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EARLY STUDIO'S INNOVATIONS CREATE A NEW ARCHITECTURAL MATERIAL

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ABSTRACT

Synopsis: John Earley unveiled the potential for use of exposed aggregate concrete as an architectural finish material. Yet, what John Earley established was not a single architectural finish, but a family of techniques to create a vast range of forms, colors and textures with concrete materials. Using innovations in production methods, he met increasing challenges with breathtaking results.

Keywords: Baha'i Temple; John Earley; exposed aggregate; mosaic concrete; precast

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INTRODUCTION

John Earley unveiled the potential for use of exposed aggregate concrete as an architectural finish material. Yet, what John Earley established was not a single architectural finish, but a family of techniques to create a vast range of forms, colors and textures with concrete materials. Using innovations in production methods, he met increasing challenges with breathtaking results.

ADAPTING TRADITIONAL TECHNIQUES

To produce architectural concrete, John Earley began adapting traditional techniques from other architectural materials. Earley was trained as an architectural sculptor in the studio of his father, James Earley.[1] Upon his father's death in 1906, John took over the studio at the age of twenty-five.[2] The studio worked in materials such as carved stone, clay, lime and gypsum plaster, and cement stucco.

Earley Studio's initial work with concrete drew parallels from historical materials and processes. As architectural sculptors they quickly shifted their plaster based modeling and molding procedures to concrete. Captivated by the idea that a mosaic might be produced in concrete materials, the craftsmen applied their experience with traditional tesserae mosaics to concrete mosaic.[3] The Studio brushed back the mortar to expose the pebbles in this new material that was cast within forms.[4]

Yet they found that concrete had unique properties which required modified techniques.[5] Applying cement-based stucco proved to be very different from the art of gypsum plastering.[6] Methods the Studio routinely used with clay and gypsum based materials were not effective when applied to concrete. Before it hardens, wet concrete lacks the stability found in the gypsum or clay materials. Solids separate. Water bleeds. Voids form. Unattractive castings are the result. After hardening, the surface of the solid concrete is extremely difficult to refine with additional carving or polishing.

EXPLORING A NEW MATERIAL

John Earley approached concrete as a craftsman. Earley's experiments and tests were based upon his craftsman's sense for the materials and their practical behavior during production operations. While attentive to concrete's strength, he was far more concerned with the workability of the mix and with the finished surface where he treated the aggregate as spots of color.[7] While maintaining consistent quality among his finished products, Earley recognized that the procedures for working with this new material must be designed for each application rather than being locked into rigid formulas.[8]

Mr. Earley then explored the special aspects of concrete that called for unprecedented methods. Instead of handling cement stucco as traditional plaster they began to treat it as miniature concrete. The artisans finished concrete by wire brushing the surface and washing it with acid to produce permanently colored surfaces. The Studio also abandoned the traditional formulas for mixing concrete.[9] They changed the sequence for batching the ingredients. They varied the time of mixing.[10] They used only two sizes of aggregate instead of a full range of sizes. They placed the wet concrete as if it was an artist's medium rather than a lumpy mass dumped into a box.[11] Most importantly, they treated concrete very differently during each of its two states – first, as a plastic substance when wet and, next, as a solid material after the time of set

Earley recognized that less force is needed to handle and shape a plastic mass than a solid mass. Less force meant less cost. Earley concluded that economy and adaptability depended upon his ability to manipulate the plastic qualities of this material.[12] He began to change the amount of water within the concrete during its plastic state. "Convinced that 'mixing water' means more to a craftsmen than to an engineer", Earley concentrated his effort on the control of water during the initial hours of the material's life.[13] Earley's production techniques relied upon

mastering this phase of concrete. The same principles were also critical in his methods for cement stucco.14 Earley took full advantage of his "freedom to do anything I might reasonably wish to do with Portland Cement in the first twelve hours after wetting it."[15]

John Earley also investigated concrete's key ingredient, the aggregate particle. He viewed the aggregate in concrete as the skeletal structure that prevented changes in volume, settlement and segregation.[16] He also relied upon the aggregate to determine the final appearance in color and texture.[17]

