January 2007

The Interplay of Technology and Durability: The Evolution of 20th Century High-Rises and Implications for Preservation Philosophy

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Buckley, Ellen C., "The Interplay of Technology and Durability: The Evolution of 20th Century High-Rises and Implications for Preservation Philosophy" (2007). *Theses (Historic Preservation)*. 64.
http://repository.upenn.edu/hp_theses/64

A Thesis in Historic Preservation Presented to the Faculties of the University of Pennsylvania in Partial Fulfillment of the Requirements for the Degree of Master of Science in Historic Preservation 2007.
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Comments

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Ellen C. Buckley

A THESIS

in

Historic Preservation

Presented to the Faculties of the University of Pennsylvania in
Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE IN HISTORIC PRESERVATION

2007

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I dedicate this thesis to my family, whose unwavering support has guided me through every pursuit I've undertaken.

Acknowledgments

I owe a debt of gratitude to my family, my friends, and my advisors who supported me through this thesis. My family's support and love always carries me through challenging projects and my friends provide support, lots of laughs, and a sounding board. I especially want to thank Patrice and Mandy for their encouragement, numerous therapeutic stories and lyrics, and for pushing through this past year together. I also wish to thank Jim for putting up with me throughout this stressful time and for consistently encouraging me and listening to my thoughts about this topic.

My advisor, Michael C. Henry, offered a helpful forum for discussing the objective and challenges of my thesis from the inception of the idea through completion. I thank him for his insightful comments and suggestions.

I also wish to thank my reader, David Fixler, who took the time to carefully read this document and make meaningful comments, which helped clarify my argument and strengthened my thesis. His suggestions were always on target and were an invaluable contribution.

Finally, I want to thank Donovan Rypkema not only for his comments on this thesis, but also for teaching me about the economic component integral to preserving buildings of any vintage.

I would also like to thank the following people who made significant contributions to my research:

William Whitaker	Architectural Archives, University of Pennsylvania
Julie Tozer	Avery Architectural Library, Columbia University
Bernard Camins	Camins Associates, Philadelphia, PA
Kathryn Bourke	Faithful + Gould Consulting, UK
Peter Flynn	Flynn Battaglia Architects
Martha Mathewson	Flynn Battaglia Architects
Kirsten Sibilia	FxFowle Architects (New York)
Jessica Wyman	FxFowle Architects (New York)
Kelly	New York Historical Society, Print Room
Emma White	Skyscraper Museum
Jason Kirkweg	State of Missouri, Design Department (Wainwright Bldg)
Dr. Takashi Nireki	Tsukuba Building Test Laboratory, Japan
Timothy Allanbrook	Wise Janney Elstner (New York)
Stephen Kelley	Wise Janney Elstner (Chicago)
Anthony Cinnamon	Wise Janney Elstner (Chicago)

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Chapter 1: Introduction

This thesis emerged from a quandary about the relationship between a building's technology and durability. This relationship is explored through a building type that uniquely characterized the urban landscape of 20th-century America: the high-rise. The central question probed in this thesis is: Since high-rises reflect the distinctive, changing technological trends and architectural expressions of their time, what do these differences reveal about the longevity of these buildings? In turn, how might technological advancements affect their lifespan and change the philosophy for their preservation?

The evolution of construction technology and the growth of high-rise construction are inextricably linked. This thesis explores how a philosophy that is sensitive to the technological developments achieved over the past century of building construction might be developed. With modern movement buildings reaching the age of eligibility for listing on the National Register of Historic Places, the unique qualities of these buildings suggest that traditional approaches to preservation philosophy may be inadequate.

To answer the questions posed above, this thesis will study the exterior envelope sections for high-rise buildings built over approximately the past one hundred years. The vertical enclosure of each building was chosen because it is the public face and image of the building, it is susceptible to weathering, and therefore it is usually the first to be preserved. To evaluate the trajectory of high-rise building trends, this thesis will examine buildings that embody a century of styles and technologies. A selection of nine buildings representing the most technologically advanced for the time in which they were built will be examined; the exterior envelope sections of these buildings will provide the data for analyzing their durability.

To forecast the lifespan of the materials and components incorporated in each building's vertical envelope, *service life* analysis will be applied. *Service life* is the concept that each component of a building has a definable period of time within which it performs without major interventions for repair or maintenance. With an understanding of the service life of the components in each building's vertical enclosure system, this thesis will analyze the lifespan of each enclosure relative to the technologies current for that period of building construction. Through this process, this thesis seeks to assess how technological advancement over the course of the last century might inform a preservation philosophy.

Chapter 2: Review of Literature

INTRODUCTION

This literature review provides the context and background for the major works that frame this thesis. Since this thesis considers a body of sources that represent definable topics, the following text is organized by themes: the modern movement, technology, service life, and preservation philosophy. Beginning with the initial trigger of the idea behind this thesis, a study of the relevant literature on architecture of the modern movement provides a preliminary understanding of the origins of the movement. Motivated by the lack of an argument for preserving buildings based on their technological merit, a history of technological advancements in building construction over the past century offers a framework for the architecture that was produced over that time frame. In order to adequately analyze the effect technology has on the lifespan of 20th-century high-rises, service life analysis is used and understood through the discussed primary resources. Finally, to contextualize and substantiate the analysis, preservation philosophy underscores the findings presented in this thesis.

MODERN MOVEMENT

Several articles published in *The New York Times* in the spring of 2005 revealed an emerging debate about the preservation of modern movement buildings and prompted me to think critically about the challenges of preserving buildings from that time period (approximately 1930-1965). Although many have established organizations, such as DOCOMOMO and the Urban Arts Committee of Miami Beach, to advocate saving midcentury buildings, it remains a contentious issue among architects, preservationists, urban planners, and others committed to designing the built environment.

The New York Times article, "Wrecking Ball Dashes for a Lapidus Work," published in early March 2005, illuminates disputes over preserving modern architecture and the conflicted relationships between those who implement a preservation plan: owner, preservationist, and regulator, in this case the Landmarks Commission chair. The article discusses a building by esteemed Miami architect Morris Lapidus, the beleaguered 1949 Paterson Silk retail building, which is deemed insignificant by its owner yet it is regarded as a treasure by advocates of mid-century architecture. Even the chairman of the New York Landmarks Preservation Commission, Robert B. Tierney, stated: "It always takes time to consider particular buildings that are of relatively recent vintage that are not slam-dunk designable and that have been heavily altered over the years."[1] Tierney's statement speaks to the apprehension he and most of the American public have about preserving buildings that are young or about 50 years old. For many it is more difficult to see the value in preserving a building of a more recent time period, especially since there is little precedent for doing so.[2]

The article of March 9, 2005 on both Lapidus's Paterson Silk building and Summit Hotel (now the Doubletree Metropolitan) focuses on why the two buildings should be preserved. The primary argument made for the buildings' preservation is that they are great examples of Lapidus's "exuberant architecture of motion and emotion."[3] The argument concentrates on the buildings' architectural value as examples of a premier architect's work.

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[1] Robin Pogrebin, "Wrecking Ball Dashes Hopes for a Lapidus Work," New York Times 9 March 2005.

[2] Ibid.

[3] Ibid.

The argument does not, however, mention the durability of the buildings' construction or why it might make economic sense to retain the buildings, even if they required adaptation for a new use. Although the aesthetic-based argument presented has merit, the exclusion of an argument based on the building's potential long lifespan and economic viability spurred the thinking for this thesis. One question it prompted was: Would it be more convincing to argue the preservation of important works because of their durable construction and their corresponding economic potential rather than based on their aesthetic value?[4]

Another *New York Times* article by Robin Pogrebin, "In Preservation Wars, a Focus on Midcentury," was published in late March 2005 and affirms the emerging debate outlined above in the preceding article. While it also cites the recent controversy over the two Lapidus buildings, this article focuses on the underpinnings of a fiery debate over the re-skinning of Edward Durrell Stone's 2 Columbus Circle. Similar to the Landmarks Preservation Commission's treatment of the Lapidus buildings, the commission was again criticized for the broader issue of neglecting postwar architecture and being unresponsive to modern architecture advocacy groups' concerns about modern buildings. Regardless of either side's reasoning, the tension between the commission, advocacy groups, and the architectural and preservation professions at large amplified over the drawn-out dispute about landmarking a late modern building.[5]

In Pogrebin's June 21st article, she reported that the debate over 2 Columbus Circle garnered so much attention that the building was listed on the World Monuments Fund watch list of endangered sites for 2006. Perhaps even more significant than the singular

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[4] Ibid.

[5] Robin Pogrebin, "In Preservation Wars, a Focus on Midcentury," New York Times 24 March 2005.

listing was the fact that the list included a total of nine 20th-century sites. The fund's president, Bonnie Burnham, explained, "There are enough people out there calling attention to the fact that we're losing these buildings that there is kind of a groundswell."[6] The listing of so many 20th-century buildings and the ensuing dispute over 2 Columbus Circle brought the discussion of preserving modern architecture to the forefront. Although these articles illustrate that the preservation of modern buildings is getting more attention, the argument to preserve modern buildings has focused on their architectural contribution, not their structural integrity, technological advancement, or economic viability.[7]

To explore texts on how technology was viewed with respect to a building's architectural form or aesthetic, Sigfried Giedion's widely regarded book *Space, Time and Architecture: The Growth of a New Tradition* offers a valuable examination and a viewpoint from the time the book was published in 1941. In the book, Giedion examines the schism between architecture and technology. Giedion's discussion looks back to the scholarship from the years that predicted the emergence of modern architecture and its relationship to technology. To support his survey of early ideas, Giedion includes an excerpt from Jobard's "L'Architecture de l'avenir" from 1850:

> Mankind will produce a completely new architecture out of its period exactly at the moment when the new methods created by recently born industry are made use of. The application of cast iron allows and enforces the use of many new forms, as can be seen in the railway stations, suspension bridges, and the arches of conservatories.[8]

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[6] Robin Pogrebin, "2 Columbus Circle Makes Group's List of Threatened Sites," New York Times 21 June 2005: E1.

[7] Ibid.

[8] Sigfried Giedion, Space, Time and Architecture: The Growth of a New Tradition (Cambridge, MA: Harvard University Press, 1997) 215.

In this quotation, Jobard claims that the origins of architectural advancement lies within technological innovation. In effect, manufacturers invent a new product first, and, in response, architects implement it. For example, Giedion cites the famed modernist Le Corbusier, who in 1924 said: "The century of the machine awakened the architect. New tasks and new possibilities produced him. He is at work now everywhere."[9] Le Corbusier validates Jobard's words from seventy-five years earlier that technology has taken the lead. This concept that technology is primary will be key to an exploration of how technological advancement has affected the built form.[10]

In Hilde Heynen's work *Architecture and Modernity: A Critique* (1999), she probes the definition of *modernity*. The book is heavily oriented toward the relationship of early 20th-century theory and philosophy to the development of modern architecture, and it establishes necessary definitions of terms used in discussions on modern architecture. Heynen defines *modernity* as a rupture with tradition and constantly mediating a socioeconomic process.[11] Heynen specifically cites *modernity* as "a project of progress and emancipation." Heynen explains that modern architecture grew out of the motivation for buildings to offer spatial experiences rooted in the ideals of modernity.[12] In this way, buildings of the modern movement embody the concepts of progress and emancipation, and therefore preservation philosophy towards the fabric of modern buildings must consider the ideals that shaped their built form. Since Heynen was motivated to write the book to resolve her own frustrations with existing definitions of modernity (including one by Giedion) and modern architecture,

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[9] Ibid., 217. The quotation is taken from Le Corbusier in L'Espirit nouveau (Paris, 1942), no. 25.
[10] Ibid.
[11] Hilde Heynen, Architecture and Modernity: a Critique (Cambridge, MA: MIT Press, 1999) 9-10.
[12] Ibid., 1.

her book is an important recent exploration of what it means for a building to exemplify these ideas.[13]

A selection of essays from *Modern Movement Heritage* (1998) edited by Allen Cunningham provides an invaluable background of understanding and critical thinking about the architecture of the modern movement.[14] Three particularly informative articles included in the book are:

- Henket, Hubert-Jan. "The Icon and the Ordinary."
- Heynen, Hilde. "Transitoriness of Modern Architecture."
- Rappaport, Nina. "Preserving Modern Architecture in the US."

