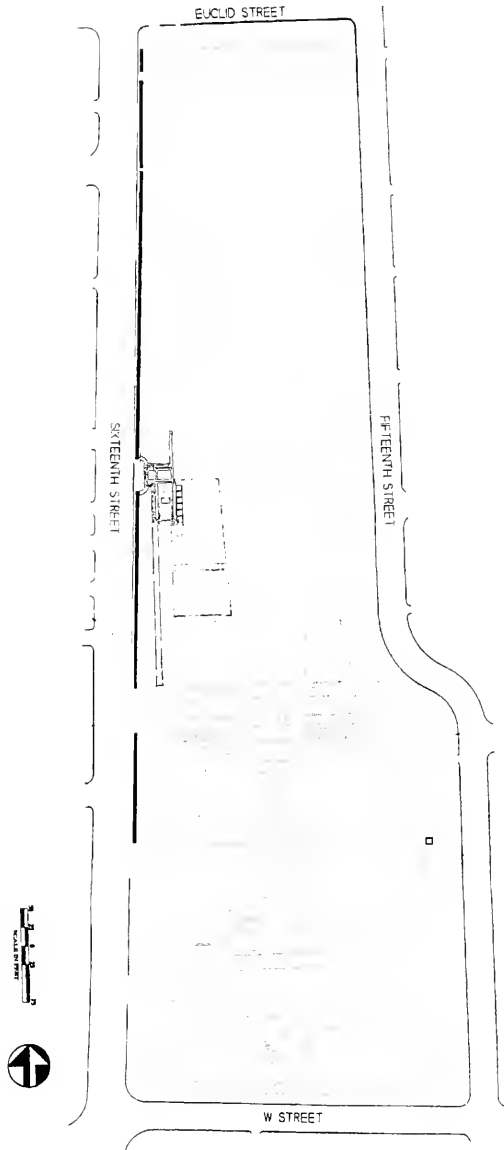
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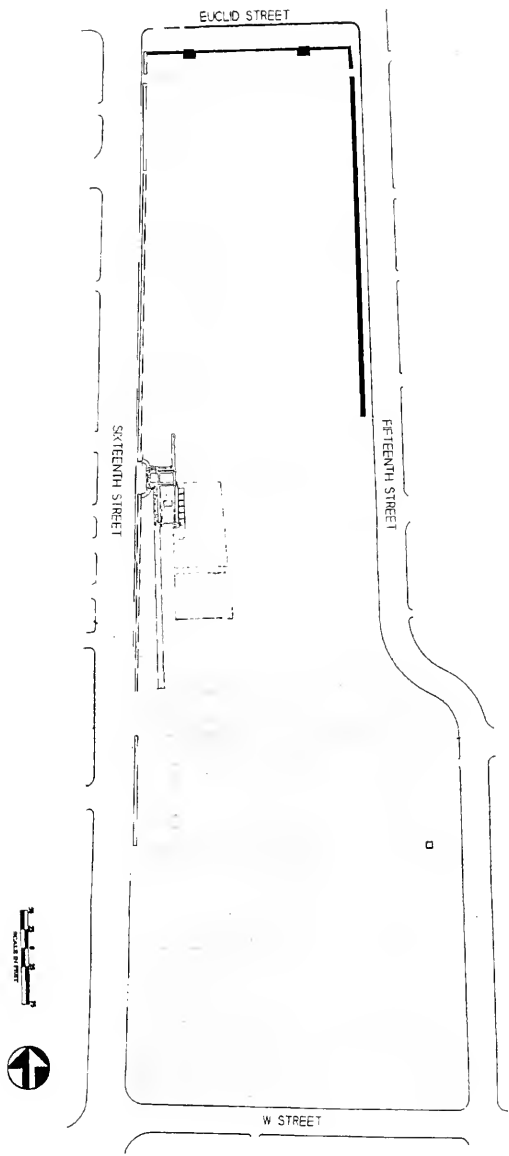
APPENDIX A: CHRONOLOGY OF PERIMETER WALL CONSTRUCTION

PERIMETER WALL CONSTRUCTION, TECHNIQUES & SAMPLING

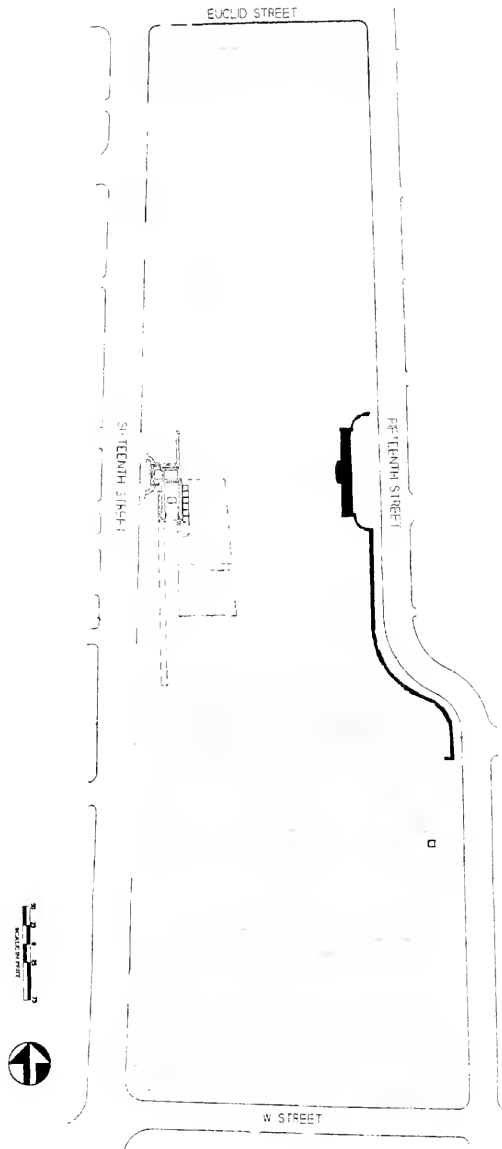
Date	Contractor	Features Constructed	Type of Construction	Samples
1915	Earley Studio	<ul style="list-style-type: none"> West Wall to N of lower 16th St. Entrance Upper 16th Street Retaining Wall S of Main Entrance to Great Terrace area 	<ul style="list-style-type: none"> Poured in place Varied mixes used in same pour Exposed Aggregate Finish of standard concrete mix 1:2:4 	1, 2, 3 Eff. 3 B.C. 1, 2 Petro. 3
1917-18	Earley Studio (Possibly another contractor, Chas. H. Tompkins Co., worked on the structural concrete)	<ul style="list-style-type: none"> Main 16th Street Entrance Wing wall N of upper main entrance 16th Street Upper Retaining Wall 	<ul style="list-style-type: none"> Structural concrete poured in place with pre-cast elements Exposed Aggregate Finish of concrete mix with step-graded aggregate Water control of pre-cast elements such as balusters and banisters 	4
1919	unknown	<ul style="list-style-type: none"> NW Entrance construction- three new posts, one new wall panel, probably northernmost West Wall panel and two flights of steps 	<ul style="list-style-type: none"> Poured in place Varied mixes used in same pour Exposed Aggregate Finish of standard concrete mix 1:2:4 	none
1922	unknown	<ul style="list-style-type: none"> North Wall East Wall to N of Chapin Street Entrance 	<ul style="list-style-type: none"> Poured in place Varied mixes used in same pour for North Wall Exposed Aggregate Finish of standard concrete mix 1:2:4 	5 Eff. 5 Petro. 1
1925	Fred Drew Company (?)	<ul style="list-style-type: none"> East Wall from Chapin Street Entrance to Service Entrance 	<ul style="list-style-type: none"> Poured in place Exposed Aggregate Finish of concrete mix with step-graded aggregate 	none
1927-28	Fred Drew Company	<ul style="list-style-type: none"> East Wall from S of Service Entrance to SE end South Wall West Wall from Lower 16th Street Entrance to SW end 	<ul style="list-style-type: none"> Poured in place Exposed Aggregate Finish of concrete mix with step-graded aggregate 	6, 7 Eff. 1, 2, 4 Petro. 2
1934-36	unknown	<ul style="list-style-type: none"> West Wall Fountain Niche 	<ul style="list-style-type: none"> Structural concrete poured in place with pre-cast elements Exposed Aggregate Finish of concrete mix with step-graded aggregate 	none



