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Understanding the "World's Largest" All-Reinforced-Concrete Office Building

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An unrecognized building is determined to play a role in the development of the modern reinforced-concrete frame, begging the question, "Is engineering history 'significant'?"

Every building has an engineering and construction history. Some of these histories may yield important insights about technical innovation, socioeconomics, and, quite literally, the structure of our built environment. However, documenting why these aspects of a building's history make it "significant" as defined by the criteria and evaluation standards of the National Register of Historic Places, administered by the U.S. National Park Service, poses several practical and perhaps even philosophical challenges for preservationists and historians. These issues include difficulties establishing the historical context of building systems for which there is little scholarship, the relative scarcity of archival engineering documents, and the way that the preservation field uses terms related to architectural style and thinks about the transmission of significance through physical materials. These challenges may not be exceptional or unique to buildings with potentially significant engineering or construction history. They may, however, be persistent. If so, they have the potential to influence the way preservationists "construct" significance,[1] limiting not only the scope of history documented by the National Register but also access to the economic benefits available for the redevelopment of some buildings in the National Register, which is defined as "the official list of the Nation's historic places worthy of preservation."

Powerful financial incentives offer compelling reasons to list buildings in the National Register. The history of old buildings is receiving new attention in many U.S. states, which, like Minnesota, have enacted state rehabilitation tax-credit programs within the last five to ten years.[2] When combined with federal rehabilitation tax credits, state-level incentives are encouraging property owners and developers to consider more carefully the economic value of older buildings and the financial feasibility of their preservation and adaptive reuse. Among the first questions they must ask is whether the building is listed in the National Register. If not, is it eligible for listing? Clearly, not all old buildings are historic. But there is good reason, along with strong market pressures, to bring new approaches, sophisticated research techniques, and creative arguments to the assessment of historical significance, which is the basis of National Register listing and, in turn, accessibility to historic tax credits. In some cases, engineering and construction history offers new perspectives on the evaluation of significance.

This article begins by introducing the Plymouth Building, a 12-story skyscraper in downtown Minneapolis built in 1909 and 1910. Its owner contracted Preservation Design Works (PVN) to evaluate the building's history in the interest of taking advantage of state and federal tax credits available for the rehabilitation of income-producing buildings listed in the National Register. The first section of the paper explains how the preliminary building history and physical details were gleaned from primary, archival source materials, such as old newspaper articles, original construction drawings, and historic photographs. The next section presents an assessment of the Plymouth Building and the evidence for significance that was established based on both primary and secondary sources. The research methods are then described, using the Plymouth Building as a case study to illustrate widespread impediments to documenting construction and engineering details and evaluating their significance within a broader context of engineering and construction history. The conclusion proposes a range of coordinated strategies which, in time, may mitigate the research challenges Preservation Design Works encountered with the Plymouth Building. These suggestions include digitizing the National Register and making nominations entirely word searchable in order to facilitate research about engineering, encouraging study of engineering and construction history as part of professional engineering pedagogy, and evaluating engineering significance with newer theoretical frameworks increasingly used to understand the history of architecture and technology.

The "Historic" Plymouth Building

The Plymouth Building was named for its first anchor tenant, the Plymouth Clothing Company. Established in 1880, the company had become one of Minneapolis' largest retailers by the time its new flagship store was finished in 1910; the clothing store, known for "new styles, large sales, small profits," occupied the entire first and basement floors of "the largest and most elaborate office building in the Northwest."[3] Upper floors were filled with offices leased by individual tenants ranging from realtors to a small local law school. Its leasing agents had no difficulty finding tenants for the space, given the rapid growth of Minneapolis at the turn of the twentieth century.[4] Between 1900 and 1910 the city's population increased from 202,718 to 301,408 residents.[5]

Likewise, reinforced-concrete construction in America saw a period of immense growth and change in the two decades leading up to the construction of the Plymouth Building. Numerous new patents, technologies, innovations, and entrepreneurs entered the market. During this transitional period, concrete construction evolved from experimental designs and proprietary products to a codified engineering specialty that was practiced by design and construction companies with expanding managerial sophistication and geographic range.[6] Designed and built amid intense growth and change, the Plymouth Building is an excellent case study to contemplate the relative significance of construction technologies and processes in a time of flux.

Accounts of construction activity found in old newspapers are well-known sources of information that may form the basis for understanding historical significance, but they can sometimes also be inaccurate and should therefore be corroborated by on-site examination of the building whenever possible. Such was the case with the Plymouth Building. A newspaper article that announced the beginning of construction and pondered "The Romance of Modern and Ancient Concrete" attributed the building's engineering design to the local Minneapolis-based engineer Claude Allen Porter (C. A. P.) Turner, who is now widely recognized as a pioneer of reinforced-concrete construction.[7] The Plymouth would not have been among the first examples of Turner's innovative Mushroom System, a four-way reinforced-concrete flat-slab structural floor system; it would have been merely one of many of that engineer's buildings located throughout the Twin Cities of Minneapolis and St. Paul, earlier examples of which were already listed in the National Register. And while it was admittedly large, or even the largest office building in the Twin Cities, as local newspapers enthusiastically reported at the time of its construction,[8] size alone seemed an insufficient basis for historical significance. More importantly, the building did not have the characteristic flared column capitals and girderless floor system that Turner made famous. Rather, a walk through the building reveals predominantly square columns and a regular grid of girders cast integrally with the two-way floor slab. The mismatch between early reporting and the physical structure of the building raised additional questions about the history of the building and its historical significance.