Without detailing the merits of each article, the three listed above explore multiple aspects of preservation that affect buildings of the modern movement. These range from broad issues of "transitoriness" to specific issues confronted in a geographical region, such as the United States.

In his 2002 essay, "A Challenge of Values," John Allan points out that architects and conservationists working on modern movement buildings have discovered that fixing modern buildings to the way they were "before" has proven "more problematic than it might first appear."[15] This realization seems to have prompted Allan and others to acknowledge that preserving modern buildings raises political, cultural, and economic factors beyond the singular, museum-like restorations of modern icons such as Le Corbusier's Villa Savoye (1929). These factors have caused professionals to embrace and commit to the

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[13] Ibid., 9-10.

[14] Allen Cunningham, ed., Modern Movement Heritage (London; New York: E & FN Spon, 1998).

[15] John Allan, "A Challenge of Values," Back From Utopia: the Challenge of the Modern Movement, eds. Hubert-Jan Henket and Hilde Heynen (Rotterdam: 010 Publishers, 2002) 20.

change a given modern building has endured over its lifetime. After accepting the realities surrounding the conservation of a particular building, Allan suggests we should seek the origins of the idea behind the original design. Out of both the original idea and the changes over time should emerge a reasonable, and perhaps more justified, conservation plan. Allan states: "Of course authenticity is a desideratum but it must include spiritual authenticity, which in MoMo's case certainly embraces a commitment to change."[16]

In *Back From Utopia: The Challenge of the Modern Movement*, Hannah Lewi provides an instructive discussion about the complexities and contradictions involved in preserving modern heritage. In her essay, appropriately titled, "Paradoxes in the Conservation of the Modern Movement," Lewi presents the inconsistencies inherent in preserving modern buildings through a case study, the battle to save Perth's Council House, and then measures these issues against the theories of Alois Riegl. Through comparison of a recent battle on a renovation project and the words of a respected theorist, Lewi concludes,

> The status of modernism thus wavers uneasily on contested territory. It still represents futurism, yet is on the verge of being engulfed by heritage values. Modernism has resisted the challenges of preserving the past through its blinkered orientation towards the future.[17]

Lewi's assessment is in agreement with Allan's view that preserving modern buildings necessarily vacillates between two worlds, that of the idea, and that of the built environment. Both these essays confirm that the issues of preserving buildings of the modern movement are complex and paradoxical. It should be noted that both essays only begin to analyze the

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[16] Ibid., 21.

[17] Hannah Lewi, "Paradoxes in the Conservation of the Modern Movement," Back From Utopia: the Challenge of the Modern Movement, eds. Hubert-Jan Henket and Hilde Heynen (Rotterdam: 010 Publishers, 2002) 356-357.

framework and basic logic upon which to base a theory for the preservation of modern buildings; they do not, however, address many of the realities involved in actual restoration.[18]

In his essay in the book *The Modern Movement in Architecture: Selections from the DOCOMOMO Registers (2000)*, David Fixler describes the origins and resulting effect the modern movement had on architecture in the United States. Fixler cites 1932 as the date when the principles of the modern movement were codified for the American architectural profession and the public. In an exhibition at the Museum of Modern Art in New York City, Philip Johnson, Henry-Russell Hitchcock and Alfred Barr, presented the movement as "The International Style." Despite an ongoing debate about the name and definition of this particular style of architecture or way of building, the buildings that represent it remain paramount. This essay cites important American representations of the 'style,' which include: the PSFS Building (1932); Lever House (1952); and Seagram Building (1958). All three high-rises are included in this study.[19]

In Bronson and Jester's article of 1997, "Conserving the Built Heritage of the Modern Era: Recent Developments and Ongoing Challenges," the authors argue that despite the vast collection of modern buildings in North America, it is "far from obvious" how and what measures should be taken to preserve them. Particularly pertinent to the lifespan analysis in this thesis, the authors assert that "many of the resources of the modern era were designed for a shorter lifespan than their earlier counterparts, and their conservation raises

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[18] Ibid., 350-357.

[19] David N. Fixler, "United States," The Modern Movement in Architecture: Selections from the DOCOMOMO Registers, eds. Dennis Sharp and Catherine Cooke (Rotterdam: 010 Publishers, 2000) 266-272.

complex philosophical and technical questions of authenticity and sustainability."[20] This article reviews multiple conferences and publications produced to explore and advance thinking on the complicated issues surrounding the safeguarding of buildings from the modern movement. Upon reflection of current scholarship, the authors offer ongoing challenges, which generally include concerns about awareness, authenticity, and sustainability. Especially relevant to this study, they suggest that an art-historical approach is beginning to be augmented by one that considers technology and function, in addition to form.[21]

TECHNOLOGY

To garner a better understanding of technological experiments employed in modern movement high-rises compared to those built prior to and after the period, a history of building technology is examined. Of the building types constructed in 20th-century America, the high-rise became akin to progress and often incorporated the most recent technological advancements.

The following statement by Carter Wiseman in his book *Shaping a Nation: Twentieth-Century American Architecture and Its Makers* (1998) effectively rationalizes the choice to study the high-rise type: "If a single building type can – and should – be identified with the twentieth-century American architecture, it is the skyscraper."[22] Architectural histories written by reputable scholars Vincent Scully and Sigfried Giedion in 1991 and 1941, respectively, also validate the significance of the high-rise as uniquely characterizing the

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[20] Susan D Bronson and Thomas C. Jester, "Conserving the Built Heritage of the Modern Era: Recent Developments and Ongoing Challenges," APT Bulletin 28.4 (1997): 4.

21 Ibid., 4-12.

[22] Carter Wiseman, Shaping a Nation: Twentieth-Century American Architecture and Its Makers (New York; London: W.W. Norton & Company, 1998) 47.

landscape of 20th-century urban America.[23] In his book of 1961, historian Lewis Mumford remarked that the high-rise became a status of modernity.[24] Despite its dominance in the 20th century, the skyscraper emerged as a new building type in the late 19th century.[25] Certain technologies, the elevator (patented in 1861) and steel, enabled the construction of high-rise structures.[26]

Starrett's book *Skyscrapers and the Men Who Build Them* (1928) provides a context on the high-rise type and the origins of the alleged first skyscraper. Although many continue to debate which building was actually the *first* skyscraper, Starrett and many other scholars believe that the skyscraper type was inaugurated with the construction of William L.B. Jenney's Home Insurance Company building in Chicago, completed in 1885. Starrett states that while many architects and engineers were dreaming of soaring towers, Jenney was the first to develop the technology to put theory into practice. The central idea and significance surrounding Jenney's high-rise, and those to follow, was that he "took the dead load off his walls and placed it on a skeleton framework of iron concealed inside the masonry – cast-iron columns and wrought-iron I beams, bolting the beams to the columns with angle-iron brackets."[27] This system pioneered what became known as the *curtain wall.* Curtain walls incorporate cladding of all material types and thicknesses, although today many take the term to be glass and metal systems. Nonetheless, the function remains the same and the effect of

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[23] Vincent Scully, The Natural and the Manmade New York: St. Martin's Press, 1991; Sigfried Giedion, Space, Time and Architecture: The Growth of a New Tradition, 5th ed. (Cambridge, MA: Harvard University Press, 1997).

[24] Lewis Mumford, The City in History (San Diego; New York: Harcourt, Inc., 1961) 430.

[25] In the late 19th century, the term skyscraper was commonly used to describe a high building of many stories. For the purposes of this thesis, the terms skyscraper and high-rise will be used interchangeably.

[26] Mumford.

[27] W.A. Starrett, Skyscrapers and the Men Who Build Them (New York; London: Charles Scribner's Sons, 1928) 27.

the curtain wall essentially removes the load from the exterior skin and redistributes the load back to the structure. The exterior layer effectively acts as a skin that is tied back to the structure.

Starrett's book also provides insight into the handmade versus the mechanized. Writing in 1928, Starrett asserted the reason that the market for craftsmanship had sustained itself was because the craftsman feared condemnation.[28] In the early 20th century, Congress rewarded select craftsman for their exceptional work. In this manner, the craft industry was encouraged to maintain a high level of quality in their workmanship.[29] Because this thesis will be examining high-rises built during the early 20th century, Starrett's statement offers an understanding of external factors specific to the time period and why craft remained valuable despite the rise of standardization and pre-construction.

Since its inception, the curtain wall has characterized high-rise construction. David Yeomans' article "The Origins of the Modern Curtain Wall" looks back at the roots of the curtain wall and its subsequent development. In addition to the informative text, Yeomans' article includes graphics from journals and trade literature that illustrate curtain wall designs current for the period during which they were published. This information is invaluable for comparing curtain wall systems employed in a building relative to what was being published or considered cutting edge at the time.[30]

In their book, *The Skyscraper: A Study in the Economic Height of Modern Buildings (1930)*, Clark and Kingston explain that building taller was most definitely an economic motivation,

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[28] Ibid., 73.
[29] Ibid.
[30] David Yeomans, "The Origins of the Modern Curtain Wall," <u>APT Bulletin</u>. 32.1 (2001): 13-18.

especially in urban environments where there are constraints due to the limited amount of space and allowable footprint. The authors explain that although taller buildings offer a form for optimizing space in a constrained urban condition, the building is only as profitable as it is well designed, laid out, and ventilated, among other aspects:

> The true economic height of a structure is that height which will secure the maximum ultimate return on total investment (including land) within the reasonable useful life of the structure under appropriate conditions of architectural design, efficiency of layout, light and air, 'neighborly conduct,' street approaches and utility services.[31]

This statement reveals that the economic potential of a high-rise was integral to its design.

Multi-storey Buildings in Steel (1985) offers a concise summary of the trends in high-rise design and illustrations of international examples of multi-storey steel framed buildings. The illustrations show the various ways in which the steel was formed and connected in each building. The book also serves as a reference for comparing the high-rises examined in this thesis to other 20th-century designs.[32]

Materials & Methods for Contemporary Construction (1982) provides a reference for standard details of the time. This source supplies a baseline for understanding how technologies evolved and were considered with respect to the high-rises examined in this thesis. This source, however, is limited in what it presents since it only captures the standard contemporary construction methods in the 1980s and must be considered for that narrow

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[31] Ibid., 8-9.

[32] Franz Hart, W. Henn, and H. Sontag, Multi-storey Buildings in Steel, trans. G. Bernard Godfrey (New York: Nichols Pub Co., 1985).

time frame. The book incorporates illustrations of different types of curtain wall systems, including a prefabricated panel system and a grid system with panels (see *Figure 2.1*).[33]

With Thomas Jester as editor, the book *Twentieth-Century Building Materials: History and Conservation (1995)* provides a comprehensive history of materials employed throughout the past century of building construction. While providing a history, Jester calls for more research to explore the mechanisms of deterioration in this era of building materials. This book is an invaluable resource for particular types of materials, when they emerged, and what factors caused their invention and subsequent production. In the book, Michael Tomlan's essay "Building Modern America," explains that, "The development of building materials may be called evolutionary rather than revolutionary."[34] Lack of labor and low cost of materials provided an environment conducive for technological experimentation and material research. Epochal historical occurrences such as World Wars I and II also stimulated a critical need for resources (such as iron, steel, and copper) that stimulated mass production and standardization. To satisfy the demand, greater scale and efficiency was necessary to realize large buildings to house production for war goods. One of the most significant shifts in the 20th-century building construction was the transition from wood and brick structures to the proliferation of metal and concrete structures, which was largely caused by the economics of supply and demand. Consequently, the standardization of

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[33] Caleb Hornbostel and William J. Hornung, Materials & Methods for Contemporary Construction (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1982).