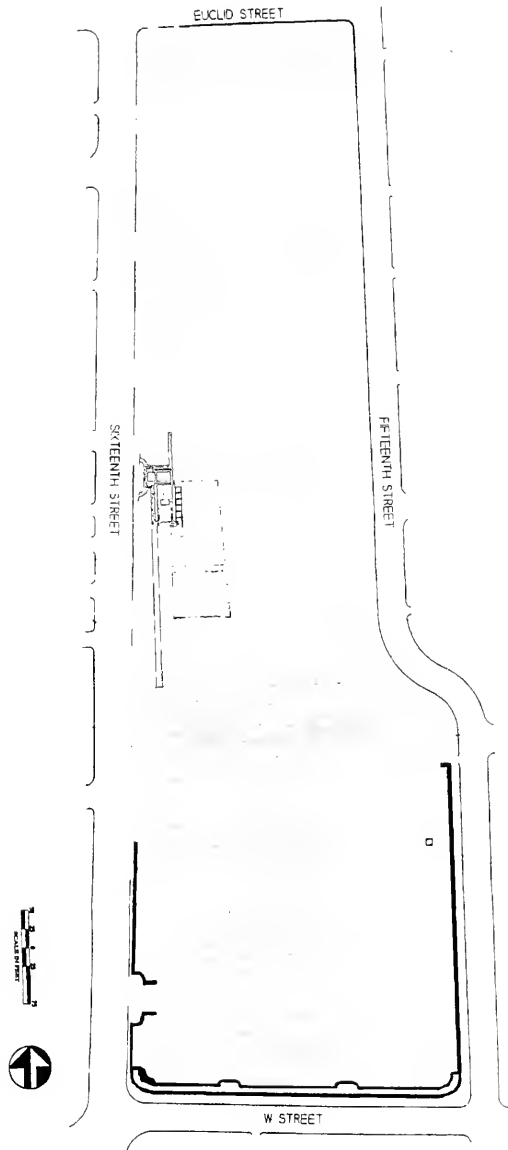
1915
Site plan from Land Ethics. Inc.



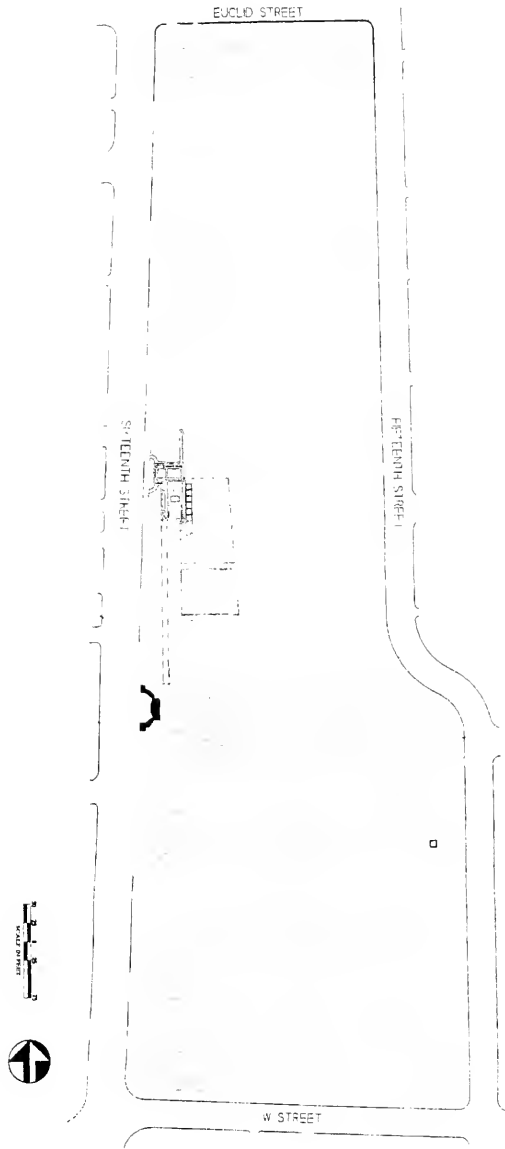
1922



1925



1927-28



1934-36

APPENDIX B: PROJECTS OF JOHN J. EARLEY AND THE EARLEY STUDIO

From the Cron-Earley Collection, Georgetown University Library, Washington, DC

DATE	PROJECT	DETAILS
1915	Meridian Hill Park 16 th and Florida Ave., NW Washington, DC	Examples of poured in place retaining walls, steps and paving
1919	East Potomac Park Field House Hains Point, SW Washington, DC	Plaster and precast ornament
1922	Fountain of Time Chicago, IL	Cast sculpture
1923	Meridian Hill Hotel 16 th and Euclid Streets, NW Washington, DC	Examples of precast ashlar
1923	Church of Sacred Heart 16 th Street and Park Road, NW Washington, DC	Interior only, ornamental figures and ornament, applied in place walls
1923	Connecticut Avenue Facade Washington, DC	Earley precast process facade
1923	St. Paul's Church Alexandria, VA	Stucco work
1924	Siamese Legation Washington, DC	Stucco work
1925	Franciscan Monastery 14 th and Quincy Streets, NE Washington, DC	Examples of poured paving, applied in place walls, precast columns, flower boxes and trim
1925	Louisiana State University Baton Rouge, LA	Stucco work
1925	Parthenon replica Nashville, TN	Exterior stucco, precast ornament
1926	Arlington Amphitheatre Arlington Cemetery	Plaster ceiling work

DATE	PROJECT	DETAILS
1926	Mullen Library Washington, DC	Interior
1927	Bird and Reptile Houses Washington Zoological Park Washington, DC	Ornamental panels at entrances
1928	Arlington Trust Company Building Rosslyn Circle Rosslyn, VA (demolished)	Applied in place walls and precast trim.
1934	Baha'i Temple Wilmette, IL	Precast panels
1934	Department of Justice Building Constitution and Pennsylvania Aves., NW Washington, DC	Ornamental ceilings, multi-colored, in porticos
1934-35	Polychrome Houses Colesville Pike, MD	Prefabricated houses
1936	Federal Reserve Board Building Washington, DC	Pebble mosaic pavements
1938	David W. Taylor Model Basin United States Naval District Carderock, MD	Interior mosaic
1938	The Normandy Building 16 th and 17 th Streets at K, NW Washington, DC (demolished)	Multi-story precast facade.
1928	Thomas Alva Edison Memorial Menlo Park, NJ	Precast exterior panels
1939	Evening Star Garage 11 th and E Streets, NW Washington, DC	Precast grill walls
1939	Scottish Rite Temple 2800 16 th Street, NW Washington, DC	Exterior ornament panel and urns at entrance

DATE	PROJECT	DETAILS
1940	National Airport Washington, DC	Mosaic walks and ceilings
1940	United States Naval Academy Chapel Annapolis, MD	Interior mosaics
1942	Washington Gas Light Building 11 th and H Streets, NW Washington, DC	Precast spandrels

SAMPLE: 1

PAGE 1 of 2

DATE OF CONSTRUCTION: c. 1915

LOCATION:

Main 16th Street Entrance, south post at sidewalk



<p>ORIENTATION:</p> <p>Gathered from crack behind post where pieces had fallen from failure of concrete at the back of the post, inner section of concrete.</p>
<p>VISUAL EXAMINATION:</p> <p>See Sample #3.</p>
<p>STEREOMICRSCOPE EXAMINATION: BROKEN SURFACE</p> <p>See Sample #3.</p>
<p>PETROGRAPHIC EXAMINATION:</p> <p>See Sample #3.</p>
<p>POWDER XRD:</p> <p>See Sample #3.</p>

DATE OF CONSTRUCTION: c. 1915
LOCATION: Main 16 th Street Entrance, south post at sidewalk See photo of location Sample #1.
ORIENTATION: Gathered from crack behind post where pieces had fallen from failure of concrete at the back of the post, back side of post. NOTE: tar coating backside.
VISUAL EXAMINATION: See Sample #3.
STEREOMICRSCOPE EXAMINATION: BROKEN SURFACE See Sample #3.
PETROGRAPHIC EXAMINATION: See Sample #3.
POWDER XRD: See Sample #3.

DATE OF CONSTRUCTION: c. 1915

LOCATION:

Main 16th Street Entrance, south post at sidewalk
See photo of location Sample #1.

ORIENTATION:

Gathered from crack behind post where pieces had fallen from failure of concrete at the back of the post, back side of post.
Unclear how long these pieces have been separate from structure.
NOTE: tar coating backside.