Preliminary research for this project suggested that the Plymouth Building might represent an important transition in the development of the reinforced-concrete frame and was potentially noteworthy in part because it was designed and constructed under the supervision of an engineer other than Turner. The investigation was facilitated by the existence of an unusually large amount of privately held archival information. Despite its more-than-hundred-year history, the Plymouth Building has had only two owners. Many of the early building documents, which are so commonly lost, misplaced, or discarded, were passed on to the current owner; they included a partial set of reproductions of the original architectural drawings, extensive photographs of the original construction and later remodeling projects, and the daily construction log. The log recorded such detailed information as the participation of different trades, quantities of materials, weather conditions, and the names of project-management personnel. Dated photographs illustrate the construction sequence and steel-reinforcement details, many of which were executed in wintry conditions. Excavation began in December 1909, with the first concrete poured in cold weather on February 7, 1910. Construction of the building was largely completed by October 25, 1910.

Four Questions

Combined with the more narrative descriptions of engineering, labor, and construction processes offered by historic newspaper accounts, these primary sources provided tantalizing leads to pursue a more complete history of the building. The research revealed that the Plymouth Building was engineered not by C. A. P. Turner but rather by the John M. Ewen Company of Chicago, Illinois, for New York investor John E. Andrus, with Minneapolis-based Long, Lamoreaux and Long as the architectural firm of record. All steel reinforcement for the concrete was a product called the "M/B Special Open Hearth Bar," which was produced by the William B. Hough Company, also based in Chicago. Rising 12 stories above grade, the building reached the maximum height permissible in Minneapolis at the time of construction. The building has a basement and subbasement; the footings extend to the limestone bedrock, approximately 35 feet below grade. The building had a skeleton frame, with a masonry exterior.[9] Beams and columns are reinforced to be continuous, and the floors consist of approximately square, two-way reinforced slabs spanning to beams.[10] The regular grid of girders is integral with the concrete slab; the elevation of the top of the girders is the same as the top of the concrete slabs, but the lower portion of the girders is visible from below. Footings and foundation walls are also constructed of reinforced concrete.

The archival documents were in themselves insufficient to explain how or why the Plymouth might be significant, but they did raise questions about the building's history that merited additional research. Four questions about the Plymouth Building seemed salient and most likely to yield historically significant insights:

- Was the concrete frame intended as a skeleton frame resisting both vertical and lateral loads, or was it yet another incremental and inadvertent step towards more modern concrete detailing?
- Were the twisted M/B Bars used to reinforce the concrete innovative?
- Who was John M. Ewen, and why was his Chicago-based engineering and construction company selected to build in Minneapolis when other well-known local alternatives, like C. A. P. Turner, were available?
- When did cold-weather concreting become a general practice within the construction industry, and what methods ultimately led to its acceptance?

Assessing Significance

These four questions were motivated by a need to situate the site-specific details of the Plymouth Building's construction within a broader historical narrative and comparative framework of engineering, technology, and the building arts. According to the U.S. National Park Service (NPS), "To qualify for the National Register, a property must be significant; that is, it must represent a significant part of the history, architecture, archeology, engineering, or culture of an area, and it must have the characteristics that make it a good representative of properties associated with that aspect of the past." NPS guidance goes on to explain that significance must be evaluated within an appropriate context, meaning "those patterns or trends in history by which a specific occurrence, property, or site is understood and its meaning (and ultimately its significance) within history…is made clear."[11]

Fig. 1. William B. Hough Company advertisement for "M/B Special Open Hearth Bars," December 1911. The Plymouth Building is proclaimed as the "world's largest all-reinforced concrete office building." From *Cement Age* 13 (December 1911): 29, digitized by Google Books.

The investigation of significance and context began with a very straightforward strategy: a Google search. Entering "'Plymouth Building,' Minneapolis" in Google Books returned a provocative bit of evidence — an advertisement for the M/B Special Open Hearth Bar in a 1911 issue of the industry journal *Cement Age* (Fig. 1). The advertisement celebrated the product's use in the recently constructed Plymouth Building, which, it claimed, was the "world's largest all-reinforced concrete office building."[12] Tempting as it was to accept this unsubstantiated assertion as fact, anyone familiar with advertisements of the early twentieth century, from "cure-all" patent medicines to building products, knows that such claims must be taken with a healthy dose of skepticism. Nevertheless, local newspaper accounts and

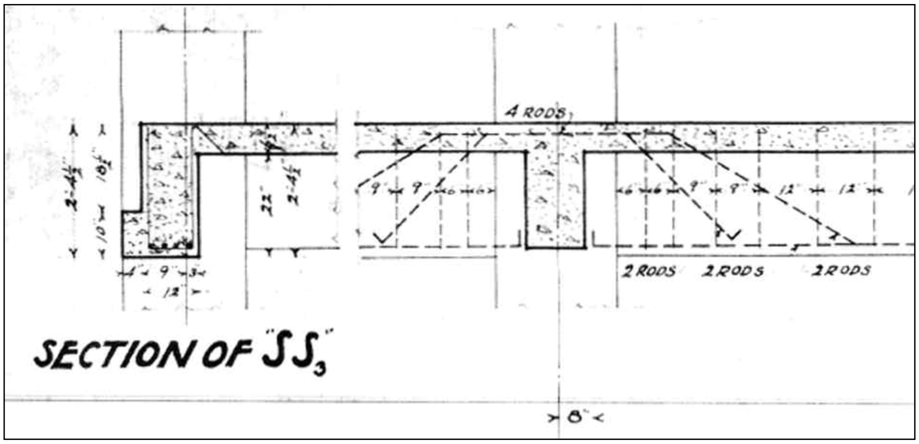

Fig. 2. Concrete-beam reinforcing, Plymouth Building, Minneapolis, Minnesota. The drawing, dated April 25, 1910, shows typical beam reinforcing with a spandrel beam condition at the left. The spandrel beam is concealed by masonry veneer at the primary facades and exposed at the secondary facades. A concrete shelf is provided to accommodate one wythe of masonry, with additional wythes placed on top of the beam and inset from the face of the building. Courtesy of Meyer Borgman Johnson, Minneapolis.

a national advertisement were suggesting that the building's construction was unique for its time.