[34] Michael A. Tomlan, "Building Modern America," Twentieth-Century Building Materials: History and Conservation, ed. Thomas C. Jester (New York: McGraw-Hill, 1995) 34-43.

modern metals and concrete limited choices and, in turn, triggered the temptation to replace rather than restore. [35]

Published two years after Jester's compilation of articles, the research in David Yeomans' book *Construction Since 1900: Materials (1997)* is limited to Great Britain. Despite the geographic specificity, Yeoman presents a few important points that merit consideration for this thesis. First, Yeomans bases the majority of his research on a variety of specific sources fundamental to garnering a complete picture of the development of building materials. These sources include trade literature, codes and regulations, journals, and technical publications. Such publications provide additional insight that is not adequately captured by most books and furthermore augments an understanding of what factors drive advancement in building technology. Second, Yeomans discusses research by the Building Research Establishment (BRE), which was founded and funded by the British government in 1915. Its purpose was to advance the field with regard to service life prediction of buildings' durability and the performance of building materials. The BRE continues to advance research in these areas and has been instrumental in the recent service life prediction research applied to the building analysis of this thesis. Third, Yeomans questions whether the major developments or discoveries by research institutions will actually be implemented by the architect through the application of the research in building design. Fourth, dissemination of the research will only be certain to directly affect design if it is incorporated into standards, codes of practice, and/or legislation. This is to say that

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[35] Thomas C. Jester, ed., Twentieth-Century Building Materials: History and Conservation (New York: McGraw-Hill, 1995).

research is most effective when required through these mandates. Thus, the role of such regulations is integral to what is actually constructed and, in turn, what we preserve.[36]

With regard to the deterioration of building systems, the British book *Envelope Design for Buildings* (1997) examines factors that affect building envelope designs. Mechanisms such as thermal and moisture movement and ventilation are explored. The chapter on curtain walls provides a helpful reference for understanding the potential mechanisms of deterioration in the high-rises to be studied.[37]

SERVICE LIFE

Service life research as applied to buildings is a developing field. Due to its relative infancy, service life remains understudied. Yet the current scholarship provides a useful framework for estimating a building's lifespan. Although research has increased over the past few years, no uniform approach has been codified. The following will highlight the strengths and shortcomings of publications on service life incorporated in this thesis.

Ted Kesik's website on enclosure durability, (http://www.canadianarchitect.com/asf/enclosure_durability/), initiated in 2002 provides concise definitions of key terms for service life analysis as well as service life data on Canadian high-rise buildings that can be applied to the American high-rises analyzed in this thesis. It should be noted that service life research has not originated in the United States; rather, most research on this subject is concentrated in Canada, the United Kingdom, Japan,

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[36] David Yeomans, Construction Since 1900: Materials (London: BT Batsford Ltd. 1997).
[37] William Allen, Envelope Design for Buildings (Oxford: Architectural Press. 1997).

Germany, and Scandinavian countries. As the website suggests, Ted Kesik is part of the Canadian consortium.

The definition for service life posted on Kesik's website is taken from Canada's CSA S478-95 (R2001) *Guideline on Durability in Buildings*: "*Service Life* – the actual period of time during which the building or any of its components performs without unforeseen costs or disruption for maintenance and repair." This is distinguished from *predicted service life*, which is defined in the same 2001 guidelines as: "the service life forecast from recorded performance, previous experience, tests, or modeling." In addition, Kesik notes that the life cycle of buildings includes multiple phases in the life of a building ranging from initial design, to rehabilitation, and, in some cases, total deconstruction.[38]

Kesik also offers a definition for the term *service quality*, which is defined as: "the totality of features and characteristics of products or services that bear on their ability to meet specified requirements."[39] This term is not commonly used in other sources on service life, but has value because its definition incorporates a building's aesthetic in addition to its function and performance.[40]

Another term, *differential durability*, encompasses the whole building system and describes how all the building components differ between components and within the

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[38] Ted Kesik, Enclosure Durability. Architectural Science Forum: 2002. http://www.canadianarchitect.com/asf/enclosure_durability/.

[39] Source: CSA S478-95 (R2001) Guideline on Durability of Buildings. Posted on website: http://www.canadianarchitect.com/asf/enclosure_durability/.

[40] Ted Kesik, Enclosure Durability. Architectural Science Forum: 2002. http://www.canadianarchitect.com/asf/enclosure_durability/.

materials. In other words, the useful life of a building is not uniform. While some systems or components become obsolete, others endure.[41]

In addition to the terminology, Kesik's website incorporates bar graphs and charts that effectively illustrate the concepts. These clear graphics are extremely useful for understanding the concept of durability in buildings and are not widely used or published in other service life publications encountered to date.[42]

In their publication "Factors Affecting Service Life Predictions of Buildings: A Discussion Paper" (1997), Bourke and Davies discuss the most recent advancements in the pursuit of accurate service life predictions for buildings. They caution that predicting service life is a complex issue that requires investigation of numerous factors that are largely unique to the building itself and with respect to its in-use condition. Additionally, they note that prediction models remain inadequate due to the lack of building material performance data. Despite the shortcomings, the current service life models offer valuable assessments for understanding the durability of buildings. They assert the following five components should be factored into service life prediction: 1) material and design for the component; 2) detail of the component; 3) workmanship execution; 4) site and environment issues; 5) maintenance level. Given time and physical constraints, it is not possible to implement all these factors into the building analysis included in this thesis, however, it is important to note their value for service life forecasting. Bourke and Davies place particular value on two publications that assign service life figures for building components: *The Principal Guide for Service Life Planning of Buildings* by the Architectural Institute of Japan (1993); and the *HAPM (*Housing

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[41] Ibid.
[42] Ibid.

Association Property Association) *Component Life Manual*, first published in 1992 and periodically updated. Both manuals inform the base values for analyzing the service lives of the high-rise buildings studied in this thesis.[43]

The *HAPM Component Life Manual* (1992) was produced by a British company, Construction Audit Ltd., and commissioned by the HAPM to provide guidelines for estimating the lifespan of building components for insurance purposes. When published the HAPM manual apparently broke new ground as the first document of its kind to provide extensive lifespan assessments for individual building components. In this manual each component is assigned a projected "insured life" in 5-year increments. The insurance period for all components is limited to 35 years and therefore lifespan projections do not exceed that estimate. The manual justifies this approach by stating: "HAPM insures components in respect of premature failure and it is therefore necessary to have "insured lives" for those components with a life expectancy less than the insurance period of 35 years."[44] The manual warns that because the document was created for insurance purposes the lives indicated are necessarily cautious and conservative.[45] Additionally, the manual notes that the service lives provided are indicative rather than prescriptive and are to serve as benchmarks against which values can be adjusted.

For each component life calculation, the manual includes adjustment factors to account for variations in local conditions such as marine environments, polluted/industrial atmosphere, and frost pockets. The adjustment factor is applied by adding a number of

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[43] Kathryn Bourke and Hywel Davies, "Factors Affecting Service Life Predictions of Buildings: A Discussion Paper," Building Research Establishment Laboratory. London: 1997.

[44] Construction Ltd., HAPM Component Life Manual (London; Glasglow: E & FN Spon, 1994) ii.

[45] Ibid.

years or subtracting a number of years from the suggested base value. In addition, this document was created with built-in general assumptions about the components in the manual. The authors assumed that "installation was performed in accordance with manufacturers' directions, good practice, relevant Codes of Practice and British Standards and the use of appropriate design details."[46] It is noted that non-compliance with these assumptions may reduce the component life. With regard to maintenance, the authors assumed that a minimum level of maintenance would be performed.[47]

For this thesis, the HAPM manual provides one of the only accessible sources that places a value (in years) for a wide variety of building components. The component lives given in the manual will provide a benchmark value for analyzing the service lives of components employed in each high-rise building analyzed in this thesis. Chapter 2: Methodology will outline the approach for analysis and how the information in this manual will be incorporated.

Similar to the motivation for the HAPM Manual, the Architectural Institute of Japan (AIJ) was prompted to publish *The Principal Guide for Service Life Planning of Buildings* to address concerns for durability of its housing. First issued in Japan in 1989, the institute published an English edition four years later in 1993. Although the document was conceived for application to new construction, because of the common objective of the durability of buildings, the concepts in this publication have been applied to both new and existing construction in subsequent publications on service life.

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[46] Ibid., iii.
[47] Ibid.

The AIJ recommends new building design should build in flexibility to prevent obsolescence.[48] AIJ defines obsolescence as: "decrease in the relative value of function or performance of an object due to change of social requirements or technical renovation."[49] Since obsolescence is the ultimate threat (aside from demolition) to a building's lifespan, preventing it is key to a building's durability and extension of its useful life.

To estimate service life, the AIJ guide views the intrinsic quality and performance of the materials as the fundamental factor. For a given building component, it cites six (6) features that should be examined; they are divided into two (2) categories. The six factors of inherent characteristics of performance over time and environmental deterioration factors are as follows:

Inherent characteristics of performance over time:

1. Performance of materials
2. Quality of designing
3. Quality of construction
4. Quality of maintenance and management

Environmental Deterioration Factors:

5. Site and environment conditions
6. Condition of building[50]

Each of these features is given a base rating of 1.0 and then adjusted by a factor. The negative factors are assigned a coefficient of 0.8 while the positive factors are given a coefficient of 1.2. By this approach the final rating for each material or component would vary depending on its material characteristics, its configuration and treatment once installed.

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[48] Architectural Institute of Japan, The English Edition of Principal Guide to Service Life Planning of Buildings (Japan: Architectural Institute of Japan, 1993) 11.
[49] Ibid., 56.
[50] Ibid., 29.

Although the AIJ guide offers an approach that gives the assessor more control over adjustment factors such as maintenance, the approach becomes more subjective than the HAPM approach, which has built-in assumptions. Unlike the HAPM Manual, the AIJ guide is more explicit about the assumptions used in applying the proposed method. In the AIJ model, the person applying the formula builds in the majority of the assumptions that become embedded in the final service life score.[51]

In addition, the AIJ guide suggests that a key factor for a long service life is the building component's maintainability. Design for maintainability includes: 1) availability of accessibility; 2) ease of installation and changing of parts; and 3) modular coordination.[52] To the extent possible, these aspects will be examined in the high-rises to be studied in this thesis.

The 1996 publication *Towards the Prediction of Building Service Life: The Standards Imperative* by U.S.-based authors Frohnsdorff and Martin reflects back on the past twenty years of service life research. Since the research has been executed by small groups of researchers, the results have are not cohesive and cannot be easily applied in as a uniform set of standards. Nonetheless, the studies that have been executed provide a solid base from which to derive a more cohesive standard that can be widely adopted and utilized. In addition to reviewing the recent history of research in this area, the authors offer national construction goals for the use of service life in the United States; these include: 1) 50% reduction in operation, maintenance, and energy costs; 2) 50% less waste and pollution; 3) 50% more durability and flexibility. The authors also point out that one of the difficulties

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[51] Ibid.