VISUAL EXAMINATION:

Coarse Aggregate:

- 0.5 < d < 1.25"
- gravel, rounded, strained quartz
- mostly coarse aggregate

Fine Aggregate:

- very fine sand visible only under stereoscope
- quartz, natural

Matrix:

- mottled gray, very dirty
- fairly thick paste between aggregates

Air:

- some large irregular voids, otherwise fairly dense

No embedded items

Fabric:

- surface is dull
- concrete is not weak enough to break with fingers
- no large cracks

STEREOMICROSCOPE EXAMINATION:

BROKEN SURFACE

Coarse Aggregate:

- quartz, smooth surface with fine strain cracks
- uniform within aggregate grain

Fine Aggregate:

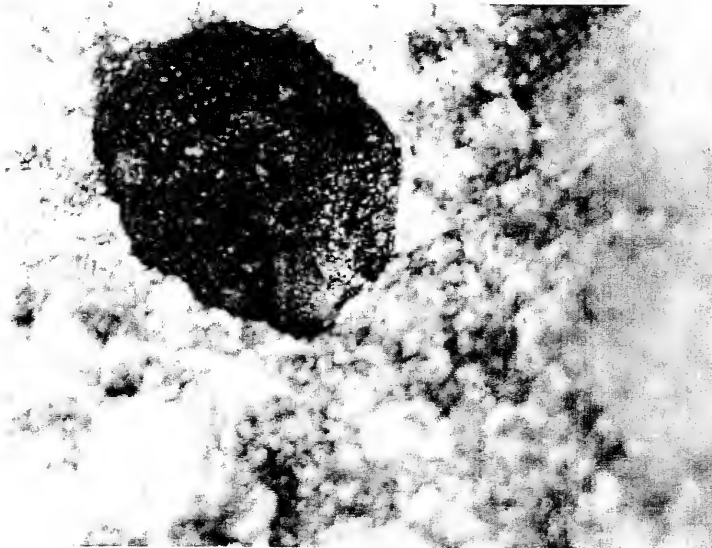
- $0.0313 < d < 0.0625$ "
- coarser than other fines
- sub-angular and rounded quartz
- evenly distributed through paste, densely packed

Matrix:

- white-beige color, dirty
- fractures around aggregate
- few stress cracks, mostly irregular settlement cracks where aggregate did not settle properly
- missing loose aggregate

Voids:

- irregular, non-spherical with ragged edges from settlement
- dirt collected in voids



Irregular Void in Matrix

PETROGRAPHIC EXAMINATION:

Photo Scale:

25x Outside Edge=1.25mm

Coarse Aggregate:

- patchwork appearance of quartz with different grains showing 90° extinction
- wavy extinction within fragment is undulose extinction, indicates geological stress and deformation

Fine Aggregate:

- quartz grains
- fractured edges and fine cracks from crushing
- muscovite flakes with bright interference colors and perfect mica cleavage

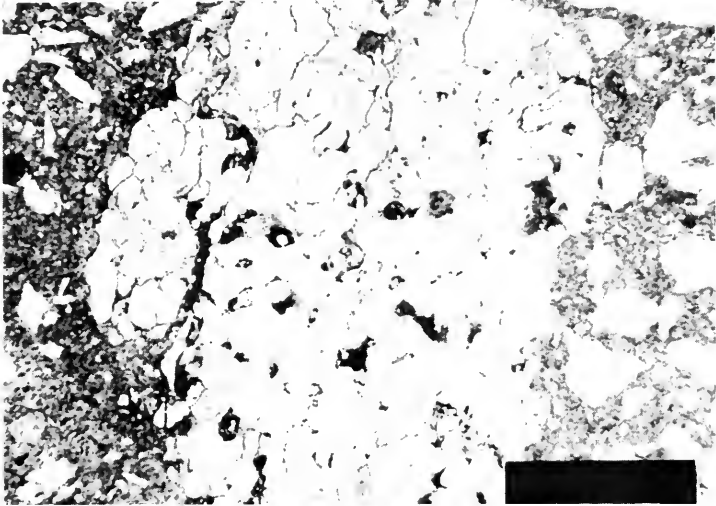
Matrix:

- fine grained, for composition see XRD
- dense with irregularly shaped pores

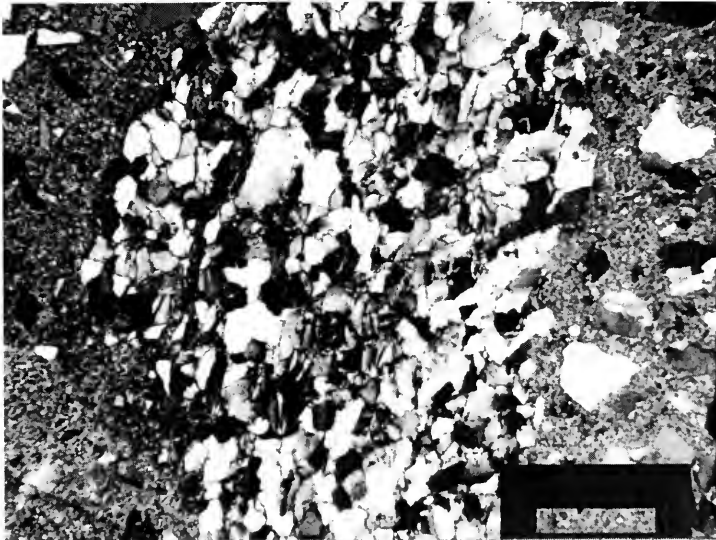


Undulose Extinction within Coarse Aggregate
25x Crossed Polars

PETROGRAPHIC EXAMINATION

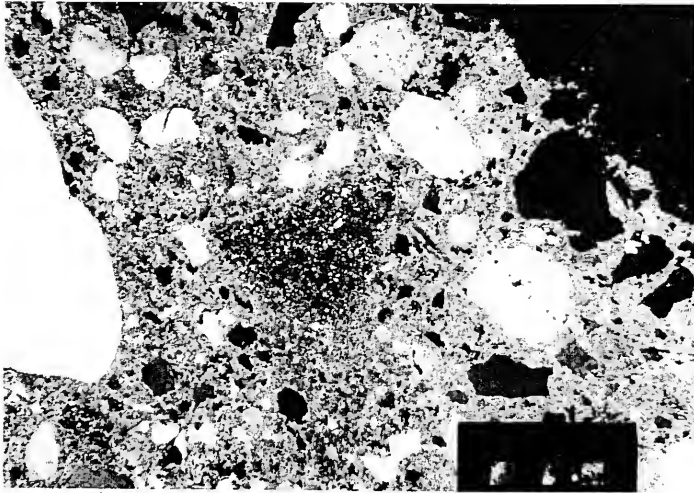


Coarse Aggregate, Quartz, 25x Transmitted Light

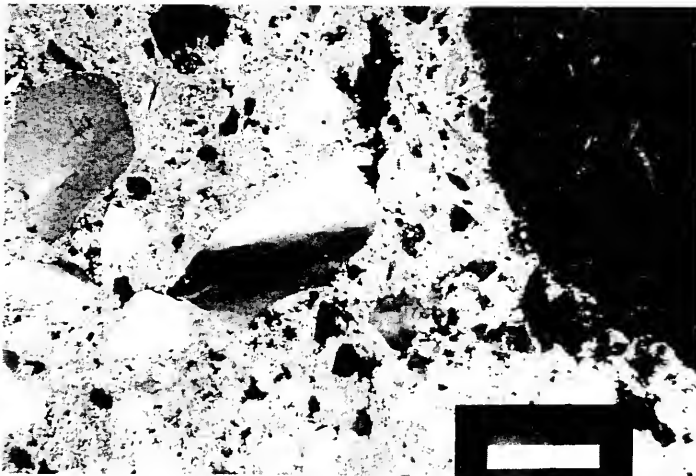


Coarse Aggregate, Quartz, 25x Crossed Polars

PETROGRAPHIC EXAMINATION:



Fine Aggregate, Quartz with triangular Chert grain in center
25x Crossed Polars

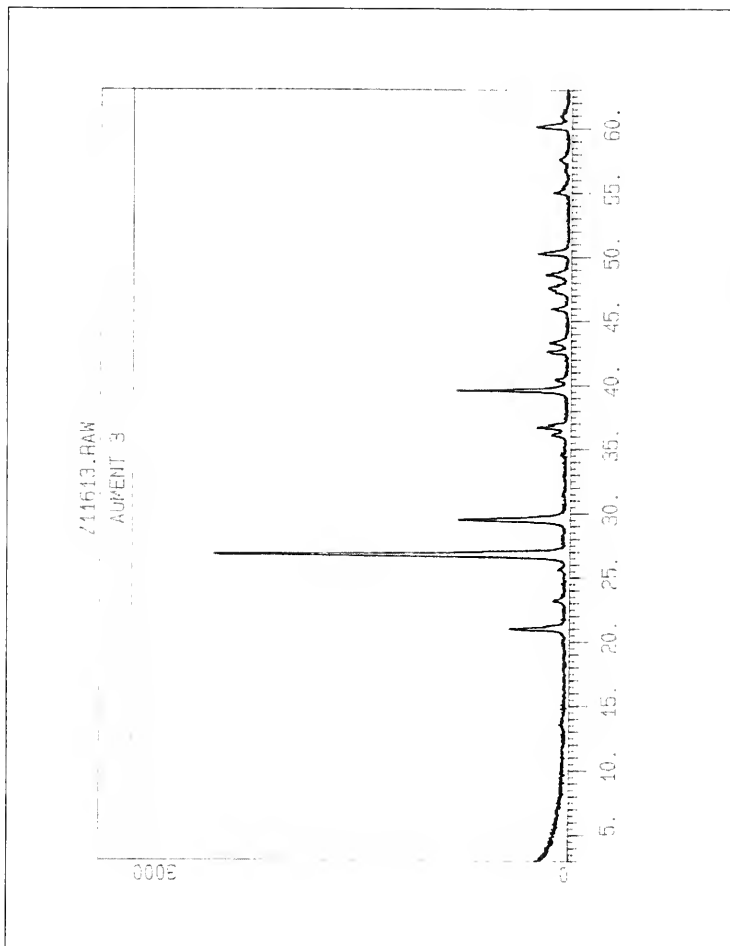


Fine Aggregate, Undulose Extinction in Quartz, Irregular Pores in Matrix
25x Crossed Polars