Structural Frame

More useful, and arguably more defensible, sources of information were found in the small but slowly growing body of secondary literature about construction history. Notable contributions include books by Peter Collins, Carl Condit, Reyner Banham, Donald Friedman, Amy Slaton, Andrew Saint, and Adrian Forty.[13] The limited yet relevant literature was reviewed in search of answers to the four questions that could form the basis for the significance of the Plymouth Building, if placed within an appropriate historical context. The first question considered the structural frame. Frame systems are generally defined as structural members that act together to resist both lateral and vertical loads.[14] The emergence and refinement of the reinforced-concrete skeleton frame is relatively understudied compared to the development of iron framing; the development of the structural-steel skeleton frame preceded the concrete frame and is usually presented as a key component of the invention of the skyscraper.[15]

While several sources describe and assess the significance of reinforced-concrete beam-and-column systems similar to the one used in the Plymouth Building, none identify the structural design intention or capacity of the system to act like a frame. For example, Carl Condit's review of the Ingalls Building in Cincinnati provides a concise history of reinforced concrete to 1903, highlighting the contributions of Ernest Ransome in particular. However, the article notes that the contribution of the frame to the lateral resistance of the building is unclear, both at the time of its construction, when the architect referred to the structure as a concrete box, as well as today.[16] In *A Concrete Atlantis* Reyner Banham describes the rise of the daylight factory as a building type that inspired Modernist architects, rather than as a structural system significant to construction history.[17] While exterior spandrel beams allowed for the use of non-load-bearing exterior masonry walls in daylight factories, the design of a concrete frame is not discussed, and possibly not intended, as part of the lateral-force-resisting system of the buildings. In contrast, the frame of the Plymouth Building appears to be designed as a system to resist lateral force. The engineering design is illustrated in the drawings.[18] Relevant details include the use of continuous beam and column reinforcing, large window openings on the exterior, lack of a designed shear-transfer mechanism at the exterior brick-masonry and interior clay-tile partitions, uniform thickness of exterior masonry walls, and the absence of any concrete walls above grade, even at the elevator and stair cores.[19]

Building upon the primary and archival sources, secondary sources were used to construct a context, a timeline, and an argument for the building's significance using the four areas of exploration as a framework: development of the reinforced-concrete frame, evolution of steel reinforcement and concrete-steel bond theories, adaptation of concrete-building delivery models, and the arrival of successful cold-weather concreting. It became clear that the Plymouth Building was not the biggest, best, tallest, or longest engineering landmark.[20] An attempt to assess the magnitude and significance of the size of the Plymouth Building in relation to other concrete contemporaries proved basically futile. Could the Plymouth have been the world's largest all-reinforced concrete office building? Based on national trends documented by Condit and Friedman, it is possible but likely also impossible to prove. More importantly, even if it had definitively been the largest, it was not clear that size mattered in the context of reinforced-concrete building development. Superlative size made for good advertising but arguably contributed little to an understanding of the building's place in history. More conclusive and meaningful was the fact that its structural system was distinct from its documented predecessors: its concrete frame appears to have been designed with the intent to resist both lateral and vertical loads. Rather than a definitive "-est," the Plymouth Building embodies advancements in several aspects of concrete-engineering knowledge and building practice, including the concrete skeleton frame, use of deformed reinforcing steel, an integrated contractor-engineering delivery, and cold-weather concreting. The Plymouth Building thus represents an important step in the development of modern reinforced-concrete engineering and design.

Plans and construction photographs revealed that a key feature of the Plymouth's structural frame was a spandrel beam built integrally into the exterior edge of the floor slab (Fig. 2). All exterior walls of the building are supported at each floor level by the spandrel beams, allowing for the use of non-load-bearing masonry infill walls and larger

Fig. 3. Plymouth Building, October 25, 1910. Decorative features of the original primary facades included rusticated terra-cotta pavilions, red brick walls laid in Flemish bond with molded-brick window sills, and a twelfth-story richly ornamented with terra-cotta cartouches, consoles, dentils, and projecting cornice, all topped by a terra-cotta balustrade. Courtesy of Northwest Architectural Archives, University of Minnesota Libraries, Minneapolis, Collection N69, Box 322—Larsen & McLaren.

Fig. 4. Plymouth Building, 1936. The photograph shows the primary facades after their "modernization." The facades appear essentially unchanged today. Courtesy of Northwest Architectural Archives, University of Minnesota Libraries, Minneapolis, Collection N69, Box 322—Larsen & McLaren.

window openings. An important distinction of the building's concrete structure compared to that of many of its predecessors was detailing that ensured that the frame could support both vertical loads due to gravity and lateral loads from wind without relying on the exterior masonry walls. Use of a reinforced-concrete skeleton-frame structural system also made it possible to dramatically alter the facade as owners of the building sought to adapt to changing architectural styles. A forward-looking *Minneapolis Tribune* article published in 1910 alluded to both the novelty and the utility of this design, noting that "The frame of the building is built separate and distinct from the outside shell. The frame therefore will be good for centuries and could not be demolished except at fabulous expense. The outside, however, can be redressed time and again; just husked like corn every century or two, and a new exterior added."[21]

When completed in 1910, the primary facades of the Plymouth followed a Beaux-Arts style popular at that time (Fig. 3). In 1936 the Twin Cities-based architectural firm of Larson and McLaren redesigned its two primary facades in a restrained neoclassical style, sometimes referred to as "Starved Classicism."[22] During this renovation a large portion of the facade was removed and replaced. Essentially, the facades were modernized by stripping off the lighter-colored terra cotta and brick details at the base and top story, as well as on the pavilions at the ends and at the beveled corner of the two primary facades; cornices and belt courses were also simplified, generally flattening the wall surfaces to achieve a more two-dimensional appearance (Fig. 4). Approximately one-third of the exterior masonry bays were removed and replaced. A 1936 newspaper article describing the recladding noted that because the Plymouth had "incorporated many designs and structural features in buildings of more recent construction, the modernizing of the building necessitates fewer changes than might otherwise be necessary."[23]