[52] Ibid., 36.

with service life prediction for building components is that such a formula cannot be revised at the same rate that interfaces between dissimilar materials are developed. They also note that the forecasting of the service life of any material is information-intensive. Thus, tension exists whereby service life must be simple enough to be utilized, yet requires an abundance of information and assessment of many internal and external factors, some of which are time or age dependent. Another objective of service life prediction is to provide a basis for maintenance management since it is assumed that regular and appropriate maintenance is key to a building's durability.[53]

PRESERVATION PHILOSOPHY

Upon consideration of the social, philosophical, and aesthetic precepts of the modern movement, a history of building technology, and the concept of service life, the following is an investigation of principles and attitudes towards preservation.

Since the National Park Service established *The Secretary of the Interior's Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings* (the Standards) in 1976, they have served as the benchmark guidelines for rehabilitation projects in the United States. The Standards are the most commonly cited principle behind many preservation efforts. As such, this thesis will consider the Standards' position on the question: restore, repair, or replace? With regard to this issue, the Standards first assert: "The historic character of a property shall be retained and preserved. The removal of historic materials or alteration of

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[53] G.J. Frohnsdorff and J.W. Martin, "Towards Prediction of Building Service Life: The Standards Imperative," Durability of Building Materials and Components: Proceedings of the 7th International Conference, Stockholm, Sweden, 19-23 May 1996, ed. C. Sjostrom (New York: E & FN Spon, 1996) 1417-1428.

features and spaces that characterize a property shall be avoided."[54] Foremost, the Standards do not recommend the removal of historic fabric and it should be avoided at all costs. Realizing it is not feasible to retain historic fabric in every circumstance, the Standards suggest the next least invasive rehabilitation method: repair. If repair is not possible, the Standards state that although repair is preferred, if a component must be replaced, it should be under the following terms:

> Deteriorated historic features shall be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature shall match the old in design, color, texture, and other visual qualities and, where possible, materials. Replacement of missing features shall be substantiated by documentary, physical, or pictorial evidence.[55]

The Standards are even more specific about the type of material for replacement: "Although using the same kind of material is always preferred, substitute material is acceptable if the form and design as well as the substitute material itself convey the visual appearance of the remaining parts of the feature and finish."[56] These approaches will become particularly important once the building analysis is complete and the results are assessed with regard to the question: retain, repair, or replace?[57]

The views of Italian theorist Cesare Brandi add to the philosophical debate about how to view cultural heritage buildings. In "Theory of Restoration" (1963) he writes: "If a work of art is the result of human activity and, as such, its appreciation does not depend on fluctuations in taste or fashion, its historical significance has priority over it aesthetic

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[54] W. Brown Morton, III, et al., The Secretary of the Interior's Standards for Rehabilitation and Illustrated Guidelines for Rehabilitating Historic Buildings, (Washington, D.C.: U.S. Dept. of the Interior, National Park Service, Preservation Assistance Division, 1992) vii.

[55] Ibid., vii.

[56] Ibid., x.

[57] Ibid.

value."[58] Brandi also states that cultural heritage is the result of human activity, that of which is not limited to sculpture and painting, but also encompasses the physical labor of humans. In sum, the embodied energy that constitutes a building should be considered part of its cultural value and should not be simply limited to its aesthetic value.[59]

More specific to the problem of conserving additions and modifications that the building might have accrued over time, Brandi states:

> Assuming that the transmission of the formulated image actually occurs through the materials, and assuming that the role of the materials is to be that of a transmitting agent, then the materials should never take precedence over the image. This means that the materials have to disappear as materials in order to be valued only as image.[60]

In spite of the importance of conserving a building on the micro level of material conservation, Brandi warns that materials alone do not make up a building. In the end, the building must operate and be valued as an entire work in its own right and the material modifications that have been made to it must be in agreement with that whole image. In other words, Brandi suggests that the whole of the building is comprised of parts rather than parts comprising the whole.

Alois Riegl (1858-1905) was an Austrian art historian who wrote "The Modern Cult of Monuments: Its Essence and Its Development" in 1903. This work has been widely cited in texts on preservation and substantiated recently under a new term, *values-centered*

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[58] Cesare Brandi, "Theory of Restoration (1963)," Historical and Philosophical Issues in the Conservation of Cultural Heritage, eds. N. Stanley Price, M.K. Talley Jr., and A.M. Vaccaro (Los Angeles: The Getty Conservation Institute, 1996) 233.

[59] Ibid., 230-235.

[60] Ibid., 378.

preservation. In his work, Riegl established the idea that cultural heritage has at least four values: historical value, age-value, use-value, and art-value.[61]

Brandi's statement that cultural heritage is the result of human activity likely considered the earlier writings of Riegl, who said with regard to historical value: "From that [history] perspective, what interests us in the monument are not the traces of nature's disintegrating force, which has brought its influence to bear through the course of time, but in the monument's original form as a work of man."[62]

Finally, Riegl addresses the issue of how we should view and treat monuments of the past in a contemporary context:

> If there is no such thing as an eternal artistic value but only a relative, modern one, then the artistic value of a monument is no longer commemorative, but a contemporary value instead. The preservation of monuments must certainly take this into account, since as a certain practical daily value it needs to be considered along with a monument's historical past – commemorative value; this contemporary value must, however, be excluded from the definition of the "monument."[63]

In sum, a building possesses a multitude of values that describe its past and its present. Both should be incorporated and acknowledged; yet the contemporary value should take precedent. The above quote from Riegl was meaningful to professor Randall Mason of the University of Pennsylvania, who opens with this quotation in his recent essay on *values-centered preservation*.

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[61] Alois Riegl, "The Modern Cult of Monuments: Its Essence and Its Development (1903)," Historical and Philosophical Issues in the Conservation of Cultural Heritage, eds. N. Stanley Price, M.K. Talley Jr., and A.M. Vaccaro (Los Angeles: The Getty Conservation Institute, 1996) 69-83.

[62] Ibid., 75.

[63] Ibid., 71-72.

Published in 2006, Mason's article "Theoretical and Practical Arguments for Values-Centered Preservation" brings Riegl's ideas into the current context. Mason endorses Riegl's acknowledgment that cultural heritage is defined by multiple values and states that until recently the artistic and historical values are the two that have been given the most importance. The concept, named *values-centered preservation*, promotes the inclusion of additional values, such as social, political, and economic values. Mason notes, "Culture is dynamic and changing, a notion reinforced by our current period of intense globalization with all its attendant cultural conflicts, shifts, and innovations."[64] After establishing that the continued use of heritage buildings must accept change, Mason elaborates to say that our culture today is characterized by the unique changes motivated by globalization. Different forces of change are in place now than were present in the 1920s or 1960s. These distinctions must be recognized and considered in the context of the built environment.[65]

CONCLUSION

This literature review by no means represents all sources that have been reviewed or incorporated into this thesis. This chapter attempts to contextualize the themes of this thesis by providing a foundation from which to frame and guide the subsequent research, analysis, and conclusions.

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[64] Randall Mason, "Theoretical and Practical Arguments for Values-Centered Preservation," CRM: The Journal of Heritage Stewardship 3.2 (2006): 30.

[65] Ibid., 21-48.

Chapter 3: Methodology

METHODOLOGY: APPROACH

The objective of this thesis is to use service life of high-rises that span the technologies and building practices of the 20th century to inform preservation philosophy. The first conceived methodology for this thesis is summarized as follows:

- **Research** building technology, modern movement, theory and attitudes towards preservation.
- **Gather data**. Collect exterior envelope section drawings of each building to be studied.
- **Apply** *service life* analysis.
- **Analyze** building sections on an aggregate level and by materials and building systems employed.
- **Compare** results.
- **Conclude** what the analysis reveals about high-rises from different time periods and how this might be related to the employed technologies.
- **Determine** the implications with respect to preservation philosophy.

First, a selection of representative buildings was chosen for analysis. High-rises were chosen based on the criteria of demonstrating the architectural and technological advancements of their time. The selection of these buildings is substantiated by texts on architectural history and articles that highlight innovative qualities of each building, which will be discussed in more detail later in this study. In addition, University of Pennsylvania's architectural historian and practicing architect David DeLong confirmed that the selected buildings were representative of the period. The examination of each high-rise is primarily based on the original (before alteration) exterior envelope sections. As stated previously, this particular section drawing is used because it details the building's vertical enclosure, which is the most visible, the most susceptible to weathering, and typically the first to be rehabilitated.

Initially, twenty high-rises were listed as meeting the criteria of being architecturally and technologically advanced for their time. Given time and accessibility constraints, a conservative number of buildings was listed in hopes that at least 50%, or ten (10) of those listed, would actually be acquired for analysis. Thus, compiling the building exterior envelope sections was the first part of the building analysis process.

The method for analyzing the lifespan of these high-rises relies upon the concept of service life. To restate this concept, *service life* is the theory whereby building components are deemed to have a definable lifespan before major maintenance, repair, or replacement renders the components obsolete or unusable. *Service life* measures the term (in years) of each building component since the completion of the building until the component is estimated to reach the stage of requiring replacement or renewal. The AIJ defines the degree of deterioration that determines the end of a component's service life as: "The state when the performance or function degrades beyond the threshold of limited allowable [the allowable limit], and when it is impossible to return this degraded state back to the allowable limit by means of ordinary repair or partial replacement or removal."[66] The diagram from Kesik's website on durability illustrates that once a component's initial service life ends, replacement or renewal extends its service life (see *Figure 3.1*). This thesis will assess the *first* service life of the component in each building's vertical enclosure.

Service life analysis provides a method for assessing building components' lifespan by assigning them a quantitative value (in years). Buildings possess many unique aspects, such as site and climate, which should be considered as part of a building's durability, yet are

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[66] Architectural Institute of Japan, The English Edition of Principal Guide for Service Life Planning of Buildings (Architectural Institute of Japan: 1993) 13.

not well accounted for in existing service life methods. Climate, for instance, plays a critical role in the way buildings are designed and subsequently weather. Numerous studies have addressed the effect of climate on the durability of buildings; however, it does not serve as the primary focus of this study. Despite its shortcomings, service life analysis offers a way in which the high-rises can be compared through a formulaic, less biased analysis.

Application of service life is primarily based on the values provided in the *HAPM Component Life Manual* (1992). As noted in Chapter 2: Review of Literature, no other publication encountered to date provides an estimate of lifespans for such a vast collection of building components. Other sources do not break out the components in a given system; rather a lifespan is assigned to the total enclosure system. Though the HAPM Manual was conceived for insuring the construction of housing projects in the United Kingdom, it offers a base value for each component that was otherwise unavailable. In addition to major building components such as facing bricks, the HAPM Manual also assesses accessory components such as joint sealants and cavity insulation.

The HAPM uses a labeling system A-H, which corresponds to the recommended service life in years that ranges from 5 to 35+ years (see *Table 3.1* below). For the purposes of this analysis, the code 'A' for a 35+ year value will be assigned a 40-year value with the understanding that the components assigned this service life could last longer than the 40-year minimum. Along with the letter code, components are also assigned a subtype, which is numbered 1 or 2. This number provides a unique code for a component that might have the same recommended service life value but is a different material or specification. To compensate for components that are unsuitable for the application specified or when there is insufficient information available on a given component, the manual assigns a 'U' for uninsurable.

Table 3.1 HAPM Method for Assigning Component Lives.

HAPM Method for Component Life	
Label	Service Life (in Years)
A	35+ (40) years
B	35 years
C	30 years
D	25 years
E	20 years
F	15 years
G	10 years
H	5 years
U	uninsurable

By utilizing this method each component shown in the exterior envelope section of each high-rise will be assigned a service life value in years.