POWDER XRD:

Quartz, Silicon Oxide (SiO_2)

Calcite, Calcium Carbonate (CaCO_3)



DATE OF CONSTRUCTION: c. 1918

LOCATION:

Main 16th Street Entrance, from top of vaulting at springline



ORIENTATION:

Inner barrel vault over west stairs, protruding aggregate on surface
NOTE: iron reinforcement attached

VISUAL EXAMINATION:**Coarse Aggregate:**

- 0.125 <d< 0.375"
- gravel, sub-angular and rounded, strained quartz- mostly rose and smoky, some black etc., looks naturally weathered not crushed
- evenly distributed, grading of one size
- various angles of aggregate on surface

Fine Aggregate:

- very fine sand visible only under stereoscope

Matrix:

- off-white to pink/orange color
- thin amount of paste between aggregate

Air:

- some large irregular voids

Corrosion products on interior surface, failure of this concrete due to corrosion

Fabric:

- surface is dull
- concrete is weak enough to break with fingers
- no large cracks
- no surface deposits, some insect infestation

STEREOMICROSCOPE EXAMINATION:

BROKEN SURFACE

Coarse Aggregate:

- quartz, smooth surface with fine strain cracks, pitted surface, few flaked surfaces
- uniform within aggregate grain
- some breaking through quartz aggregate along fracture lines
- naturally weathered
- non-porous

Fine Aggregate:

- angular and sub-angular quartz, natural
- evenly distributed through paste, densely packed

Matrix:

- mottled by abundance of fines finely coated with cement paste
- few cracks, especially on surface
- well bonded aggregate and matrix
- no loose aggregate

Voids:

- many small voids, irregular and elliptical voids around aggregate and within matrix
- no difference between void and matrix

STEREOMICRSCOPE EXAMINATION:
BROKEN SURFACE



Elliptical Void in Matrix and Good Aggregate to Matrix Bond

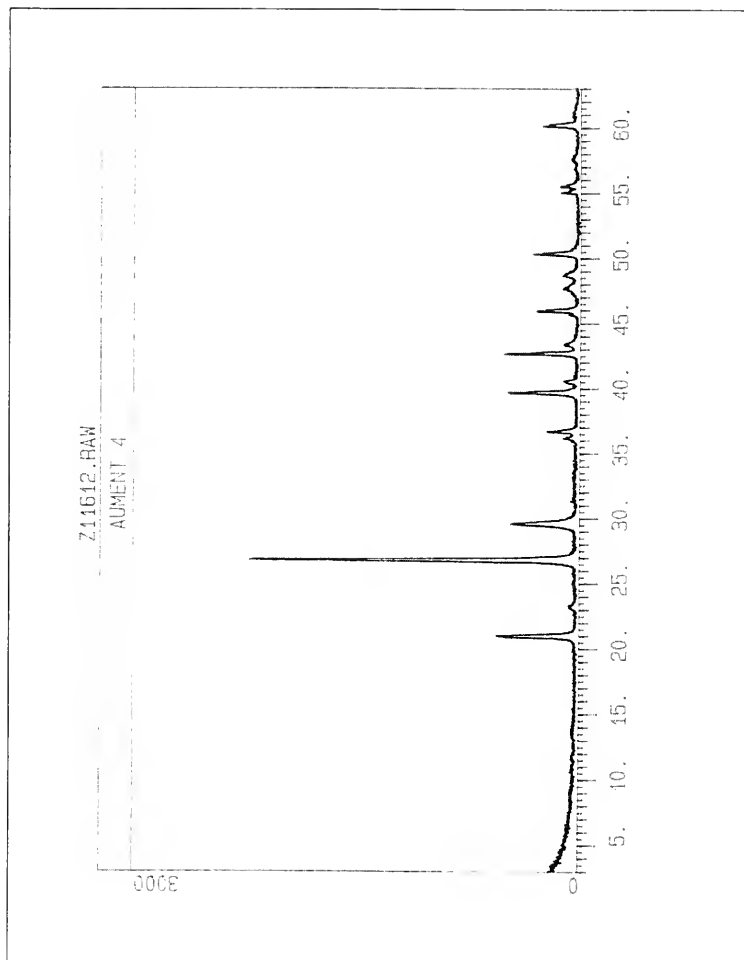


Corrosion Products on Interior Surface

POWDER XRD:

Quartz, Silicon Oxide (SiO_2)

Calcite, Calcium Carbonate (CaCO_3)



DATE OF CONSTRUCTION: c. 1922

LOCATION:

North Wall, west side under iron grille



ORIENTATION:

From area of active spalling, inner section of concrete

VISUAL EXAMINATION:

Coarse Aggregate:

- $\frac{1}{4} < d < 1 \frac{1}{2}$ "
- rounded, strained quartz
- large amount of cement paste between mostly medium to coarse aggregate

Fine Aggregate:

- very fine sand visible only under stereoscope
- quartz, natural (assumed)

Matrix:

- even beige color
- fairly thick paste between aggregates

Air:

- few visible voids
- difficult to discern

No embedded items

Fabric:

- surface is dull
- concrete weak enough to break with fingers
- many fine cracks running through matrix
- cracks filled with dirt & dust particles where exposed to elements, clean on interior surfaces

STEREOMICRSCOPE EXAMINATION:
BROKEN SURFACE

Coarse Aggregate:

- smooth surface with fine strain cracks
- uniform within aggregate grain
- non-porous

Fine Aggregate:

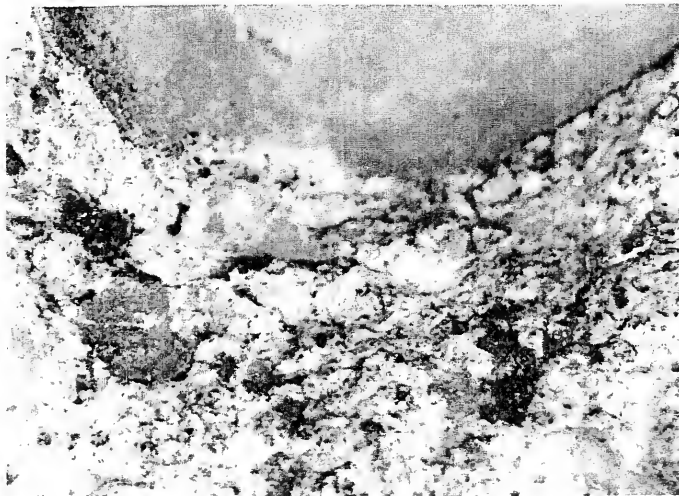
- mostly angular, some rounded quartz
- evenly distributed through paste, densely packed

Matrix:

- white-beige color
- cracks throughout matrix, fractures around aggregate
- half aggregate closely bonded to matrix. half with large gaps between
- missing loose aggregate

Voids:

- small, irregular voids
- few spherical voids



Interior surface

PETROGRAPHIC EXAMINATION:

Photo Scale:

25x Outside Edge=1.25mm

Coarse Aggregate:

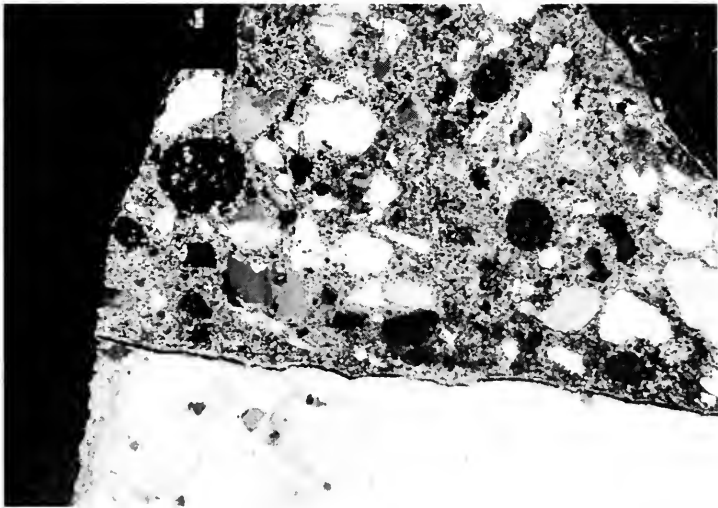
- Quartz, strained under geological pressures, patchwork appearance of grains
- Quartz grains show undulose extinction, sign that rock has been strained