Concrete Reinforcement

The use of the twisted steel M/B Bars for reinforcement was also an indication that the Plymouth Building was more demonstrative of national trends than of the local concrete building techniques influenced by Turner, which favored smooth reinforcing bars (Fig. 5). Publications about steel reinforcement of concrete, such as the Concrete Reinforcing Steel Institute's *Evaluation*

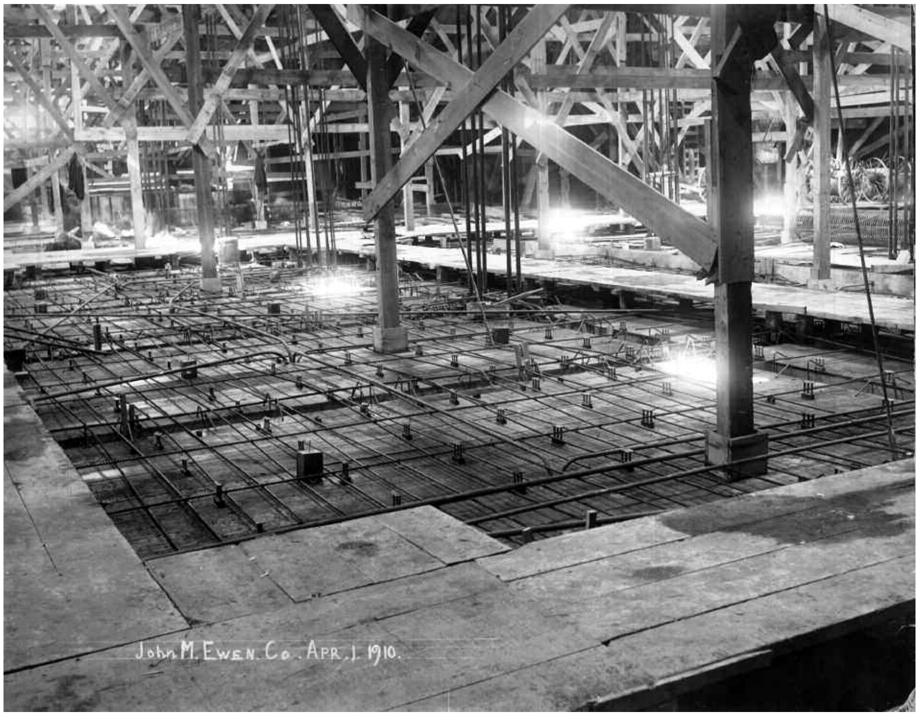

Fig. 5. M/B Bar twisted square-steel bar reinforcement, Plymouth Building, April 1, 1910. The photograph of the slab construction was taken at an atypical one-way slab near the elevator opening. Typical floor slabs had the same size and spacing of steel reinforcement in both directions. Courtesy of Historic Plymouth Building, LLC.

of Reinforcing Steel Systems in Old Reinforced Concrete Structures, and writings by proponents of other reinforcement systems from the time when the Plymouth Building was constructed (such as Ernest Ransome and C. A. P. Turner) helped to situate the Plymouth Building's M/B Bars within a broader context of early concrete reinforcement.

While M/B Bars were a brand-name product, they were just one of many twisted "Ransome style" bars available at that time.[24] Documenting types, or even brands, of reinforcement used in construction is difficult today, much less in structures that are contemporary with the Plymouth Building. However, the use of the M/B Bars was prescient of the eventual acceptance of the relationship of deformed (i.e., twisted or textured) steel reinforcement and adhesion with concrete by the American Concrete Institute in 1919, as Ransome promoted.[25] It was a clear departure from accepted contemporary local practice of smooth round bars, as Turner strongly advocated.[26] Ransome argued, and proved through testing, that deformed reinforcement achieved greater adhesion with concrete compared to smooth reinforcement, resulting in greater strength of the overall reinforced-concrete system. This type of twisted reinforcement, often referred to as the "Ransome System," eventually gained widespread use nationally.[27]

Delivery Method

John M. Ewen's involvement in the project can in part be understood in the context of professional realignments that led to the consolidation of some formerly separate sectors of the building industry in the early decades of the twentieth century. Historian Amy Slaton describes three methods used historically to construct reinforced-concrete factory buildings. The first method required building owners to employ their own forces for all construction work, enlisting an engineer or architect to create plans and engaging subcontractors for specialized work. The second option involved the owner's soliciting plans and specifications for a building from an engineering firm, then submitting them to general contractors for bids. The third option was to hire firms that offered both contracting and engineering as integrated services, an approach that began to gain national acceptance around 1910.[28]

The expertise offered by in-house engineers familiar with reinforced-concrete construction, the third option, resulted in increased economy through efficient design, as well as higher "quality of services" by controlling variables through enhanced managerial sophistication.[29] This advantage may have been recognized by the developer of the Plymouth Building and may help to explain why he selected a firm from Chicago. The John M. Ewen Company advertised as engineers and builders (Fig. 6).[30] There were a number of competent local concrete contractors in Minneapolis at the time of the Plymouth Building's construction, including C. F. Haglin, James Leck & Company, and J. L. Robinson, among others, but they advertised only as contractors and builders.[31] In addition to integrating engineering and construction, Ewen was also known for having developed an innovative method for simultaneously excavating and constructing subgrade foundations and structures, which, based on newspaper reports, appears to have been utilized in the construction of the Plymouth Building.[32] He described his method as "leaving the earth unexcavated until such time as the super-structure is well along, the exact reverse of the present method."[33] The arrival of an outside engineer and contractor in a local market substantiated the position of the Plymouth Building as demonstrative of national trends.