The primary structural steel frame of each building's vertical enclosure will not be included in the service life analysis. While the structure in some buildings is integral to the enclosure systems, in other buildings the structure is separated. It is acknowledged that for those buildings in which the steel structure is integrated into the vertical enclosure, the structure is more susceptible to exterior weathering than for those buildings in which the structure is separated and recessed from the exterior enclosure. Moreover, all buildings examined in this thesis are framed in steel and steel frames are estimated to have a 100-year service life. Because of these two common factors, the analysis is somewhat normalized and the service lives of each building's vertical enclosure would not be drastically modified by the inclusion or exclusion of the structural steel frame.

Acknowledging that each high-rise possesses unique characteristics, each building will be studied singularly and adjustments will be applied as required. The overall analysis of each building will focus on its components, the way in which they were assembled, and the technological trends surrounding their production and ultimate implementation. The service life analysis serves as a method for comparing the selected high-rises. This comparative analysis is intended to elucidate similarities, differences, and general trends revealed through the service life analysis. Graphs and charts will graphically illustrate the relationships of the high-rises that encompass a century of high-rise construction. After analyzing the buildings individually and collectively, this thesis will examine the implications of the results relative to *The Secretary of the Interior's Standards for Rehabilitation* with regard to fabric retention.

On a macroscopic level, the comparative analysis will also be utilized to explore overarching, philosophical questions about preservation, such as:

- Is replacement of original material in fact more acceptable for modern architecture because of their origin in experimental technology?
- How does technological advancement play a role in the service lives of the buildings examined?
- What does the service life analysis indicate for future preservation issues that contemporary high-rises may face?

METHODOLOGY: APPLIED

After seeking drawings for approximately twenty high-rises, drawings for nine buildings were obtained for analysis. Representing a century of high-rise construction, loosely categorized into quarter centuries, the following is the list of high-rises analyzed in this thesis:

- C. 1900 – Guaranty Building, Woolworth Building
- C. 1925 – PSFS Building
- C. 1950 – Lever House, Alcoa Building, Seagram Building
- C. 1975 – Citicorp Center, AT&T Building
- C. 2000 – New York Times Tower

Despite conservative planning, collecting the building sections proved to be a challenging and time-consuming task. For any who wish to obtain architectural drawings of high-rises in the future, he or she should be cautioned that the information is not easily accessible from any single source nor is it made easier in these times of heightened national security. The September 11, 2001 attacks on the World Trade Center sent a ripple effect of precaution that was still very much alive in the fall of 2006 and spring of 2007 and is likely to remain for sometime. Architects and building maintenance persons were openly more hesitant to provide access to drawings than they were prior to the devastating events in the fall of 2001. For instance, architects Hugh Stubbins and Associates were unwilling to provide exterior section drawings of the Citicorp Center because of their concerns for security and liability. In another case, SOM's archivist cautioned that copies of Lever House drawings would be costly and would require execution of multiple legal documents. These procedural obstacles carry the information-gathering phase beyond the timeline of a thesis.

Nonetheless, the initial methodology was applied to the nine buildings for which drawings were obtained. When service analysis was applied, it was clear that the HAPM base values required an adjustment factor to account for the shortcomings of the manual. By applying an adjustment factor to the base value, *Figure 3.2* shows the typical form used to calculate the total service life. For the purposes of this analysis, the adjustment factor is defined as a factor which alters the service life by deducting or adding years based on a positive or negative characteristic of the component. The adjustment factor is informed by knowledge of building material properties, manufacturer's data, and warranty information. For the components that required adjustment to a base value, justification for the adjustment is included under the service life analysis section for each building.

With these modifications to the initial methodology, the analysis is applied to each of the nine high-rises. The succeeding chapters will introduce each high-rise and discuss the architectural and technological context in which they were conceived and constructed. Then, the service life analysis of each high-rise will attempt to measure and inform correlations between each building's technology and its serviceable lifespan.

Chapter 4: High-rises c. 1900

GUARANTY BUILDING

The offices of Dankmar Adler and Louis Sullivan finished drawing up the design of the Guaranty Building in 1895. Their design was an attempt to perfect the high-rise type after completing four high-rise designs together, most notably the Wainwright building (1891) which Sullivan saw as the first example of an emerging building type -- the skyscraper. Historians and critics largely agree that the Guaranty Building succeeds as the finest example of Adler and Sullivan's high-rises. Even beyond the scope of the two architects' work, the building has been heralded as one of the finest and most perfect high-rises built at the turn of the 20th century. For Sullivan, the Guaranty most certainly achieved his vision of a skyscraper as "a proud and soaring thing."[67] Although the thirteen-story structure was viewed as a high-rise then, many neighboring buildings have since risen past its cornice line. Nonetheless, it remains an important example of the early high-rise type and provides a base point for understanding how the type evolved over the 20th century (see *Figures 4.1* & *4.2*).

The Guaranty Building, later renamed the Prudential Building due to change in ownership, was erected in the midst of a transforming Buffalo, New York.[68] Adler and Sullivan delivered to the city a landmark that brought a sophisticated aesthetic identity to an otherwise cold and industrial urban landscape. In the partnership of the two architects, Sullivan's primary contribution was the design of the ornamentation and facades while Adler's primary concern was the working efficiency of a building, most likely due to his

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[67] Cesar Pelli, "Skyscrapers," Perspecta 18 (1982): 135-136.

[68] Subsequent to the building's 1982 restoration, the building returned to its original name, the Guaranty Building. Jason Aronoff, "Jack Randall: Preservation on Principle," Western New York Heritage Fall 2006: 19.

training as an engineer.[69] Sullivan saw the pragmatics of a building, the physical functions, structural requirements and clients' needs as transient and far less significant than a building's external appearance. Conversely, Adler viewed an architect as a master craftsman that utilized all the planning strategies and technologies available to him "to solve architectural problems economically, efficiently, and nobly."[70] One could reasonably conclude that the eventual success they achieved in the design of the Guaranty Building was the result of their collaboration, which ultimately married both Adler's pragmatism and Sullivan's emphasis on ornament.

Construction

As the pragmatist, Adler had written about "fireproofing, steel, and glass in the modern era" in contemporary engineering and architectural journals, and was likely most responsible for the technology employed in the building. As mentioned previously, the invention of the elevator (patented in 1861) and the curtain wall system, which eliminated the need for thick masonry-bearing walls, introduced in Jenney's Home Insurance Company building enabled the first period of skyscraper design. Since Jenney's groundbreaking achievement in 1885, architects sought to refine the design of the type and improve upon the new curtain wall technology. The Guaranty Building was no exception to this. The thirteen-story building was one of the first steel-frame buildings in Buffalo when it officially opened in 1896. The building is constructed as a riveted steel frame sheathed with brick and terra cotta cladding. Terra cotta offered the look and feel of stone but was lightweight and comparatively less expensive. After the Great Chicago Fire in 1871 and the subsequent

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[69] Narciso G. Menocal, Architecture and Nature: The Transcendentalist Idea of Louis Sullivan (Madison, Wisconsin: The University of Wisconsin Press, 1981) 43.
[70] Ibid., 44.

heightened awareness of fireproofing properties in building materials, the Guaranty Building's terra cotta cladding was also used to fireproof the steel frame.

As steel took the place of masonry and emerged as the structural material that enabled high-rise construction, apprehension surfaced about the relationship between the structure and the exterior aesthetic. In his book on Sullivan, Robert Twombly highlights some of the questions that arose: "Did a steel-frame building have to look the part, or could it be legitimately disguised as a masonry-supported structure? Conversely, if it was very tall and looked like a steel-frame building but was not, what then?"[71] As Cesar Pelli notes in his article on skyscrapers, architects of the time who struggled with the need to integrate modern elements into high-rise design acknowledged that a new architecture was necessary to respond to new technologies, new materials, new functions, and new social systems.[72] Since the skyscraper was a new type, architects were more pre-occupied with these questions than they are today.

In the case of the Guaranty Building, the integration of structure and skin appears seamless. The primary structural columns are set forward of the windows, and in this way reinforces the steel frame that enabled the building to reach its height (see *Figures 4.3* & *4.4*). The combination of continuous vertical expression of the steel frame and the surface changes of the building's terra cotta cladding effectively achieves an upward-reaching effect, an ambition that often characterizes the high-rise type. This effective marriage of the frame and the skin in the Guaranty Building is best summed up in the words of a leading

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[71] Robert Twombly, Louis Sullivan: His Life and Work (New York: Viking, 1986) 283.
[72] Cesar Pelli, "Skyscrapers," Perspecta 18 (1982): 136.

architectural critic of the time, Montgomery Schuyler: "I know of no steel-framed building in which metallic construction is more palpably felt through the envelope of baked clay."[73]

The great strength of steel reduced the solids and increased the voids. While steel permitted wider openings and smaller piers, the recently developed plate glass spanned the increased space between the frame. One writer said of the relationship: "It may be said, therefore, that if steel construction is the master, plate glass is the faithful servant."[74] Continuing to analyze the effect of steel construction, the writer suggests that any cladding takes a backseat to the structure:

> But as the steel will give certain suggestions to the form of the covering, which are natural to the steel construction and not to the covering material, the material used for the covering, on the other hand, will tend to give to the design certain of its own peculiarities. Hitherto the covering has practically given all and the steel nothing to the detail.[75]

The cladding is, in effect, molded and shaped to fit the steel and conform to the architect's aesthetic vision for the structure. At the time, some were excited by the innovations while others were apprehensive. In the 1896 article from which the above excerpt is taken, the writer does not necessarily view the technologies of steel and plate glass as positive. In fact, he believes they have a negative aspect. He explains that these technologies significantly challenge architects in their attempt to create harmony and grace in their designs. In November of 1896, the author felt that it was fraud to imitate a building with brick or terra cotta when the chief building material was steel.[76]

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[73] "The Prudential (Guaranty) Building," Architectural Record Aug. 1909: 92.

[74] J.W. Yost, "Influence of Steel Construction and of Plate Glass Upon the Development of Modern Style," The Inland Architect and News Record Nov. 1896: 34.

[75] Ibid., 34.

[76] Ibid., 34.

In most buildings, the interface of the structure and the cladding is where a building is most susceptible to deterioration and the ultimate destruction of its aesthetic and technological integrity. In light of the technologies and debate surrounding the construction of early skyscrapers, what is the projected *first* service life of the components that comprise the Guaranty Building's vertical enclosure?

Service Life Analysis

After decades of believing that the original construction documents of the Guaranty Building had been lost, the drawings were rediscovered within the past year. An anonymous individual claims that he possesses the drawings and they are now the objects of a bidding war among the nation's major museums.[77] For now, however, they remain inaccessible. In lieu of the original drawings, the exterior envelope section of the Guaranty used for this analysis is a drawing from Cannon Design's 1982 renovation of the building. The section shows the modifications intended to be made to the envelope and, in many cases, does not clearly distinguish between new and existing elements (see *Drawings 4.1* & *4.2*). Therefore, knowledge of building practices of the time as well as notations on the drawings inform which elements were likely original or added later.

The following outlines each component that comprises the Guaranty's vertical enclosure and explains the service life value assigned to each.

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[77] This information is derived from a conversation with Louis Sullivan historian, Tim Samuelson, on Oct. 27, 2007 at the Louis Sullivan Terra Cotta Symposium in New York City.

Terra Cotta Veneer
Service Life = 35 years

The Guaranty's front facades are adorned with a glazed brick-colored terra cotta while the rear façade is faced with white glazed terra cotta tiles. The HAPM Manual does not include a category that specifically assesses terra cotta. Since terra cotta is a fired clay product, its manufacturing process and base material is more similar to brick than the alternative Facing Stone Block. As a result, the 40-year estimate for brick is used as the base service life value of the terra cotta veneer. This value is reduced by 5 years because it is a more porous material than brick and relies on its glazing to protect the ceramic material. As adjusted, the total service life of the Guaranty Building's terra cotta veneer is 35 years.