Earley Studio exploited the material advantages of concrete to optimize visual results while also achieving efficiency in production. The craftsmen applied the aesthetic of mosaic tesserrae to concrete mosaics. Small pieces of stone are cemented together in both materials. Traditional mosaics require breaking innumerable pieces of colored stone into small sizes and then individually placing them into a soft mortar. For concrete mosaics the stone is crushed by machine, then cement and water are added to facilitate casting a mass of the stones into a mold. Rare and beautiful materials are used for both techniques.[18]

The Edison Memorial Tower in Menlo Park, New Jersey provides an example of Earley's artistic blending of aggregates to create a single color, in this case, black. "To the black glass we added two values of black ceramics because one value of black is always monotonous…." Ceramics were added to the black glass so that their matte finish would soften the specular lighting reflected from the broken glass surfaces. In addition, a small number of red glass particles were "included to decorate the surface and make it interesting when seen from near at hand."[19]

Potential aggregates were gathered from natural stones such as marble, granite and quartzes, from the ceramic materials and from the glass enamels.[20] Employing the Munsell system of color identification, Earley identified sources for 200 unique colored aggregates to generate a complete range of hue and value for his mosaic concretes.[21]

ESTABLISHING THE EARLEY PROCESS

John Earley refined a sequence of standard practices for creating architectural concrete. Artisans and craftsmen in Earley's studio worked as a team. The first step was for Leander Weipert, the studio's master sculptor, to create full-scale sketches and then a model in clay. From the clay, studio craftsman made a plaster mold and then a plaster reproduction of the clay model. The back of the plaster was reinforced with jute and two-inch diameter steel pipe.[22]

Another craftsman, "Lindy," used carving tools to finish the curved surfaces of the plaster model to sharpen up its detail and to make the lines of the design as true as possible.[23] Next, finished models were fit together on full–size templates of the building.[24] On the templates they were further sculpted to create a perfect match across the joints.

Each model was used to create a watertight mold of many interlocking plaster parts.[25] If the molds were to be used only once, they were given two coats of orange shellac. But if they were intended for mutiple castings, the molds were completely lined with thin lead, aluminum[26] or metal foil.[27] All of the joints in the metal foil were soldered and filed smooth. Before each cast was made, the molds were cleaned and coated with a release agent.[28] Earley kept his recipe for the release agent a closely guarded secret.

The reinforcing rods that were embedded into the concrete panels had to be prepared like an intricate sculpture. Brass rods were used within delicate elements of statuary. For structural strength, steel rods one-quarter of an inch in diameter were bent to follow the concrete's irregular shape and yet remain exactly one-inch below the surface. The rods were then spot welded together into a rigid cage that would be bolted into the mold.[29] After 1930, the Studio galvanized all of their steel reinforcing.[30]

The Studio knew that the sparkling quality of the finished appearance depended on the precise size and color of the small stones that would be seen in the completed concrete. They were so fussy about getting just the right size and color that no stone supplier would deal with them.[31] So the Studio had railroad cars full of rock delivered directly from the quarry to their Studio. They hand selected rocks for color and quality, then crushed and screened the stones

to the exact sizes they needed[32] – sizes that John Earley never revealed. The Studio made both the aggregate and the sand.33 Before crushing a different color of stone they had to meticulously clean the entire thirty-foot tall crushing operation – every roller, bin, hopper, screen and lift mechanism part.[34]

The sand and aggregate were combined with pure white cement and clean water in small one-bag mixers.[35] After his second patent expired Earley revealed the proportions of cement, sand and aggregate.[36] The casting process required two different mix formulations.[37] The face mix would show in the finished panel. It was made with more water than the backing mix that filled the bulk of the mold.[38] For economy the backing mix often used a less expensive aggregate than the face mix.