Cold-Weather Concreting

The Plymouth Building is also a well-documented early example of cold-weather concreting, which Slaton asserts was not possible in the United States prior to 1910.[34] Historic construction photographs and the foreman's log indicate that laborers began pouring concrete for the Plymouth Building's massive foundations on February 7, 1910, when temperatures were well below freezing. Workers continued to mix and pour concrete in the weeks that followed, as temperatures dropped to a low of 2°F on February 16 and 17. Earlier concrete construction in the United States had been

Fig. 6. Construction of the exterior masonry walls, Plymouth Building, September 12, 1910. The John M. Ewen Company advertised as "Engineers and Builders." A billboard advertised "Lower Floors Are Open For Business." Courtesy of Historic Plymouth Building, LLC.

limited to months when temperatures were above freezing. While working in warm weather was a practical solution, it tended to increase the cost of concrete construction due to labor demands in warmer months, thus delaying national acceptance of the material for the structure of tall office buildings.

Early articles promoted the use of salts in the concrete mix to prevent freezing of the water during curing, which even Ransome supported.[35] Another method of casting concrete in below-freezing weather involves the heating of the concrete materials: aggregate, sand, cement, and water. A Portland Cement Association handbook, *Cold Weather Concreting* (1916), describes the use of tubes and stoves to heat the concrete materials and then the poured structure during curing.[36] On February 10, 1910, the Plymouth's Building's foreman noted in his log that "smoke caused by fire in the tubes with which we heat the concrete materials, has been leaking out at the edge of the roof…annoying the chinamen" who operated a chop-suey restaurant adjacent to the work site (Fig. 7).[37]

Persistent Research Challenges

Efforts to situate the Plymouth Building within a historical context of local, state, or national concrete-construction technologies, typologies, and processes were complicated by several factors, none of which was unique to this case study. Rather, the history of engineering is in some ways arguably more difficult to research than architectural histories that are based on associations with notable architects or exemplary styles. There is a relative paucity of information about engineers and their associated designs and construction methods compared to the types of records documenting the relationships between architects and their clients. There is a wide range of reasons why this is true.

First, there are pragmatic motives and practical difficulties. While architectural drawings of notable buildings and structures are often saved in libraries and archives as much for their visual beauty as for the information they may convey, engineering drawings were typically destroyed. Insurance and liability considerations led to the common practice of shredding engineering records after the "statute of repose" had expired, a trend that continues today.[38] Building owners who have retained structural plans are becoming increasingly reluctant to share them with the public out of concern for safety in the face of terrorism. Although National Register nominations are usually public record, even that access is sometimes limited.[39]

Another reason for the emphasis placed by preservationists on the architecture of buildings is that the structure is often completely concealed. Structural systems may be clad by a facade on one side and sheathed with interior finishes on the other. A "windshield survey" is a useful method for historians seeking to document the variations and nuances of architectural style, sorting the representative or exemplary from those that are more common or have lost integrity. Rapid visual investigation of structural systems in the field is, however, difficult at best; comparative analysis within or across structural types verges on the impossible, short of lurking in subbasements and poking around attics.[40] As a result, the engineering components are often overlooked in the analysis of the historical significance of building elements. This trend is reflected in publications by the National Park Service, whose criteria seem to imply that the integrity of a building, which it defines as "the ability of a property to convey its significance," must be present in physical features that are "visible enough to convey their significance," although it admits this is "sometimes a subjective judgment."[41] This require-

Fig. 7. Excavation and construction of the building foundation, Plymouth Building, January 1910. Workers continued to mix and pour concrete as temperatures dropped to a low of 2°F in February 1910. Smoke from tubes used to heat the concrete mix bothered the owners of the adjacent chop-suey restaurant, whose sign is visible in the upper-left corner of this image. Courtesy of Historic Plymouth Building, LLC.

ment seems to potentially disqualify a building's structure from being significant if it is hidden underneath architectural finishes, which is common in historic buildings. The reinforced-concrete structure of the Plymouth Building is exposed in the subbasement and attic floors and is also detailed in the original drawings, allowing it to be described and photographically documented following the guidelines of the National Park Service.

Comparisons to other buildings listed in the National Register of Historic Places with similar characteristics can often be invaluable in establishing the significance of a building. However, there is a large emphasis on architectural significance in the National Register, and the engineering significance of a structure is not always included, even when it is merited. Most engineering curricula in the U.S. are structured around the requirements of the Accreditation Board of Engineering and Technology, which does not mandate the coverage of engineering history.[42] A lack of coverage of this field in engineering curricula leads to a subsequent lack of awareness of it, which limits the quantity of research and analysis by those who can potentially best understand the subject material.

Another challenge often encountered when determining the engineering significance of a structure is the implied need to use what is referred to in this article as the "superlative approach" to establish significance. When it comes to engineering significance, experience has shown that it is sometimes not enough to merely "embody the distinctive characteristics of a type, period, or method of construction"; numerous examples of National Register nominations associated with engineering suggest that a more superlative benchmark is often used to demonstrate "significance," one that distinguishes the structure as the "first," the "tallest," the "longest," or in some way the singularly greatest example of a type. This approach is problematic because it obscures the more common elements and themes in the development of historical ideas, methods, and designs that foster a richer understanding of engineering history.

Conclusion

Several strategies could be implemented to mitigate the challenges encountered in establishing the engineering significance of the Plymouth Building. First, the National Park Service should be given the resources needed to completely digitize the National Register archive. To date, it has digitized the nominations of all but 11 states; the digitized nominations are entirely word searchable with the help of Google.[43] The National Park Service guidelines suggest that historic resources must be considered in the context of other examples of the same property type to evaluate significance and determine eligibility.[44] Yet, until the entire archive is digitized, it is not possible to search among all nominations for details about building technologies or structural systems. The National Park Service might also consider modifying the National Register evaluation form to require or encourage information about the structural design, equaling the detail now dedicated to descriptions of architectural style and ornamentation.