Brick Veneer
Service Life = 40 years

Although the facade of the Guaranty Building is most celebrated for its terra cotta, the exterior face is a mixture of terra cotta and brick, especially at the rear (see *Drawing 4.2*). In this case, the brick veneer falls within the Facing Bricks category in the HAPM Manual with a service life of 40 years.

Double-Hung Mahogany Windows
Service Life = 35 years

In the Hardwood Windows category, the HAPM Manual is very specific in its description of the type of hardwood used in a given window system. For example, it specifies the type of joint (e.g. mortise), type of mechanical joints, and coatings. Because that level of specificity is not known for the Guaranty Building's windows, the service life is based on the class B2 that describes an untreated hardwood of a species designated for external use. For this category, the manual assigns a 35-year service life. With regard to maintenance, the manual assumes that the windows be either stained at 3 years or painted at 5 years, whichever might be applicable. Iron parts are to be replaced at 10 years while the stainless steel components should be replaced at 20 years. Unfortunately, this detailed level of information for the Guaranty Building is not known. With the assumption that the building owner has reasonably maintained the original windows until they were replaced, this analysis retains the 35-year service life for the building's double-hung windows.[78]

Steel Angle Lintel
Service Life = 35 years

The service life of the steel angle support in the Guaranty Building is based on the description of a hot rolled steel lintel of austenitic or ferritic stainless steel, which is coded as class A1 for external masonry walls in the HAPM Manual. This class is assigned a 40-year service life from which 5 years are deducted because the steel lintel, or sometimes called a shelf angle in this type of application, is more susceptible to corrosion because it is exposed on the exterior and because it did not likely have a stainless finish (see *Drawings 4.1* & *4.2*). In total, the service life of the steel lintel is 35 years.

Since the renovation drawings are not explicit, it cannot be determined that the steel lintel was incorporated into the original wall construction. Moreover, construction during the late 19th century did not always employ steel lintels in window openings. In lieu of a steel lintel, builders oftentimes constructed a flat arch to carry the load of the brick veneer above.

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[78] The windows were replaced as part of Cannon Design's restoration of the building in 1982. It is not known whether they were replaced prior to that time.

3" Masonry Back-up Wall
Service Life = 40 years

Though the renovation drawings show a 3" concrete block back-up wall, concrete blocks likely replaced original brick or structural clay tile. It was not until 1900 that S. Palmer's block machine was patented for manufacturing concrete blocks. Between 1900 and 1920 blocks were manufactured by the hand-operated Palmer machine, which produced only single blocks. Concrete blocks were not put into mass machine-made production until after 1920. Both brick and tile are shown as back-up wall materials in typical wall sections of early masonry curtain walls comparable to that of the Guaranty Building (see *Figure 4.5*).[79] Thus, the service life for the Guaranty's back-up wall is based on brick as the back-up material, which is assigned a 40-year service life in the HAPM Manual.

Iron Terra Cotta Anchors
Service Life = 15 years

In the category of Bolts and Fasteners, the HAPM Manual does not include iron. Since iron is the main component of steel, the G1 designation for steel screws was the most acceptable class for the iron anchors. This designation is described as the recommended default value where specific coatings are not identified and the screws are assigned a mere 10-year service life. Because of the high content of carbon, the iron anchors are more corrosion resistant than carbon steel. Therefore, 5 years are added to the 10-year base value, giving the iron anchors a 15-year total service life.

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[79] Philip G. Knobloch, Architectural Details from the Early 20th Century: A Book of Traditional Details. 1931, 2nd ed (Washington, D.C.: American Institute of Architects Press, 1991) pl. 7.

Metal Flashing
Service Life = 35 years

In the HAPM Manual, metal flashing is listed under the Roofing Components section and not under the Walling and Cladding Components section. The type of metal flashing is not called out in the drawings. Thus, the value is conservatively based on designation C2, a flat roof installation of stainless steel flashing at a 30-year service life. Because this flashing is used within the wall construction and not fully exposed to the weathering of a roof condition, 5 years are added to its service life. The total adjusted service life for the metal flashing is 35 years.

Although flashing is included in this analysis, it is questionable whether it was original to the building's wall construction since labeling on the drawing is not explicit as to whether the flashing is new, original, or intended to replace extant flashing. Additionally, published construction details of early curtain walls from that period do not show flashing within a masonry wall (see *Figure 4.5*).[80]

Conclusion

In addition to the above components, fibrous insulation was also added to the Guaranty Building's vertical enclosure in the 1982 restoration (see *Drawing 4.2*).[81] In this manner, the wall construction has been modified to accommodate new technologies and augment the performance of older technologies, such as the brick back-up wall. Without including such modern additions to the Guaranty Building in the analysis, the total service life values of the components are shown in *Graph 4.1*. Where the base value has been

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[80] Ibid.

[81] Jason Aronoff, "Jack Randall: Preservation on Principle," Western New York Heritage Fall 2006: 16.

adjusted, the negative or positive adjustment factor graphically demonstrates how the overall service life is affected.

The graph reveals that six of the seven components in the analysis are estimated to have a 35-year service life or more. The data also reveals that the iron anchors, at a 15-year service life, is the component that most negatively affects the enclosure's total service life. Without the iron anchors, the service life values for the six components range from 35 to 40 years. The way in which the anchors might affect the serviceability of the façade will be analyzed in further detail in Chapter 9: Comparative Analysis.

WOOLWORTH BUILDING

The Woolworth Building is no doubt architect Cass Gilbert's most famous skyscraper (see *Figure 4.6*). Built between 1911 and 1913, the Woolworth Building was constructed in New York City as the headquarters for the Woolworth Company, a large retail business. The highly decorative building was rendered in what some say is a merge of Gothic and French Empire styles. At 792 feet and 60 stories, the Woolworth stood as the tallest building in the world until 1931 when the Empire State Building secured the title.

Construction

The Woolworth Building is constructed of a riveted steel frame and clad with limestone-colored terra cotta glazed panels. The white terra cotta cladding is anchored back to the steel structure with iron straps. Set within the brick back-up wall, the original windows were copper clad double-hung hardwood windows. Thus, the building's construction is not unlike that of the Guaranty Building, a steel frame with exterior cladding anchored back to the structure with iron straps.

As building construction advanced, the debate about how the steel skeleton and exterior cladding should act together continued. Architectural critic Montgomery Schuyler said of the Woolworth building in a 1913 article, "For this [the Woolworth Building] is a distinctly utilitarian erection, to be justified of its utility, or not justified at all."[82] Although a highly decorative building, Schuyler asserts that its utility took precedent over its beauty. In fact, the earliest known scholar on architecture, Vitruvius, established that architecture should be a combination of *firmitatis*, *utilitati*s, and *venustatis* or strength, utility, and grace.[83] Though Schuyler believed that utility dominated the Woolworth Building and Sullivan believed ornament was primary to the Guaranty Building, it is evident that the way the three elements were integrated, one perhaps having more weight than another, was being tested during the first thirty years of skyscraper construction.

In a 1913 article, the building's structural engineer, Gunvald Aus, noted that architects had become more accepting of the steel clad system and less distraught by its apparent fraud: "Fortunately architects are gradually recognizing that steel and stone should act together in such a way that one does not have to guess the support of an apparently unstable structure…"[84] As time passed, more architects and engineers, in particular, believed the lines of strength in a building could actually be revealed through the cladding and in that way be true to its structure.[85] Even though more were being swayed that steel clad construction was not deceptive, it is true that the utility of the structure en masse was diminished. The walls of the steel structure had lost the function of supporting the floors

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[82] Montgomery Schuyler, "'The Towers of Manhattan,' and Notes on the Woolworth Building." Architectural Record Feb. 1913: 108.
[83] Part of Vitruvius's treatise *De Architectura* completed before 27 B.C.
[84] Gunvald Aus, "Engineering the Design of the Woolworth Building Cass Gilbert, F.A.I.A., Architect," The American Architect 26 Mar. 1913: 158.
[85] Ibid., 158.

and roofs. In the earlier masonry-bearing structure, the walls had been responsible for bearing load. The new purpose for the exterior walls was to make buildings habitable and beautiful.[86]

With the Woolworth Building as one of the finest examples of the new steel frame construction, Woolworth's engineer Gunvald Aus, claimed that architect Cass Gilbert was at the forefront:

> In fact, I think it is not too much to say that Mr. Gilbert is the leading exponent of modern steel frame architecture, in which the enclosing walls in a great measure serve to show the actual construction of the skeletal frame. There are probably no better examples of this form of architecture than the Woolworth Building and the West Street Building.[87]

Based on articles of the time, the Woolworth Building and its architect were indeed heralded as successes.

By the time construction was underway on the Woolworth Building, the choice of terra cotta for the exterior cladding was not a new concept. Though the production of terra cotta began in the United States in the late 1860s, and had been employed in the Guaranty Building fifteen years earlier, the practice of using terra cotta as a decorative material was barely more than a generation old.[88] It was a preferred material because it was less expensive than stone and it was extremely adaptable to the expression of the structure.[89] For roofs and cornices, it was also a more efficient and durable substitute for sheet metal.[90]

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[86] Ibid., 158.
[87] Ibid., 158-159.
[88] Ibid., 108.
[89] Ibid., 111.
[90] Ibid., 108-109.

Subsequent to its birth as a New York City landmark, the Woolworth has undergone numerous repair and restoration campaigns. Over the past 94 years of its existence, preservation philosophy has changed from generally being more invasive to less invasive. The Woolworth Building has endured the trajectory of those philosophies. While it is not possible to test the success of those campaigns and ideologies in the context of this thesis, service life analysis approximates the first service life of the original components of the building's vertical enclosure.

Service Life Analysis

The following outlines each component that comprises the Woolworth Building's vertical envelope and explains the service life value assigned to each.

Glazed Terra Cotta Veneer
Service Life = 35 years

The service life estimation for the Woolworth's terra cotta veneer was determined using a similar method to that applied to the Guaranty Building. The 40-year value for brick veneer was used and reduced by 5 years due to terra cotta's fairly porous properties and its reliance on glaze to protect from moisture absorption. For these reasons, the total adjusted service life is 35 years.

Copper Clad Hardwood Double-Hung Windows with (2) Panes of Plate Glass
Service Life = 40 years

For estimating the service life of the copper clad hardwood double-hung windows, the same B2 designation is used for the Woolworth as was applied to the Guaranty's hardwood double-hung windows. However, 5 years are added to the 40-year base value because of the copper cladding. Copper is an exceptionally durable, corrosion resistant material and provides an additional layer of protection to the wood window frame. Compared to other metals such as steel and aluminum, copper also outperforms them in urban environments like New York City where the building is located.[91]

Brick Back-up Wall
Service Life = 40 years

The brick back-up wall retains the 40-year service life value recommended in the HAPM Manual.

Rolled Steel Angle Lintel
Service Life = 35 years

The 40-year base service live value is established using the HAPM Manual's class A1 for hot rolled steel lintels. The 40-year base value is reduced by 5 years because the wall construction leaves a portion of the steel lintel exposed to the threat of corrosion caused by moisture. This condition can be seen in the section drawing (*Drawing 4.3*) wherein the terra cotta tile extends past the steel angle by no more than an inch and the wood frame of the window is installed to the underside of the steel angle and set back from the terra cotta. If moisture lingers at the intersection of these three materials, the lintel is in danger of corrosion, and its structural purpose might ultimately be compromised. Moreover, corrosion of the steel angle and the resultant expansion would eventually affect the integrity of the neighboring terra cotta veneer and wood window frame. It should be noted that the section drawing shows no sealants at this vulnerable joint. In fact, sealants were a nascent technology at the time and the first production of acrylic sealants occurred in the 1920s.