The wet concrete was then moved by wheelbarrow and gently hand-placed into the ornate molds. Small scoops and tiny trowels lifted and packed small amounts of concrete in thin layers. Earley's precise two sizes of sand and aggregate gave the concrete far better workability than other sizes. It prevented segregation and bridging of the stones. It provided better flow of the wet concrete. It permitted the craftsmen to fill the most complicated molds.[39] Within two to four hours after placement into the mold, excess water was removed from the wet concrete[40] by vibration and absorption[41] using burlap,[42] newspapers and fine sand.[43]

Within 12 to 20 hours the concrete had stiffened enough to be removed from the mold.[44] In order to expose the dazzling aggregate they scraped the surface with wire brushes that were the size of toothbrushes. On sculpted shapes, they used thin metal scrapers cut to the profile of the design. Many men worked on one piece because the concrete hardened very quickly.[45] They had less than 40 minutes to expose the aggregate on an entire panel. The exposed aggregate was washed with a dilute acid,[46] rinsed and then cured for fourteen days in a humidity-controlled chamber. The finished concrete generally received an additional seven days of air curing before being shipped.[47]

INNOVATING TO MEET NEW CHALLENGES

When new projects pushed Earley Studio beyond the limits of what they had already accomplished, Earley's craftsmen developed fresh innovations.[48] As a plaster and stucco contractor Earley Studio was asked in 1911 to install test panels for the Bureau of Standards to evaluate cement stucco. In 1916 John Earley was asked to prepare all of the samples for a second round of tests and to personally sit on the Committee evaluating the results.[49] Earley experimented and discovered how to control water during critical steps in the process of applying cement stucco. This breakthrough was fundamental to Earley's later development of architectural concrete. Earley continued to work with J. C. Pearson of the Bureau of Standards in a third and fourth series of tests. Defying conventions, Earley and Pearson treated the stucco as a miniature concrete and determined what sizes of aggregate and sand provided the closest packing and the greatest movement of water.[50]

In 1916, Earley Studio created some of the first exposed aggregate concrete in the United States for Meridian Hill Park.[51] The Studio implemented a two-step gap grading of aggregates for a refined appearance.[52] This process was protected by Earley's second patent.[53] After casting the concrete into molds Earley extracted its excess water. This permitted removal of the molds and exposure of the aggregate at the most opportune time.[54] Earley Studio continued to work with contractor Chas. H. Tompkins Co. to complete portions of the Park in later years.[55]

When building the East Potomac Park Field House in 1920, Earley Studio combined cast-in-place concrete, large precast components, thin precast elements and hand-applied stucco to economically create a uniform architectural finish.[56] To eliminate the tedious job of touching up the plaster molds after each casting of concrete, Earley started to use a thin metal lining within the molds to make them more durable. These linings were so effective that all of the column capitals were cast in one set of molds.[57] Earley received his third patent for molds.[58]

Lorado Taft's monumental sculpture for the Fountain of Time presented the Studio with an unprecedented challenge in 1922. The work required a 4,500-piece mold, the largest ever made.[59] To cast the gigantic, 120 foot-long sculpture Earley had to control the water-cement ratio inside a completely closed mold at the time of set. He moved his

method to extract excess water into the mold itself by using an absorptive core. With this innovation the concrete did not shrink away from the mold but hardened with strong sharp relief in the surface details.[60]

During the same year, 1922, Earley introduced polychrome concrete with multi-colored aggregate in concrete mosaics for the Shrine of the Sacred Heart Church. The Studio applied the polychrome mosaics in a wet process on the walls by using squeeze molds to create ridges in the underlying brown coat. The ridges separated different colored concrete mixes placed by the craftsmen.[61] The Studio refined their technique with precast polychrome mosaics by using raised contour lines on the mold's surface to separate the many colors placed during a single casting.[62] Earley Studio also began to incorporate small precast polychrome concrete pieces into larger precast components such as column capitals. John Earley had invented a way to create concrete with colored patterns.