Fine Aggregate:

- Show fractures and stress cracks from crushing
- Muscovite mica flakes

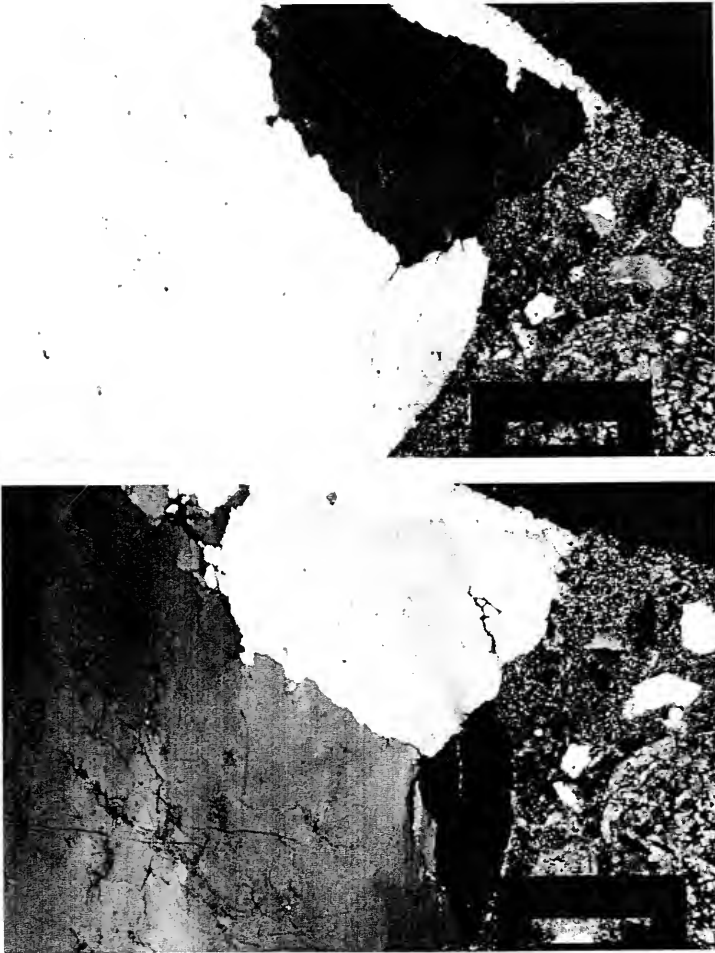
Matrix:

- many fractures through the matrix
- small voids and large irregular voids from poor packing



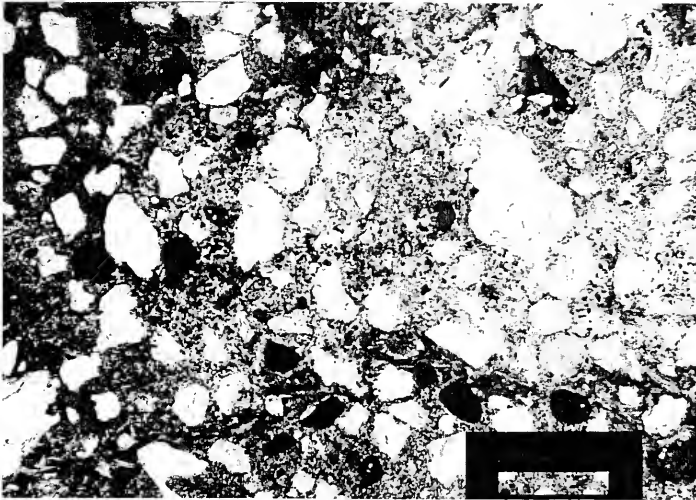
Matrix and aggregate Bond
Orange Muscovite flakes
25x Crossed Polars

PETROGRAPHIC EXAMINATION:

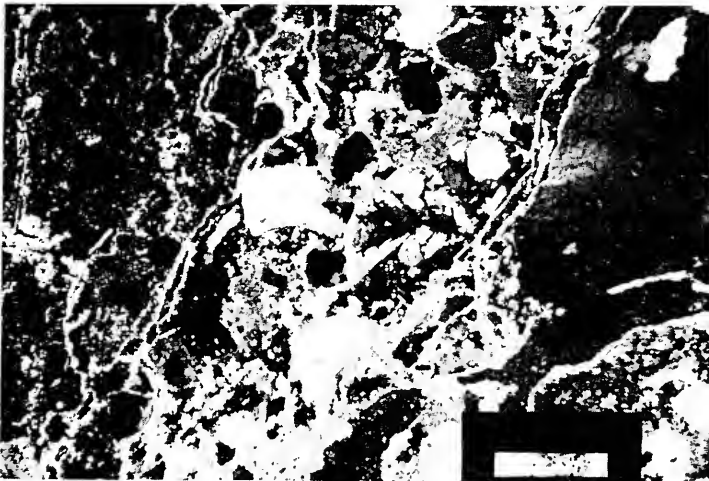


90° Extinction of Quartz
Undulose Extinction of Bottom Left Grain
25x Crossed Polars

PETROGRAPHIC EXAMINATION:



Fine Aggregate Quartz and Pore Structure in Matrix, 25x Transmitted Light

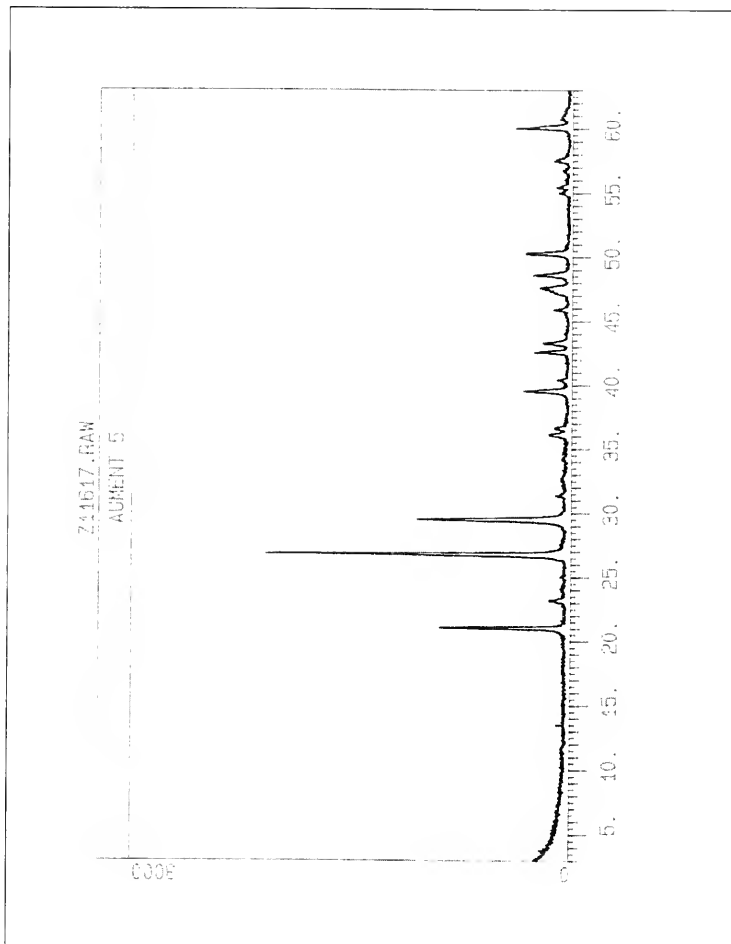


Large Cracks and Breakdown of Matrix, 25x Crossed Polars

POWDER XRD:

Quartz, Silicon Oxide (SiO_2)

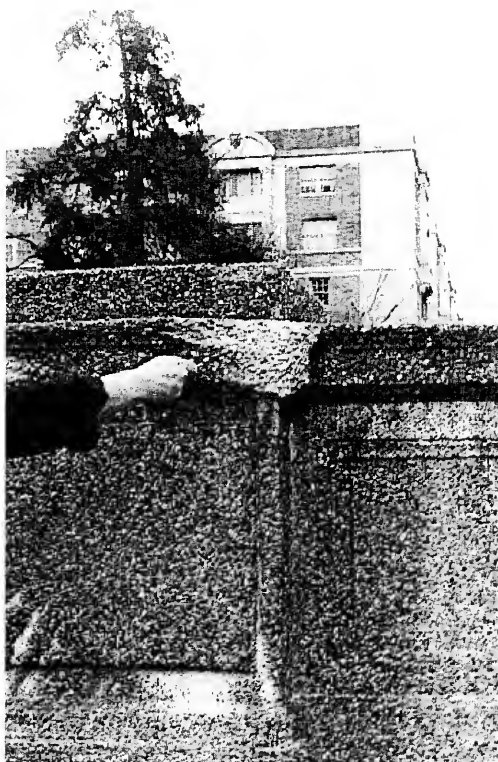
Calcite, Calcium Carbonate (CaCO_3)