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[91] Part II: Metals Systems and Architecture 14 Mar 2007 <http://ocw.mit.edu/NR/rdonlyres/Architecture/4-461Fall-2004/46D31163-F862-461F-B314-D0E7506860C8/0/lect17b.pdf>.

Terra Cotta Iron Straps
Service Life = 15 years

The service life estimation for the iron straps is based on the Bolts and Fasteners category in the HAPM Manual. Given the limitations of the manual, the service life was determined based on the same G1 class 10-year default value for steel screws that was applied to the Guaranty Building's terra cotta iron anchors. The base value is increased by 5 years because iron has higher carbon content than steel and is therefore more corrosion resistant. Therefore, the adjusted service life of the iron straps is 15 years.

Conclusion

The aggregate results for the service life of the components in the Woolworth Building's vertical enclosure are displayed in *Graph 4.2*. The results are very similar to those of the Guaranty Building in which four of the five components have a service life of 35 years or more. Also similar to the Guaranty Building, the terra cotta iron straps are the outliers at a low 15-year service life. It may not be a surprise that the focus of the Woolworth Building's many restoration projects was the anchorage of the terra cotta units. The original iron anchors corroded fast and their placement within the exterior wall assembly did not allow for natural expansion and contraction (see *Drawing 4.3*).[92]

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[92] Theodore H.M. Prudon, "Saving Face: Preservation: Curtain Wall Restoration." Architecture: AIA Journal 79. 11 (1990): 105-110, 114.

Chapter 5: High-rises c. 1925

PSFS BUILDING

Built in Philadelphia between 1929 and 1932, the PSFS (Philadelphia Saving Fund Society) Building was designed by architects George Howe and William Lescaze (see *Figure 5.1*). The skyscraper rises 33 stories and is recognized for pioneering the American approach to modern architecture that frontrunners of the movement, Le Corbusier and Walter Gropius, were practicing in Europe. At a Museum of Modern Art exhibition in 1932, the same year the building was completed, the PSFS was immediately showcased as a key example of what American architects and critics coined the International Style, a distinctly American interpretation of the modern movement. This trend in architecture was characterized by reductive elegance.

The PSFS dominated Philadelphia's skyline as the city's tallest building until Helmut Jahn's Liberty One tower superseded it in 1987. The PSFS functioned as the Philadelphia Saving Fund Society's headquarters until the company's demise in 1992. Subsequently, the building was converted to a hotel and opened as the Philadelphia Loews Hotel in 2000. The building's listing on the National Register of Historic Places (1976) helped protect innovative aspects of the pioneering modern skyscraper throughout the renovation for its new use.

Prior to the construction of the PSFS, worldwide events such as World War I had a substantial and pivotal effect on the American building technology industry. The demand for building construction was heightened by the need to house production for mass quantities of ammunition and other war goods and deliver them in a timely manner. To control the fast-paced construction necessary to keep up with demands of the war, the War

Industry Board formed a building materials division in March 1918 to oversee the needs for products like brick, tile, Portland cement, and gypsum products.[93] In this way, the federal government's recommendations solidified industry standardization and regulation.

During the 1920s, thermal insulation had evolved in response to the increased use of the steel frame. The steel structure accelerated the need for cladding and therefore necessitated effective insulation and moisture transfer between the structure and the skin. Despite the aesthetic achievements steel and glass enabled, earlier experiments in glass, such as Walter Gropius's Bauhaus (1926) in Dessau, Germany, were largely ineffective with regard to insulation and moisture transfer. Notwithstanding the functional flaws, the Bauhaus's glass facade revealed deep transparency in its exterior skin and revolutionized the concept of a thin glass wall.

In 1930, researcher and writer Robert L. Davison also promoted a different form of exterior wall construction – a thin, metal insulated panel. He asserted that the new thin skin would consume less floor space and correspondingly increase the rentable square footage on the building's interior. It is not known if Davison's idea was actually ever built, but his drawings of the concept were published in a 1930 article in Chicago. The drawings showed metal-faced panels with 3" rockwool insulation behind them. The architects behind the design were Bowman Brothers, who also presented a project at the same 1932 MoMA exhibition where the PSFS was displayed.[94] The idea of a new curtain wall system that was

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[93] Michael A. Tomlan, "Building Modern America," Twentieth-Century Building Materials: History and Conservation, ed. Thomas C. Jester (New York: McGraw-Hill, 1995) 34-43.
[94] David Yeomans, "The Origins of the Modern Curtain Wall," APT Bulletin 32.1 (2001): 15.

lighter and thinner than the earlier masonry cladding was gaining more attention and began to be implemented in the late 1920s and early 1930s.

The PSFS Building's thin granite veneer and 4-story glass wall at the banking level exhibit how the PSFS attempted to achieve the thinness evident in the Bauhaus's façade (see *Figure 5.2*). In addition to the innovations of its exterior envelope, the PSFS was also the second skyscraper in the United States to be built with air conditioning.[95] Similar to Schuyler's claim that the Woolworth Building was ultimately utilitarian, in 1930 the Society's president described the PSFS to one interviewer as "ultra-modern only in the sense that it is ultra-practical."[96] In fact only five years prior to breaking ground on the PSFS, Le Corbusier proclaimed in 1924: "The century of the machine has awakened the architect."[97] Standardization, mass production, and prefabrication that emerged in during World War I provided a new technical framework that emphasized *utilitas* and motivated the modern era of American architects.

Construction

The PSFS Building is constructed of a steel frame and faced with veneers of two dominant materials: granite and brick. The façade's veneer is detailed with stainless steel and striped with horizontal stainless steel framed windows at the banking hall and punched with single-hung aluminum windows at the upper floors. The use of aluminum for the windows in the PSFS was among the very early large-scale implementations of the material for that

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[95] William H. Jordy, "PSFS: Its Development and Its Significance in Modern Architecture" The Journal of the Society of Architectural Historians 21.2 (May 1962): 53.

[96] George Howe, et al., "The PSFS Building, Philadelphia, Pennsylvania, 1929-1932," Perspecta 25 (1989): 136.

[97] Giedion, 215.

purpose.[98] The use of aluminum as a building material was relatively new with the first use of commercial anodized aluminum occurring in the 1920s. By 1900 a hydraulic press had been developed that was capable of extruding aluminum and other materials. This invention enabled the availability of aluminum on a commercial scale in 1920s. The newly popular metal revolutionized curtain wall construction.[99] The recognized success of the PSFS Building no doubt helped advance the use of aluminum windows.

At approximately 5 inches thick, the PSFS Building's granite veneer is much thinner than the terra cotta cladding used in predecessor high-rises, the Guaranty and Woolworth Buildings. In the late 1890s, the word *veneer* emerged as a term to describe building stone hand cut to as thin as 4 inches.[100] In the late 1930s, stone veneer began to gain acceptance as cladding for entire facades.[101]

In addition to the above-mentioned technologies, plate glass was installed in the PSFS Building's storefront system at the banking level and achieved the effect of a transparent and expansive surface. Considering that the first machine-drawn plate glass production occurred in Belgium in 1914, this was a notable achievement. Improvements in glass manufacturing throughout the 1920s facilitated commercial use of plate glass. Although plate glass as a single material does not have a major effect on a building's service life, it was an innovation that enabled the advancement of other technologies. As plate glass technology improved and the allowable widths of the glass increased, the allowable module

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[98] Jordy, 58.
[99] Stephen J. Kelley, "Aluminum," Twentieth-Century Building Materials: History and Conservation, ed. Thomas C. Jester (New York: McGraw-Hill, 1995) 48.
[100] Michael J. Scheffler and Edward A. Gerns, "Thin Stone Veneer," Twentieth-Century Building Materials: History and Conservation, ed. Thomas C. Jester (New York: McGraw-Hill, 1995) 168.
[101] Ibid.

for curtain wall systems also expanded. Thus, plate glass had a major impact on the subsequent metal and glass systems employed in high-rises.

Even though the PSFS utilizes plate glass, its use is limited to the banking level fenestration so the majority of the façade is not dominated by large expanses of glass (see *Figure 5.2*). On the contrary, the widespread use of granite and brick on the exterior presents the solidity of fine masonry. Thus, the PSFS embodies elements of the forward-looking reductive elegance of the International Style as well as elements that look back to the earlier masonry-clad skyscrapers. Its modern, streamlined aesthetic, the aluminum windows, and the thinness manifest in the glass and stone exhibit ways in which the PSFS Building departs from its predecessors, the Guaranty and the Woolworth Buildings.

In a 1949 article published in *Architectural Record*, author Frederick Gutheim remarked that the 17-year old PSFS was ageing gracefully. Questioning its preservation and potential to make a good ruin, Gutheim wrote: "We can see that a modern building does not age in the same way a traditional building does. Modern materials – and double entry book-keeping, perhaps – assure that in age the modern building will have a special charm of its own that we have not known before."[102] Gutheim suggests that, in some ways, the style has aged, not the building.[103]

Service Life Analysis

The service life analysis attempts to assess how the components in the PSFS's vertical enclosure were estimated to age since the time of their original implementation. The

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[102] Frederick Gutheim, "Saving Fund Society Building: A Re-appraisal," Architectural Record Oct. 1949.
[103] Ibid., 139.

analysis also tests whether these components indicate service lives different from traditional building components employed in the Guaranty and Woolworth Buildings. The following outlines each component that comprises the PSFS Building's vertical enclosure and explains the service life value assigned to each.

6" Granite Veneer
Service Life = 40 years

The granite veneer retains the HAPM Manual's 40-year service life estimate for natural stone.

Brick Veneer
Service Life = 40 years

Likewise, the brick veneer is assigned a 40-year service life as suggested for facing brick in the HAPM Manual.

Aluminum Single-hung Windows
Service Life = 25 years

Starting with a 30-year service life derived from the HAPM Manual's class C1 for anodized aluminum windows, 5 years are deducted from the base value for the following reasons. The window has no thermal break and has only a single pane of glass. Both conditions can cause condensation inside the window system. Moreover, a service life table presented on Kesik's website suggests a 22-year average service life for aluminum single-hung windows. This value originates from more recent data published in 2000 that includes service life estimates for wall elements in Canadian high-rise residential buildings.[104]

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[104] Ted Kesik, Enclosure Durability. Architectural Science Forum: 2002. <http://www.canadianarchitect.com/asf/enclosure_durability/>.

Therefore, an adjusted 25-year service life value for the PSFS's aluminum windows more closely aligns with the 22-year average service life.

Concrete Back-up Wall
Service Life = 40 years

In the HAPM Manual all concrete blocks except those of indeterminate strength are assigned a nominal 40-year service life.

Steel Angle Lintel
Service Life = 35 years

The 35-year service life value of the steel angle lintel is based on the HAPM Manual's value for a mild steel section described as hot dipped and galvanized. This value is not adjusted because the steel angle appears to be embedded in the concrete back-up wall such that it is reasonably protected from moisture infiltration at the exterior.

Bolts
Service Life = 30 years

The service life for the bolts used to fasten the windows to the structure is determined by using the HAPM Manual's class C1 for anodized alloy fasteners. The manual assigns these fasteners a 30-year service life. Because the fasteners in the section drawing are not labeled, it is assumed that they are aluminum to avoid a galvanic reaction caused by the interaction of dissimilar metals.

Aluminum Flashing
Service Life = 25 years

Due to the shortcomings of the HAPM Manual, the service life of aluminum flashing is based on class E1 for a flat roof installation of commercial grade aluminum flashing, which assigns a 20-year service life. Because the flashing is installed within the wall and not fully exposed to the weather as in a roof condition, five years are added to its service life. Thus, the total adjusted service life for aluminum flashing is 25 years.