In 1925, Earley Studio implemented production techniques to completely separate the architectural finish from the supporting structural materials. For the Louisiana State University buildings, Earley imported his high quality aggregate and then trained local craftsmen to apply an architectural finish of exposed aggregate stucco on top of a rough masonry structure built by modestly skilled labor.[63]

Earley continued the separation of finish from structure in the Parthenon replica at Nashville, Tennessee in 1925. Once again he imported high quality aggregates and trained local craftsmen to apply exposed aggregate stucco onto masonry surfaces. Earley introduced another new production technique when he used permanent, porous forms of cement stucco on the interior side of the cast-in-place columns and entablature.[64]

By 1927, John Earley had perfected his "adjusted slump and mix" casting method using variable amounts of water in the concrete mixes within a single concrete component.[65] This enabled the concrete to completely fill more intricate shapes in the molds.[66]

The entrance to the Reptile House in the National Zoological Park demonstrates superlative control of concrete mosaics with intricate three-dimensional shapes. In just five years since they invented polychrome concrete for the Shrine of the Sacred Heart, Earley Studio had achieved astounding effects with this new architectural material. Not only were the craftsmen creating fine distinctions between different fields of color, but also within a single field they were combining sands and aggregates of many colors to create subtle variations of hues.

The dome for the Baha'i House of Worship presented both an opportunity and a set of new challenges. In John Earley's words, "The character of the work was such that one major technical development was not sufficient to meet all requirements. Many minor improvements and ingenious devices were also needed."[67] In solving the numerous problems Earley Studio created some of the first architectural precast concrete panels installed on a structural steel framework. The principles and techniques that John Earley and Basil Taylor developed remain sound practices to this day. They provided a gap between the panels for freedom of movement due to thermal expansion and contraction.[68] They used stainless steel connections. They sized the panels for economic efficiency in production, shipping and installation. This was the ultimate separation of the finish from the structure. Yet, to produce the panels in 1930, Earley found that it was necessary to develop greater initial strength in the concrete than they had previously achieved. He did it by increasing the minimum diameter of the sand particles by fifteen-thousandths of an inch. This gave him improved control of the water during the times of placement and set of the concrete. The Studio also had to overcome severe complications due to the intricate geometry and elaborate sculptural ornamentation of the Baha'i Temple. Yet they reached new heights of artistry and created their most elaborate models and molds, continuing to use plaster because of its ability to be freely shaped when wet.[69]

In 1933, the requirements for the polychrome ceilings in the Department of Justice Building presented quite a different problem. None of the Studio's techniques permitted them to place and finish such a large area of polychrome ornamentation within the time required for simultaneous construction of the structural concrete. To solve the problem, Earley invented the use of thin precast, reinforced, polychrome concrete slabs and boxes to serve as the formwork for the structural concrete. The structural concrete was placed after the polychrome elements were installed in their final position on the building. By eliminating the cost of the structural concrete forms and reducing the cost of applying a decorative surface Earley achieved a double savings.[70]

Prefabrication came next with the polychrome houses in 1934. Earley Studio prefabricated thin precast architectural slabs complete with windows, trim and connections.[71] They shipped them to the jobsite on a light truck and then mounted them onto a framework using simple A-frames and chain hoists. This opened up an entirely new use of architectural concrete as thin cladding panels, a generic system of construction that would be adopted around the world. Unfortunately, although John Earley and Basil Taylor had carefully designed the simple system to be within the capabilities of the small homebuilder, the housing industry remained indifferent to its benefits.[72]

As his patents expired, John Earley licensed other contractors and trained them in his techniques to produce precast architectural concrete of the exposed aggregate type. He provided direction to the Dextone Company to build the David W. Taylor ship-model basin in 1936.[73] It was a pivotal project that demonstrated the ability of other craftsmen to apply the refined methods of Earley Studio and create outstanding architectural concrete. Additional contractors followed Dextone's lead and entered the market. Earley's style of architectural concrete was soon available throughout the United States.