DATE OF CONSTRUCTION: 1925-1927

LOCATION:

Lower 16th Street Entrance, top corner of coping, south post at top of steps



ORIENTATION:

From area of active spalling, surface section of concrete, protruding aggregate on surface

VISUAL EXAMINATION:

Coarse Aggregate:

- 0.25 <math>d < 0.625''</math>
- sub-angular, naturally weathered, aggregate found at various angles on surface
- thin ribbon of cement paste between aggregate
- even distribution, good packing of one size

Fine Aggregate:

- sub-angular, quartz, natural
- revealed on surface, capture dirt, loosely bound to surface

Matrix:

- mottled light brown to white

Air:

- few visible voids, fairly dense material
- difficult to discern

No embedded items

Fabric:

- surface is dull
- concrete is not weak enough to break with fingers
- aggregate easily dislodges from matrix, dirt and biological growths well within the cracks between aggregate and paste
- many fine cracks running through matrix
- surface has biological growths and black crusts on surface aggregates

STEREOMICRSCOPE EXAMINATION:

BROKEN SURFACE

Coarse Aggregate:

- sub-angular quartz like aggregate, smooth, fine cracked surfaces, thin layer of dirt, low porosity
- some pitted surfaces, not carbonates, highly porous, round globular growth rather than thin layer of dirt, high porosity
- some fine grained aggregate, no carbonates, irregular pitted surface, small grains within aggregate

Fine Aggregate:

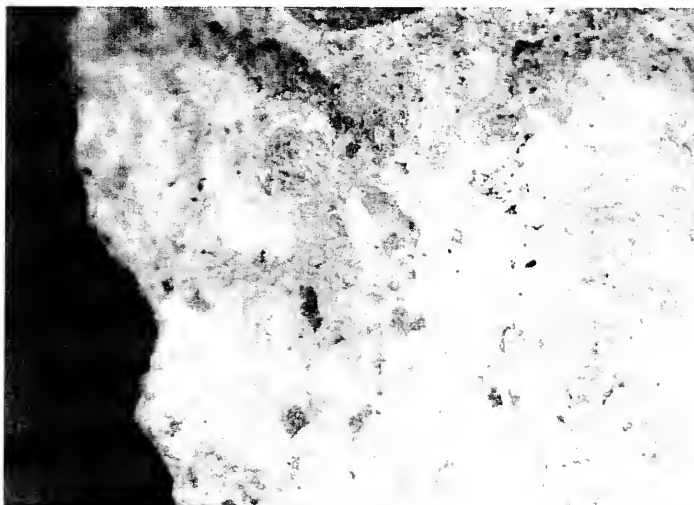
- $0.015 < d < 0.125''$
- mostly sub-angular, some rounded quartz, smooth surface
- evenly distributed through paste, densely packed

Matrix:

- white & off-white with black specks
- cracks throughout matrix, fractures around aggregate
- large gaps between surface aggregate and matrix
- aggregate easily dislodged from paste (samples tended to crumble)

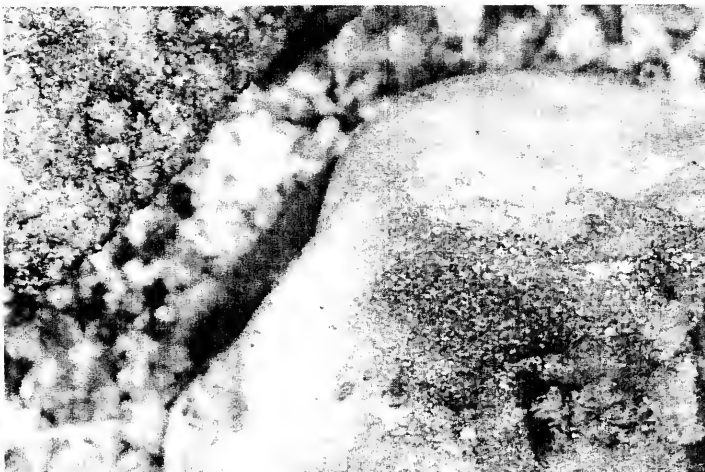
Voids:

- difficult to ascertain, see petrographic exam.



Interior Surface

STEREOMICRSOPE EXAMINATION:
BROKEN SURFACE



Exposed Aggregate Surface with Thin Black Layer on aggregate



Crust Growth on Surface of Pitted Exposed Aggregate

PETROGRAPHIC EXAMINATION:

Photo Scale:

25x Outside Edge=1.25mm

100x Outside Edge=0.33mm

Coarse Aggregate:

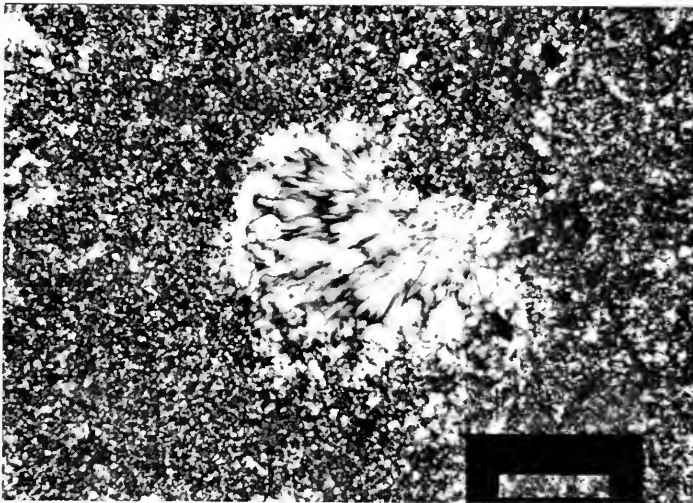
- very fine grained quartz chert
- inclusions of fibrous quartz chalcedony

Fine Aggregate:

- quartz grains with different extinction than other fines, shows black to orange extinction
- also muscovite flakes present

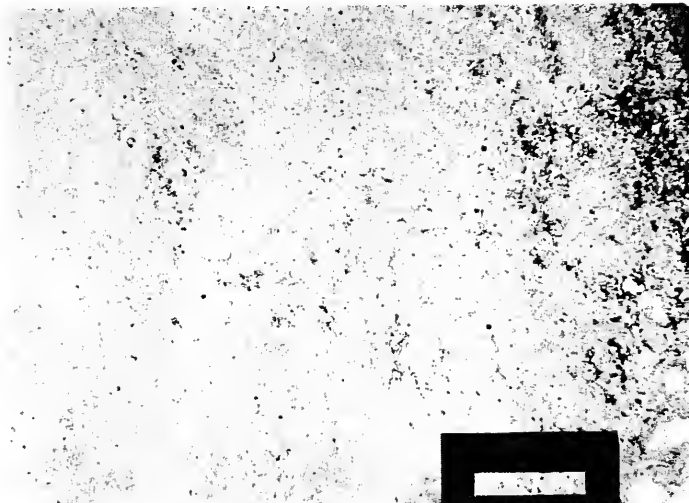
Matrix:

- cracks throughout cement matrix and around aggregate
- small and medium irregular pores

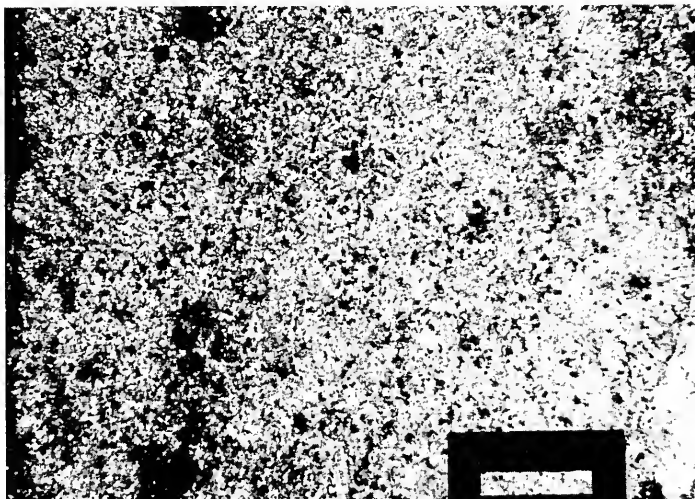


Chalcedony inclusion within fine grained chert aggregate
Note: feathered appearance from extinction of quartz fibers
100x Crossed Polars

PETROGRAPHIC EXAMINATION:

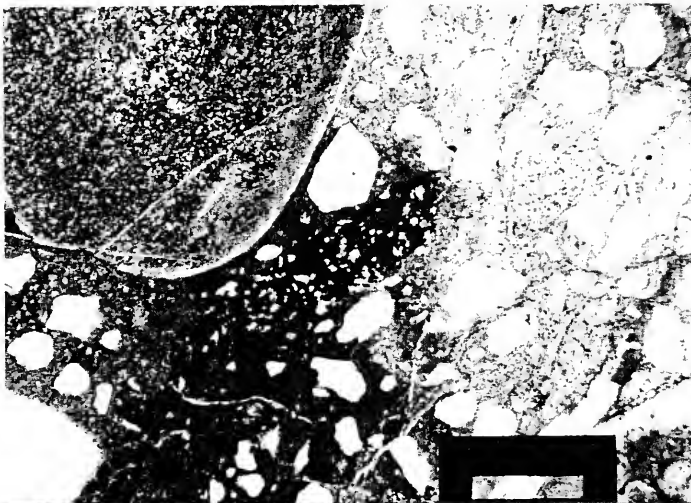


Fine Grained Chert, 100x Transmitted Light

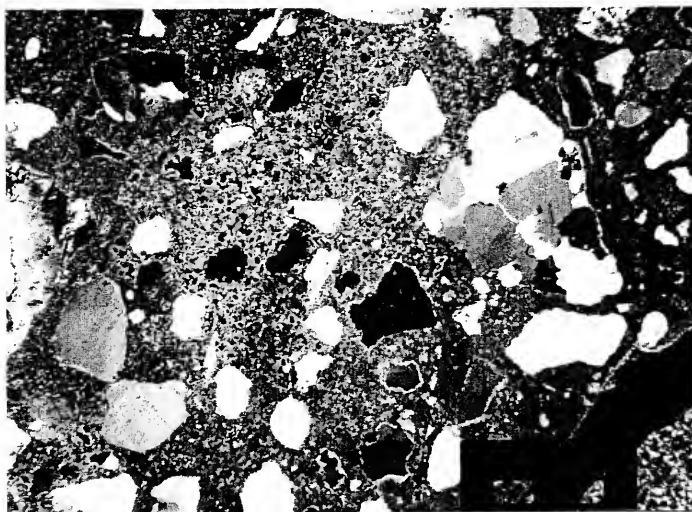


Fine Grained Chert, 100x Crossed Polars

PETROGRAPHIC EXAMINATION:



Matrix with Coarse Chert Aggregate and Fine Quartz Aggregate
Cracks through Matrix, 25x Crossed Polars

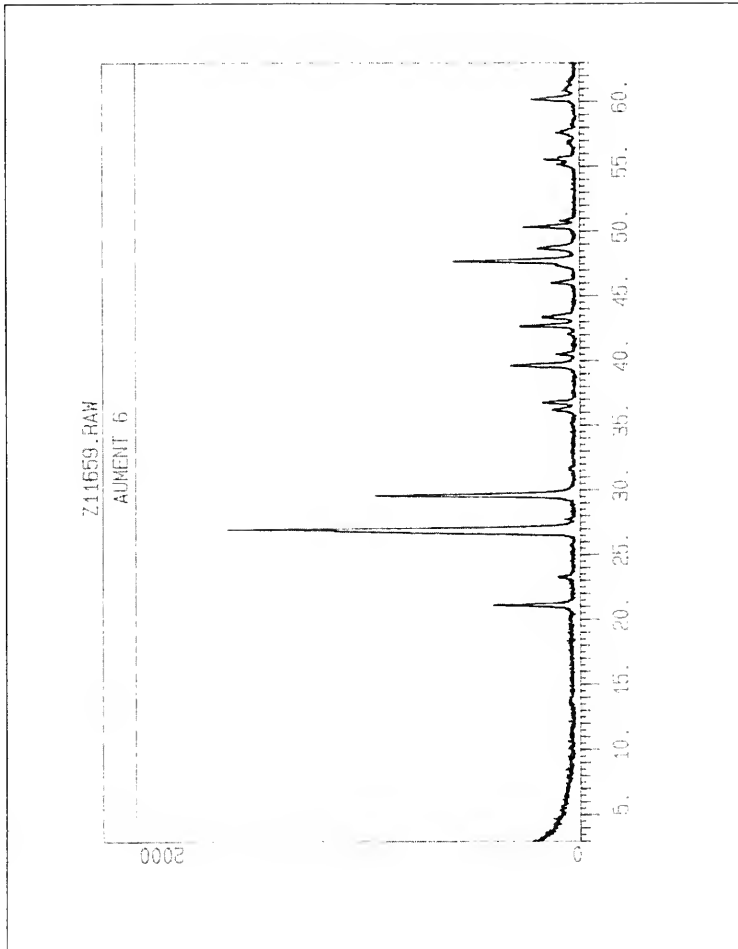


Matrix with Metamorphic Fine Quartz Grains and Muscovite Flakes, , 25x Crossed Polars

POWDER XRD: CEMENT PASTE

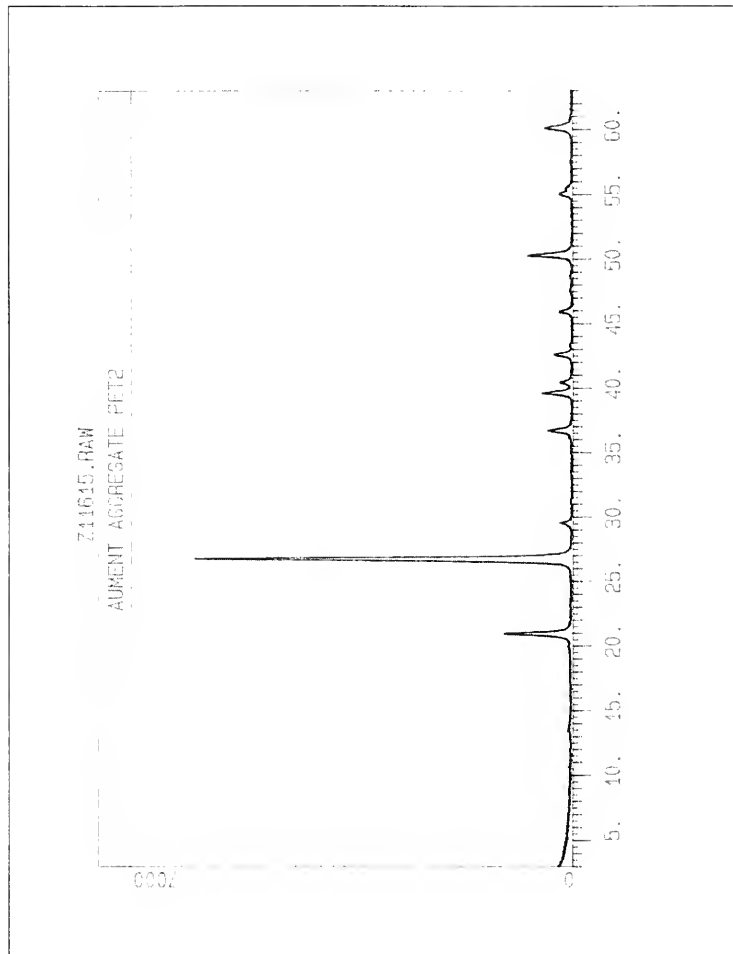
Quartz, Silicon Oxide (SiO₂)

Calcite, Calcium Carbonate (CaCO₃)



POWDER XRD: AGGREGATE FROM PETRO. 2

Quartz, Silicon Oxide (SiO₂)



DATE OF CONSTRUCTION: 1925-27
LOCATION: Lower 16 th Street Entrance, top corner of coping, south post at top of steps See photo of location Sample #6.
ORIENTATION: From area of active spalling, inner section of concrete
VISUAL EXAMINATION: See Sample #6.
STEREOMICRSCOPE EXAMINATION: BROKEN SURFACE See Sample #6.
PETROGRAPHIC EXAMINATION: See Sample #6.
POWDER XRD: See Sample #6.