Details about the structure and the significance of related technologies and building processes might be more readily infused into the National Register program if engineering history became a component of engineering education and if the Park Service developed preservation engineering as one of the Secretary of the Interior's Professional Qualification Standards.[45] Accreditation standards for undergraduate engineering programs in the United States, first established in 1932, consistently recommended or required a minimum percentage of overall coursework in the humanities, among which history was specifically named, until this criterion was eliminated in 2000.[46] Scholars and practitioners have since suggested that knowledge of engineering history would cultivate better engineers by presenting them with a broader perspective of the field and the career opportunities within it; moreover, it has recently been suggested that the time is ripe for academic training specific to preservation engineering.[47] Professional programs that train preservationists should also be encouraged to include more about engineering and construction history as a companion to architectural-history courses that have for so long been at the core of preservation pedagogy.[48]

Preservation Design Works was able to make a series of unconventional arguments for the engineering significance of the Plymouth Building. The Minnesota State Historic Preservation Office and the National Park Service determined that it was eligible for the National Register of Historic Places under Criterion C as a representation of the development and acceptance of the reinforced-concrete skeleton frame by the American building industry, as an early example of cold-weather concreting, and as the product of innovative design and construction processes at a pivotal period in the history of concrete architecture. Constructing this narrative forced the project team to reject the superlative approach, a way of thinking about engineering significance that is analogous to what architectural historian Richard Longstreth called the "problem with style." "Instead of a complex and nuanced construct developed to analyze meaning," Longstreth argues, architectural style often binds preservationists to a "rigid set of characteristics," a faulty classification scheme in which anything less than a pure example is seen as a "hybrid," and therefore something insignificant.[49] An early newspaper description of the Plymouth Building not only misidentified the building's "style" of engineering; it also raised questions about whether association with a well-known engineer was enough to make the structure significant when there are already so many other earlier, documented examples of his work listed in the National Register. This line of thinking prevents considering aspects of significance that Longstreth argues make for a "fuller sense of…historical value." These include function, structure, processes, labor, systems, and patronage, all of which informed an understanding of the Plymouth Building's significance.

Historians and sociologists of technology have similarly largely abandoned attempts to document technological "firsts" and to see the individual inventor as a "genius" figure operating in isolation from other economic and social forces. Instead, scholars like Thomas Hughes have long encouraged a "systems" metaphor for understanding the interconnectedness of physical artifacts, economic forces, and institutions. In a similar vein, sociologists of technology advocate research to understand the influence and interactions of consumers, patrons, professional associations, and users of artifacts in the acceptance or rejection of technological systems. These insights may provide preservationists with new theoretical perspectives to construct significance.[50]

These more recent approaches to studying the history of architecture and technology helped make sense of the Plymouth Building as an artifact, a story, and the product of processes whose significance was complex, nuanced, and not initially clear. Ultimately, even though the National Park Service formally agreed that the building was eligible for listing in the National Register, its significance may still be subject to debate. While similar examples of its particular reinforced-concrete details applied to a skyscraper or earlier examples of cold-weather concreting or Ewen's methods of excavation were not located, it was also not possible to prove that the Plymouth Building was a forerunner, the first, or in some way the most significant. Such are the difficulties writing National Register nominations for building typologies, technologies, and practices (like stripping and recladding a facade, as was partially done to the Plymouth Building) in the absence of publications that provide historical context. This is a call for more research.

Modulating iteratively back and forth between primary and secondary sources was the key to the successful investigation of the Plymouth Building. The Plymouth Building reminds us that historical significance is not an inherent quality of buildings — something imbedded in materials from the past. Rather, we construct, and hopefully continuously reinterpret, the significance of all types of cultural resources in the present.[51] After all, significance is an argument, and the National Register needs new ones to invigorate the preservation movement and to sustain the economic redevelopment of older and potentially historic buildings.[52]

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Notes

1. Howard L. Green argues that not all preservationists are willing to accept that significance is a social construct; see his essay "The Social Construction of Historical Significance" in *Preservation of What, for Whom?: A Critical Look at Historical Significance*, ed. Michael Tomlan (Ithaca, N.Y.: National Council for Preservation Education, 1998), 85-94.

2. The most up-to-date list of states with historic-rehabilitation tax-credit programs can be found in Rutgers Center for Urban Policy Research, "Third Annual Report on the Economic Impact of the Federal Historic Tax Credit," 2012, http://www.nps.gov/tps/tax-incentives/taxdocs/economic-impact-2012.pdf (accessed March 13, 2013).

3. "$1,500,000 Office Building Planned," *Minneapolis Tribune*, July 16, 1909.

4. Ibid.

5. John Borchert, David Gebhard, David Lanegran, and Judith Martin, *Legacy of Minneapolis: Preservation Amid Change* (Minneapolis: City of Minneapolis, 1983), 31.

6. For a brief but well documented introduction to the history of reinforced concrete, see Amy E. Slaton, Paul E. Gaudette, William G. Hime, and James D. Connolly, "Reinforced Concrete," in *Twentieth-Century Building Materials: History and Conservation*, ed. Thomas Jester (Washington, D.C.: National Park Service, 1995). Subsequent citations throughout this paper provide additional detail.

7. "The Romance of Modern and Ancient Concrete," *Minneapolis Morning Tribune*, May 15, 1910.

8. "The Plymouth Building: Something in the Nature of a Record Breaker in Structural Operations Made Here," *Minneapolis Morning Tribune*, Sept. 4, 1910.

9. Complete plans, drawings, and construction specifications for of the structure are located at the Northwest Architectural Archives, Univer-

sity of Minnesota Libraries, Minneapolis, Minn.

10. Typical bay dimensions range in plan from 20 feet 4 inches by 21 feet 2 inches to 22 feet 2 inches by 23 feet 5 inches, with the proportions generally being square.