SHARING THE DISCOVERIES

While describing completed projects in his published papers, John Earley outlined his innovations and his production techniques. Mr. Earley was an articulate writer who addressed the interest of his audience, but he was also an astute businessman. His articles did not divulge Earley Studio's critical procedures. For example, Earley's patents and papers stated that the aggregate was smaller than 3/8ths of an inch and larger than 1/16th of an inch.[74] While this was true, Earley's process actually required a much narrower range of size for successful results. Earley often reported that the Studio used wire brushing to expose the aggregate,[75] but he never mentioned that only metal scrapers could provide enough control to maintain sharp, crisp arrises on the most complex shapes. Earley also expressed dissatisfaction with retarders as a means to slow the rapid hardening of the cement paste on the surface and claimed not to use them.[76] Yet, Studio records mention that a coating was applied to the form in order to achieve a minimum exposure of the concrete aggregate.[77]

John Earley maintained Earley Studio's unmatched quality and economy as a competitive advantage for more than forty years. The Studio's versatility in production techniques allowed them to take complete advantage of reinforced concrete's characteristics to tackle extreme requirements of form or of color.[78] Earley Studio routinely produced concrete with a compressive strength of more than 5,000 pounds per square inch when structural concrete of 3,000 pounds per square inch was the norm.[79] Estimates of the cost to cover the Baha'i Temple in carved stone were ten times the price of Earley Studio's mosaic concrete.[80] The Studio completed the ceilings in the Department of Justice building at "one fifth of the competitive cost of a reinforced concrete structure finished with conventional mosaics."[81] Earley Studio's bid to fabricate the interior ornamentation of the Baha'i Temple in polychrome concrete mosaic was $12,000 less than the bids for ornamental plaster.[82]

REDISCOVERING EARLEY'S PROCESS

Further insights into John Earley's production techniques have now been gleaned beyond the descriptions in his articles. Technical information has been obtained during restoration projects by investigating original assemblies and analyzing concrete components.

Enough original concrete samples have been acid-digested to determine the specific sizes of the large aggregate and the sand used by the Studio. A variety of metals cast into the concrete for different purposes have been examined; these include expanded wire lath and rods of plain steel, galvanized steel, stainless steel and brass. Forensic investigations have uncovered ingenious methods employed by the Studio to provide installation tolerances without interrupting the visible architectural patterns.

Intricate puzzle-like assemblies have been discovered on the Baha'i House of Worship that combine precast, cast-in-place, and grouted components. Cast-in-place materials were found to lock precast components such as arches into position and to create a seamless finished appearance. Surface joints at corners were made invisible by creating precast pieces with 45-degree beveled edges. These precast elements were set into molds and cast-in-place concrete material completed the 90-degree corner. Precast modillions had steel loops that extended through openings in precast soffit panels so that the modillions' loops could be "stitched" together with steel rods before the interior of the soffit was filled with cast-in-place concrete. In this way only a few critical measurements were required for installation at the jobsite. The precast pieces and molds nested into each other and wet concrete filled the cavities between the components.

At the Parthenon, in a cornice that appears monolithic, Earley combined cast-in-place structural fill, narrow cast-in-place drips, cement stucco, precast polychrome trim and thin colored stucco renderings in order to simplify field construction. Removing a "cap" from the head of a pediment figure explained how the craftsmen filled the hollow core of the statue's precast concrete shell with grout while just inches away from the previously finished surface above. The cap was installed with mortar matching the concrete. A horse's head was also cast as a hollow, thin shell and then filled using grout but no reinforcing steel.

Examinations of original molds, shop drawings, photos of construction and Studio records add to an understanding of Earley's production process.[83] The Parthenon museum's collection includes many original molds. Plaster piece-molds for the pediment statuary are shellacked because they were used only one-time. Plaster column molds are lined with thin lead sheeting required for multiple castings. Intricate piece-molds for the arms of statues were made of plaster and gated in incremental, short sections for no other reason than to let the craftsman use his fingertips and small tools to place and pack the wet concrete into every crevice.

Basil Taylor's shop drawings for the Baha'i Temple convey his strategy for mold making and assembly. Photos of production and installation often reveal the craftsmen's tools and techniques. Photos also provide visible evidence of the characteristics of the wet concrete mixes. Studio records confirm John Earley's published descriptions. The Studio's test reports of their "proprietary" mixes were cloaked in a shield of non-disclosure to their clients. Yet the tests reveal quantitative information that can be translated and then combined with other clues in order to reverse-engineer the concrete mix design. This illuminates some long-kept secrets of the Earley process.