SAMPLE	LOCATION	OBSERVATIONS	TESTING	
			Chemical Testing	XRD
Eff. 1	Lower 16 th Street entrance, top of south post at top of steps	Fine gray powder on surface of concrete near area of active spalling (location of samples 6 & 7).	Carbonates +++ Phosphates + Sulfates- none Chlorides- none Nitrites- none Nitrates- none	N/A
Eff. 2	West Wall, post between 41E-42E	Gray to white masses forming around cracks in post. Rippled texture indicates formation from continuous water flow.	Carbonates ++ Phosphates- none Sulfates- none Chlorides- none Nitrites- none Nitrates- none	Calcium Carbonate (CaCO ₃) Quartz (SiO ₂)
Eff. 3	West Wall 8W, south joint near base	Gray to white masses forming around joint between wall panels. Form shows accumulation of thin layers of material from continual water flow.	Carbonates +++ Phosphates- none Sulfates- none Chlorides- none Nitrites + Nitrates- none	Calcium Carbonate (CaCO ₃) Quartz (SiO ₂)
Eff. 4	West Wall, base of post between 40W-41W at the joint of post and wall panel	Gray to white masses forming around joint between wall panels. Shows color change from dark gray on interior to white on the surface. Form shows accumulation of thin layers of material from continual water flow. See photo.	Carbonates ++ Phosphates- none Sulfates- none Chlorides- none Nitrites + Nitrates- none	NOTE: see Eff. 3 XRD results
Eff. 5	North Wall, joint of 3N	Gray to white masses forming around joint between wall panels. Shows color change from dark gray on interior to white on the surface. Form shows accumulation of thin layers of material from continual water flow. Stalactite type formation occurring as drips form between rusticated blocks of posts. See photo.	Carbonates ++ Phosphates- none Sulfates- none Chlorides- none Nitrites + Nitrates- none	NOTE: see Eff. 3 XRD results



Multiple Layers of calcreous efflorescence at joints

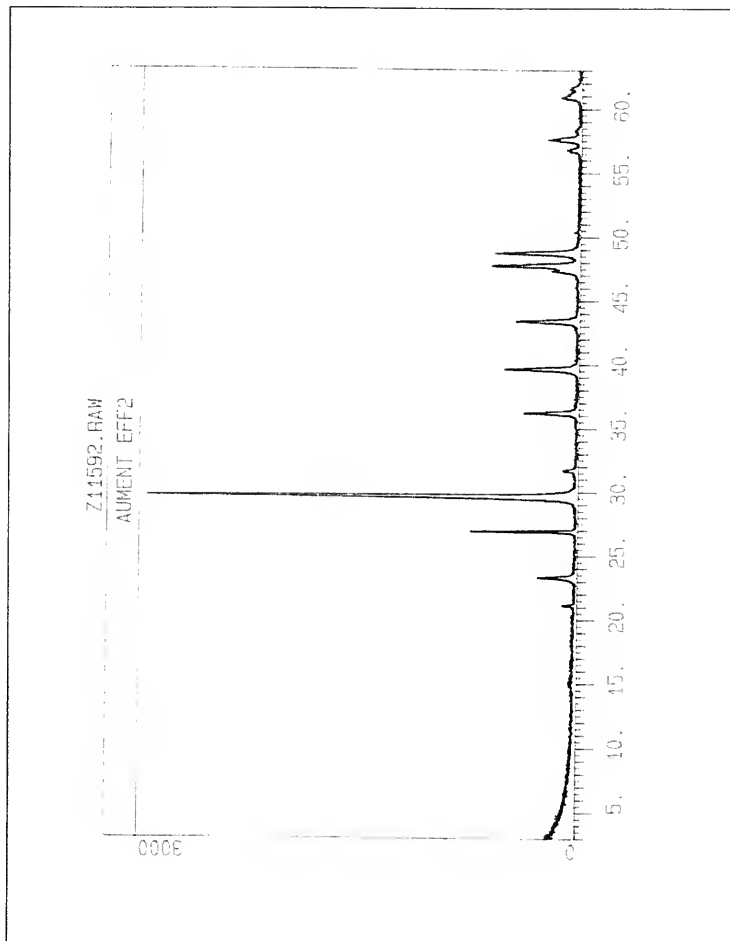


Stalactite formation of calcreous efflorescence at rusticated piers

POWDER XRD

Calcite, Calcium Carbonate (CaCO_3)

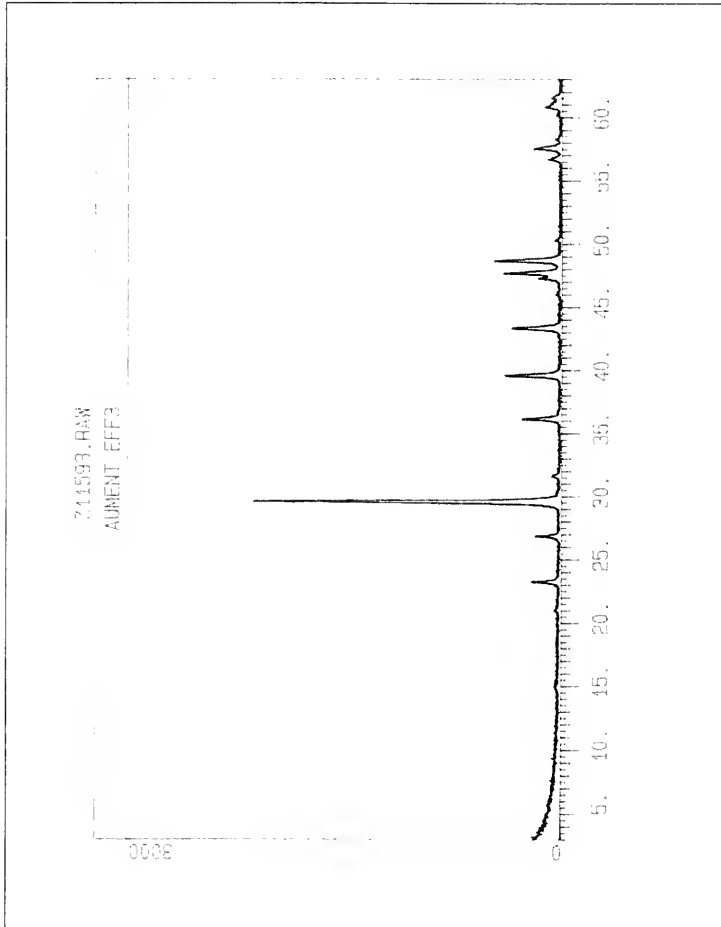
Quartz, Silicon Oxide (SiO_2)



POWDER XRD

Calcite, Calcium Carbonate (CaCO_3)

Quartz, Silicon Oxide (SiO_2)



SAMPLE	LOCATION	OBSERVATIONS	TESTING	
			Chemical Testing	XRD
B.C. 1	West Wall 15W, approx. 18" from top of wall	NOTE: black crusts appear in wavy line only along upper section of West Wall, normally found approx. 18" below the top of the wall unit in the top area of the inner border. Location indicates connection with a failure of the gutter system.	Carbonates- none Phosphates- none Sulfates +++ Chlorides- none Nitrites ± Nitrates ±	Gypsum, Calcium Sulphate (CaSO ₄ •2H ₂ O) Quartz, Silicon Oxide (SiO ₂)
B.C. 2	West Wall 28W, approx. 18" from top of wall	NOTE: See above.	N/A	NOTE: See B.C. 1 XRD results.

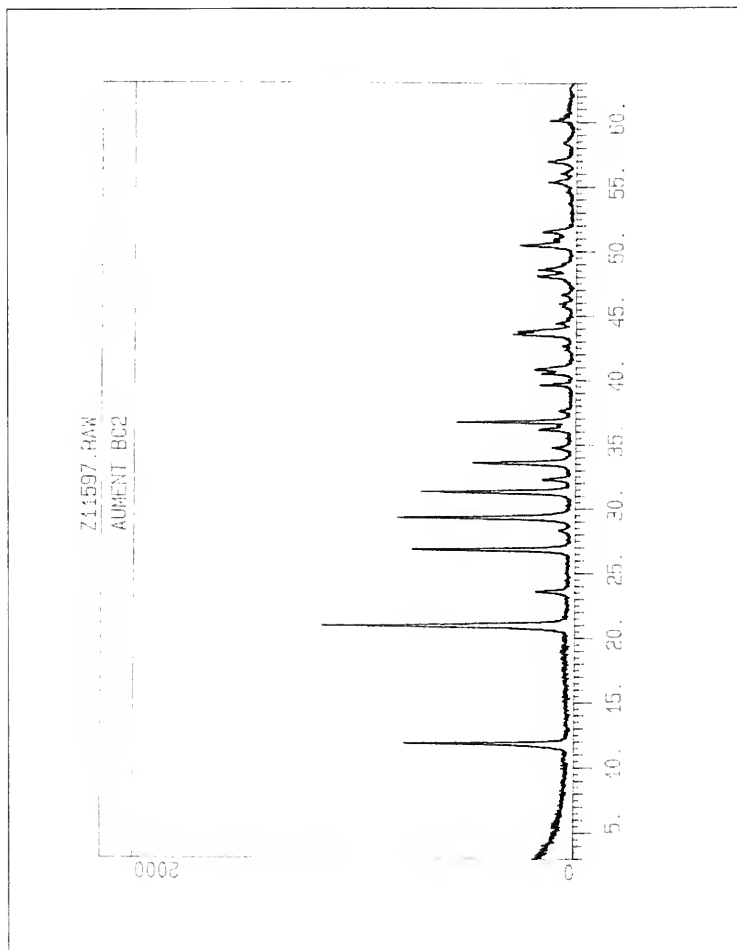


Granular Surface of Gypsum Crust under Stereomicroscope

POWDER XRD

Gypsum, Calcium Sulfate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$)

Quartz, Silicon Oxide (SiO_2)



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