11. National Register of Historic Places staff, *National Register Bulletin 15: How to Apply the National Register Criteria for Evaluation*, revised for Internet 2002, http://www.nps.gov/nr/publications/bulletins/nrb15/ (accessed Nov. 10, 2012).

12. "Call the Roll," *Cement Age* 13 (Dec. 1911): 29.

13. Peter Collins, *Concrete: The Vision of A New Architecture* (London: Faber and Faber, 1959). Carl Condit, *American Building Art: The Twentieth Century* (New York: Oxford University Press, 1961). Reyner Banham, *A Concrete Atlantis: U.S. Industrial Building and European Modern Architecture* (Cambridge: MIT Press, 1989). Donald Friedman, *Historical Building Construction: Design, Materials, and Technology* (New York: W. W. Norton & Co., 1995). Amy Slaton, *Reinforced Concrete and the Modernization of American Building*, 1900-1930 (Baltimore: Johns Hopkins Univ. Press, 2001). Andrew Saint, *Architect and Engineer: A Study of Sibling Rivalry* (New Haven: Yale University Press, 2007). Adrian Forty, *Concrete and Culture: A Material History* (London: Reaktion Books, 2012).

14. Donald Friedman, "The Development of Modern Building Skeletons," *APT Bulletin* 43, no. 4 (2012): 18.

15. On the development of the structural-steel frame, see for example Thomas J. Misa, *A Nation of Steel: The Making of Modern America, 1865-1925* (Baltimore: Johns Hopkins Univ. Press, 1995), 45-89; Friedman, *Historical Building Construction*, 41-55. For a discussion of how architects and engineers debated the relative merits of steel versus concrete structures in the early twentieth century, see Saint, *Architect and Engineer*.

16. Carl Condit, "The First Reinforced-Concrete Skyscraper," *Technology and Culture* 19 (Jan. 1968): 16.

17. Banham, *A Concrete Atlantis*.

18. Engineering drawings, separate and distinct from the architectural drawings, were prepared for the Plymouth Building.

19. While the engineering drawings indicate that the masonry walls were most likely not intended to contribute to the lateral-force-resisting system, any practicing engineer would note that, in reality, the exterior masonry and interior clay-tile partitions increase the lateral stability of the building.

20. One rare, if not superlative, attribute of the Plymouth Building was the vast trove of primary sources documenting its design and construction.

21. "The Romance of Modern and Ancient Concrete," *Minneapolis Morning Tribune*.

22. The style was widely utilized in the mid-1930s for the design of large public and institutional buildings like federal post offices. See for example James H. Bruns, *Great American Post Offices* (New York: Wiley, 1997), 95.

23. "Plan Refacing of Plymouth Building Soon," *Minneapolis Journal*, June 4, 1936.

24. Ernest Ransome's patent on twisted-steel reinforcement expired in 1901; see U.S. Patent 305,226, Sept. 16, 1884.

25. The American Concrete Institute appears to first make the distinction between the differences in concrete-to-steel bond strength of smooth versus deformed reinforcement in their *Proceedings of the Fifteenth Annual Convention* (Atlantic City, N.J.: American Concrete Institute, 1919), 393.

26. Henry T. Eddy and C. A. P. Turner, *Concrete-Steel Construction* (Minneapolis: Author, 1919), 21. In the textbook he coauthored with Henry Eddy, a professor at the University of Minnesota, Turner argues that steel reinforcement is held in place by concrete due to shrinkage and provides reasoning for the appropriateness of smooth reinforcement. An example of a building that Turner designed that incorporated smooth reinforcement was the Northwest Knitting Company Building in Minneapolis, described in the article "Reinforced Concrete Warehouse for Northwest Knitting Co., Minneapolis, Minn," *Engineering News* (June 8, 1905): 593-594.

27. Friedman, *Historical Building Construction*, 139, 150.

28. Slaton, *Reinforced Concrete and the Modernization of American Building*, 139. Today, these three types of building-industry relationships might be described as "in house," "design-bid-build," and "bid-design-build."

29. Ibid., 140.

30. "Large Manufacturing Plant Under Construction," *The Cement Era* 8 (February 1910): 53. Advertisement titled "John M. Ewen Company: Engineers and Contractors for Large Buildings" *The Omaha Daily Bee*, April 1, 1907. Ewen advertises the services he offered: "Co-operate with Architects and Owners to advantage of both. Erect Buildings for cost plus a fixed sum for services rendered. Have an experience of 25 years with office and commercial buildings."

31. Today, C. F. Haglin and J. L. Robinson (now Kraus-Anderson) are still prominent contractors in Minneapolis. In the early nineteenth century, the firms advertised, or were described as, "contractors and builders" in the following sources: "C. F. Haglin Contractor and Builder Hotel Radisson," *Minneapolis Morning Tribune*, Dec. 15, 1909, 12; "James Leck & Co.," *Minneapolis Morning Tribune*, Sept. 21, 1913, A3; "The New Fawkes Building Houses Many Prominent Tenants," *Minneapolis Morning Tribune*, Nov. 26, 1916, 6.

32. A 1910 newspaper article about the construction of the Plymouth Building notes, "So rapidly was the work done, that the contractors did not wait to remove the entire portion of the earth from the basement before beginning the rearing of the building. Enough earth was removed at first to plant the rafts and moulds [sic] for the heavy concreting to support the walls and pillars, and then the toilers began to mount with the concrete." "The Plymouth Building," *Minneapolis Morning Tribune*, Sept. 4, 1910.

33. John M. Ewen, *Ewen's Method of Sub-construction as Applied to Steel Buildings, Subways Etc.* (Chicago: 1905), 1.

34. Slaton, *Reinforced Concrete and the Modernization of American Building*, 225-226. See also John S. Nicoll, "Cold Weather Concrete Work," *Cement Age* 14 (Feb., 1912): 81-84; Charles E. Anderson, "Reconstruction of Bridge 298, New York Central Railroad—Concreting in Cold Weather," *Engineering and Contracting* 36 (Dec. 6, 1911): 616-618.