Practical knowledge has been enhanced through interviews with retired craftsmen of Earley Studio. Martin Smith described the crushing process which he operated for twenty-five years and verified the screen sizes. Another craftsman explained concrete placement techniques, the use of metal scrapers to expose the aggregate on the most intricate pieces and the use of concrete itself as another material for molds. Wilbur Creighton, Jr., an engineer who worked on the Parthenon's construction, verified Earley Studio's success at training local plasterers and the use of thin metal scrapers to expose the aggregate.

The experiences of present-day craftsmen restoring Earley Studio projects have also been invaluable. There is no substitute for years of hands-on experience casting, finishing and installing Earley Studio concrete to understand the practical and aesthetic nuances of the material.

BREATHING LIFE AND SPIRIT INTO CONCRETE

Earley Studio's innovations were numerous. John Earley pioneered in the use of aggregates for aesthetic effect by exposing multi-colored ceramics, glasses and natural stones. Precise control of the aggregates' appearance came only through Earley's process of selection by high-grading rock from the quarry, crushing and screening it to exact sizes, and precise mix formulation. Production of modern architectural concrete has required the Studio's innovations in model making, in mold technology, in control of water over time, and in casting with multiple mixtures. The precast architectural concrete industry has been built upon Earley Studio's methods of surface finishing, reinforcing, connections, joints, transportation and installation.

Speaking to the American Concrete Institute in 1938, John Earley must have had a smile on his face and a sparkle in his eyes as he explained that, "When our craftsmen approached the problem of extending a fairly well developed technique for making plastic mosaics to include the making of architectural concrete and wrapping it around a reinforced concrete structure, they enjoyed a freedom which a scientist can hardly understand or approve."[84] With this freedom to manipulate concrete as craftsmen, Earley Studio innovated when they installed architectural concrete. They often combined precast concrete, cast-in-place concrete and hand-placed cement stucco in entirely new ways. The Studio also developed precast concrete shells that were filled after installation, thin precast finished concrete sections used as molds for cast-in-place structural concrete and thin precast concrete panels grouted or cast into place.

Confident in the value of these accomplishments, John Earley said, "Let the Baha'i Temple be admitted to evidence to support my testimony that concrete of the exposed aggregate type is no longer in an experimental state but is ready for use and is an entirely satisfactory architectural medium . . . there is no masonry material with which as much form and color can be expressed as with exposed aggregate concrete . . . it is now time to make an end of unbelief and doubt in concrete as an architectural material."[85]

Each of John Earley's techniques produced high quality finishes. Each technique offered advantages for different situations. Any one technique could be described as inventive. But in their total effect, John Earley's innovations breathed life and spirit into concrete as a modern architectural material.

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[69] Earley, “Architectural Concrete of the Exposed Aggregate Type”: 253-257.

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[72] Earley, John J. “Architectural Concrete Makes Prefabricated Houses Possible”: 519-524.

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[75] Earley, “Architectural Concrete of the Exposed Aggregate Type”: 255; Earley, John J. “Architectural Concrete Makes Prefabricated Houses Possible”: 519; Earley, “Mosaic Ceilings, U.S. Department of Justice Building": 560; and Earley, “On the Work of the Committee on Architectural Concrete”: 597.

[76] Earley, “Architectural Concrete of the Exposed Aggregate Type”: 255.

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[78] Earley, John J. "The President's Address." *Journal of the American Concrete Institute.* Vol. 10, No. 5. (Proceedings Vol. 35) April 1939. : 387.

[79] Avery: 133.

[80] Earley, “Architectural Concrete of the Exposed Aggregate Type”: 275.

[81] Earley, John J. "The President's Address.” : 387.

[82] McDaniel: 78.

[83] Documents, drawings, photos and molds are in the collections of the Baha’i House of Worship, Wilmette, Illinois and the Parthenon Museum, Nashville, Tennessee. Additional documents, drawings and photos are in the collection of the “Frederick W. Cron Papers” at the Georgetown University Archives, Washington, DC.

[84] Earley, “On the Work of the Committee on Architectural Concrete”: 601.

[85] Earley, “Architectural Concrete of the Exposed Aggregate Type”: 258.