35. R. K. Meade, "Prevention of Freezing in Concrete by Calcium Chloride," *Engineering Record 55* (April 20, 1907): 501-502. Ransome supported use of salts because tests indicated that it increased the fire resistance of concrete; see Ransome and Saurbrey, *Reinforced Concrete Buildings*, 185. It is now well recognized that chloride ions react with the steel reinforcement resulting in corrosion and ultimately failure of the system; therefore most current construction projects place strict limits on the addition of salts to the concrete mix. See for example Adam Neville, "Chloride Attack of Reinforced Concrete: An Overview," *Materials and Structures* 28 (1995): 63-70; American Concrete Institute, *ACI 318-05: Building Code Requirements for Structural Concrete and Commentary* (Farmington Hills, Mich.: 2005), 54; and Elizabeth Ward-Waller, "Corrosion Resistance of Concrete Reinforcement" (PhD diss., Massachusetts Institute of Technology, June 2005), 9-18.

36. Portland Cement Association, *Concreting in Cold Weather* (Chicago: 1916), 5-6.

37. Plymouth Building Daily Report, Feb. 10, 1910; the logs do not mention the use of any salts.

38. National Society of Professional Engineers Professional Liability Committee, *Document Retention Guidelines* (March 2005).

39. A recent request by the authors to the Missouri State Historic Preservation Office for the NRHP nomination form for the historic Bagnell Dam and Osage Power Plant was denied because the property owners requested the withholding of the information from the general public due to "homeland security" issues.

40. Some researchers are overcoming these challenges by combining multiple sources and survey strategies; although it aims to identify buildings in need of seismic retrofit as opposed to documenting historic significance, see for example the Concrete Coalition, which is currently active in California and the Pacific Northwest, www.concretecoalition.org/.

41. National Register of Historic Places staff, *National Register Bulletin* 15, Section VIII.2.

42. ABET Engineering Accreditation Commission, *Criteria for Accrediting Engineering Programs* (Baltimore: Oct. 29, 2011).

43. The remaining states ranked by number of NRHP listings from smallest to largest are Illinois, Michigan, Missouri, Arkansas, North Carolina, Virginia, Texas, Pennsylvania, Ohio, Massachusetts, and New York. NPS is currently seeking funding to digitize these remaining states, possibly in partnership with the National Archives. NPS National Register staff recommends a two-step process for word-

searching the text of nominations that have already been digitized. First, use the Google Advanced Search feature at: www.google.com/advanced_search and put the value of pdfhost.focus.nps.gov in the search within a site or domain box, in addition to search terms of interest. Second, once you find the documents in the Google Advanced Search in pdfhost.focus.nps.gov, pull up the PDF of interest and use the "find" utility to see exactly where in the PDF document that term appears, since documents can be quite long. Information and suggestions were provided by NPS NRHP staff by email to Greg Donofrio dated May 31, 2013. Also useful are the HABS/HAER/HALS archives, most of which is digitized and accessible online at the Library of Congress http://www.loc.gov/pictures/collection/hh/digitizing.html (accessed June 5, 2013).

44. National Register of Historic Places staff, *National Register Bulletin* 15.

45. The NPS recently launched an initiative to revise and expand the SOI Professional Qualification Standards to include several new professions, including preservation engineer; see "SOIS Professional Qualification Standards," https://ncptt.nps.gov/articles/c2a/soi-professional-qualification-standards/ (accessed June 5, 2013).

46. See Karl D. Stephan, "All This and Engineering Too: A History of Accreditation Requirements," *IEEE Technology and Society Magazine* (Fall 2002): 8-15.

47. Christopher Bissell and Stuart Bennett, "The Role of the History of Technology in the Engineering Curriculum," *European Journal of Engineering Education* 22, no. 3 (1997): 267. John A. Matteo, "Preservation Engineering: Framing a New Curriculum," *Preservation Education and Research* 4 (2011): 93-106. *APT Bulletin* 41, no. 1 (2013), special issue on preservation-engineering education.

48. On the history of preservation education, see Michael Tomlan, "Historic Preservation Education: Alongside Architecture in Academia," *Journal of Architectural Education* 47, no. 4 (1994): 187-196; Richard Longstreth, "Architectural History and the Practice of Historic Preservation in the United States," *Journal of the Society of Architectural Historians* 58, no. 3 (Sept. 1999): 326-333.

49. Longstreth, "Architectural History and the Practice of Historic Preservation in the United States," 327-328; see also Richard Longstreth, "The Problem with 'Style,'" *The Forum, Bulletin of the Committee on Preservation*, SAH, 6 (Dec. 1984).

50. An excellent overview of this literature is provided by Weibe E. Bijker, Thomas P. Hughes, and Trevor Pinch, eds., *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge: MIT Press, 2012).

51. Among the scholars to make this point most persuasively in the context of preservation practice in the United States is Randall Mason, "Fixing Historic Preservation: A Constructive Critique of 'Significance,'" *Places* 16, no. 1 (2004): 65.

52. Historic Plymouth Building, LLC, purchased the Plymouth Building for $14.5 million in December 2002. The building's assessed value had fallen to $9.7 million by 2013, and only 55 percent of the Class B office space was occupied. A developer is currently proposing to adapt the building into 252 market-rate apartments. See Burl Gilyard, "Developer Wants to Turn Plymouth Building Offices into Apartments," *Finance and Commerce* (Minneapolis), March 7, 2013. The developer plans to take advantage of federal and state historic-rehabilitation tax credits, each of which has a potential face value of 20% of qualified rehabilitation expenditures (in other words, 40% total). Using rehabilitation tax credits, preservation standards will be maintained through SHPO and NPS oversight of interior and exterior rehabilitation, which would not have been the case without NRHP designation.