Conclusion

The graph displaying the service lives of all components in the vertical enclosure of the PSFS Building reveals that four of the seven components total a 40-year service life (*Graph 5.1*). The other three components have a respectable service life between 25 and 30 years. Therefore, the range of service life values is from 25 years to 40 years. Unlike the earlier Guaranty and Woolworth Buildings, no single component dips below a 25-year service life estimate.

Chapter 6: High-rises c. 1950

LEVER HOUSE

When construction of Lever House was completed in 1952, it immediately set a precedent for modern architecture and glass and metal curtain wall construction in America (see *Figure 6.2*). The 1950s marked a new era of design motivated by the tenets of the modern movement, and Lever House was looked to as an exemplary model. Few buildings in the postwar era reached the level of recognition amongst the masses as did Lever House. The 24-story high-rise was designed by SOM Architects and built exclusively to house the office headquarters for the Lever Brothers Company, a soap manufacturer, who occupied the building until the late 1990s.

The designs of modern skyscrapers of the late 1940s and early 1950s, such as Lever House, adapted and employed many technological advancements associated with World War II. Although the curtain wall emerged in the late 19th century, the 1950s marked the era in which the glass and metal curtain wall system was developed as a commercial product.

Construction

Lever House is a steel-framed structure enclosed in a blue-green glass and stainless steel curtain wall system. All horizontal mullions and muntins are clad in 16-gauge Type 302 stainless steel and anchored back to steel channel sections (see *Drawings 6.2* & *6.3*). Placed in front of the horizontals, the vertical mullions project out and break up the glass surface. The verticals are constructed of a pair of steel channels and are at least twice the size of the horizontals in section. Unlike the PSFS Building, Lever House has no operable sash. Although the building does not have operable windows to aid ventilation, the heat resistant glass installed at the spandrels was purported to reduce the air conditioning load and the sun glare.[105]

Upon the building's completion in 1952, an article in *Architectural Record* explained how the materials and components in Lever House were integral to its modern design:

> As much as the entire open first floor and the thin taut materials, this idea makes the building stand clear and light and multiplies the significance of its industrial components; at the same time this detail of design also asserts the architects' function in our civilization beyond that of being merely a good mechanic.[106]

In 2002, Lever House underwent a major restoration in which the entire curtain wall was removed and re-skinned with a new system that was visually "in-kind" to the original, but with many technical improvements (see *Figures 6.1* & *6.2* and *Drawing 6.1*). Even if the same 1950s curtain wall system were available, it was not desirable to reproduce the same system because of the inadequacies and failures of the original (these issues will be discussed in further detail in Chapter 10). Though the original curtain wall has already been replaced, this service life analysis strives to assess the lifespan of the *original* curtain wall compared to other high-rise vertical enclosures.

Service Life Analysis

The following outlines each component that comprises the Lever House's vertical enclosure and explains the service life value assigned to each.

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[105] "Lever House, New York: Glass and Steel Walls," Architectural Record June 1952: 131.
[106] "Lever House Complete," Architectural Forum June 1952: 104.

Stainless Steel and Glass Curtain Wall with Heat Resistant Wire Glass (at Spandrel) Service Life = 25 years

Since the HAPM Manual does not provide component lives for glass and metal curtain walls, other sources were consulted to estimate a reasonable service life of Lever House's curtain wall. A contemporary aluminum curtain wall system carries a warranty of only ten (10) years. This information is based on the EFCO Company's standard aluminum curtain wall.[107] The nominal 10-year warranty likely reflects a conservative estimate in an attempt to limit the manufacturer's liability. The warranty does not assume that the system would suffer complete failure after the coverage period ends.

The service life estimate for Lever House's original stainless steel-framed curtain wall considers both the warranty information and the estimate suggested by the HAPM Manual for steel double-hung windows. It should be noted that even an operable system, such as Hope's Windows steel double-hung windows, carries the same 10-year warranty. Alternatively, the HAPM guide suggests a 25-year service life for steel windows hot dip galvanized and painted on site. Unfortunately, drawings and articles have not revealed the manufacturing process used for curtain wall's steel frame construction. The HAPM guide also specifies that steel windows be maintained by refinishing the steel after 20 years and every five years thereafter. It also assumes that sealants and weatherstripping will be replaced at 20 years.

In addition to the above stated sources, Kesik's website on enclosure durability suggests an average 35-year service life for a curtain wall system.[108] This estimated lifespan

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[107] The EFCO Company is a prominent curtain wall manufacturer that has been in existence since the 1950s.

[108] Since the table is not explicit, it is assumed that the curtain wall system referenced in the table is a glass and metal system.

value originates from a May 2000 publication by the IBI Group for Canada Mortgage and Housing Corporation that evaluated component lives for residential high-rise projects in Canada.

In sum, the warranty estimates 10 years, the HAPM suggests 25 years, and the Canadian source recommends a 35-year service life. No single source provides an estimate that adequately describes Lever House's curtain wall system. Since the warranty is conservative and largely motivated by liability concerns, it is jettisoned as a probable service life value. The 25-year value from the HAPM guide does not take into account the characteristics of curtain wall construction; rather, it assumes a traditional hung window. Given the publication date, the Canadian source's 35-year service life estimate is probably modeled after a contemporary curtain wall system, which likely incorporates improved technologies that Lever House's original curtain wall did not. Despite the shortcomings of these sources, an average of the HAPM and Canadian source values provides a base value from which to adjust. The average of these two values provides a base value service life of 30 years.

After arriving at a 30-year base value, this value is deducted by 5 years due to the inadequacies of the Lever House system. Since there are no thermal breaks, and steel connectors and fasteners are used extensively throughout the wall, the entire system is more susceptible to corrosion caused by moisture infiltration.[109] In addition, the experimental use of a polysulfide sealant at the joints makes the system particularly vulnerable to weathering upon premature failure of the sealants. It is important to mention that since Lever House

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[109] Theodore H.M. Prudon, "Saving Face: Preservation: Curtain Wall Restoration," Architecture: AIA Journal 79. 11 (1990): 109.

has garnered so much attention throughout its history, much has been written about its construction and its subsequent decay. The information in published articles has informed the analysis. The total adjusted service life is 25 years.

The multiple considerations necessary to calculate a reasonable service life for the Lever House curtain wall underscores the experimental nature of enclosure technology at the time and the shortcomings of current service life research.

Polysulfide Sealant
Service Life = 15 years

Polysulfide sealant was the first elastomeric sealant used for curtain wall construction in this period.[110] Although the use of polysulfide sealants signaled their widespread acceptance, their ultimate failure motivated the sealant manufacturers to produce longer lasting sealant products. This factor may have been considered in the HAPM's service life estimate for the polysulfide sealant, which is 20 years. This base value is reduced by 5 years because the sealant was installed while the product was still in its developmental stage. In other words, the sealant had not been proven effective for curtain wall construction before it was integrated into Lever House's curtain wall system.

Rolled Steel Angle Lintel
Service Life = 40 years

Similar to the method used for the PSFS Building, the same 40-year service life suggested by the HAPM Manual is applied to the steel angle lintel in Lever House.

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[110] Stephen J. Kelley and Dennis K. Johnson, "Metal and Glass Curtain Wall: History and Diagnostics," <u>Modern Heritage Movement</u>, ed. Allen Cunningham (London; New York: E&FN Spon, 1998) 79.

Stainless Steel Clips
Service Life = 20 years

The HAPM Manual advises a 20-year service life for "steel fixings of Class 2: minimum zinc coating of 30 microns." As in many previous cases, it is not known how the stainless steel clips were coated. Nonetheless, this is the description in the HAPM Manual that best matches the clips employed in Lever House and so a 20-year service life is estimated for the purposes of this analysis.

Steel Straps (12 Gauge)
Service Life = 35 years

Since the steel straps in Lever House essentially act as cavity wall ties, the Cavity Wall Ties category in the HAPM Manual is used. Class B1 describes a masonry wall tie manufactured of stainless steel and assigns it a 35-year service life.

Cinder Block Back-up Wall
Service Life = 40 years

In the HAPM Manual all concrete blocks except those of indeterminate strength are given a 40-year service life estimate. Employed in Lever House, *cinder block* is a 20th-century phenomenon. In 1917, F.J. Straub patented *cinder blocks*, which used a lighter weight aggregate to decrease the weight problem of the earlier concrete block. By 1926 Straub was producing more than 70 million blocks annually from his plant in Lancaster, Pennsylvania.[111] By the time cinder block was installed in Lever House, the terms cinder block and concrete block were used interchangeably.

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[111] Simpson, Hunderman, and Slaton, "Concrete Block," Twentieth-Century Building Materials: History and Conservation, ed. Thomas C. Jester (Washington, D.C.: McGraw Hill, 1998) 82.

Glass Wool Insulation
Service Life = 35 years

Two inches of glass wool insulation is applied to the inside of the cinder block wall and in the gap between the vertical mullion and the cinder block wall (see section and plan drawings *Figure 6.3*). To account for this component, the HAPM Manual assigns a 35-year service life to "man made flexible resilient glass fibre rolls."

Since the insulation is applied to the cinder block wall and the vertical mullions and is located approximately 10 inches away from the exterior face, it does little to help insulate the glass and steel curtain wall.

Stainless Steel Flashing
Service Life = 30 years

Like the method used for the flashing in the PSFS Building, service life of the metal flashing in the Lever House is based on designation C2, a flat roof installation of stainless steel flashing. The base value for this designation is a 30-year service life. Because this flashing is installed within the wall and not fully exposed to the weather as in a roof condition, 5 years are added to its service life, adjusting the total service life for stainless steel flashing to 35 years. Then, 5 years are deducted from the service life because the flashing is so integral to the stainless steel curtain wall system that is it susceptible to corrosion by moisture. Thus, the 5 years added for the wall installation and the 5 years deducted for the curtain wall cancel each other out and the total service life of the stainless steel flashing remains 30 years.

Conclusion

The results of the service life analysis for Lever House are illustrated in *Graph 6.1*. Four of the eight components have an estimated service life of 35 years or more. One component, the stainless steel flashing, has a service life of 30 years, but the remaining three components have a service life below 25 years. These three components comprise the outermost portion of the exterior assembly. Of the three, the polysulfide sealant is the most ephemeral with a service life of only 15 years. As noted earlier in the discussion on Lever House, its curtain wall was experimental for the time. The service life results seem to prove that the experimental nature of the components effectively shorten the life of its vertical enclosure. Moreover, since the outermost components of the system have the shortest service lives, the building is particularly susceptible to weathering.

ALCOA BUILDING

To showcase both the innovations and standard uses of their product, Alcoa (Aluminum Company of America) chose to clad their new corporate headquarters entirely in aluminum (see *Figure 6.5*). Alcoa selected New York architects Harrison & Abramovitz to execute the design of the first tall office building ever erected with an all-aluminum skin. Located in Pittsburgh, the 32-story Alcoa Building was completed in 1953. Upon its completion one writer called it the most daring experiment in a modern office building.[112]

The Alcoa Building's all-metal cladding was an alternative response to the growing prominence of glass curtain wall construction, which had gained popularity in the past

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[112] "Alcoa Complete: Pittsburgh's 3-story Aluminum Waffle is America's Most Daring Experiment in Modern Office Building," Architectural Forum Nov. 1953: 125.

decade. This alternative was a direct reaction to buildings like Lever House (1952), discussed in the previous section.

The architectural application of aluminum in the United States traces back to the late 19th century. The first recorded architectural use of aluminum in this country was the aluminum cap cast for the Washington Monument in 1884.[113] By 1888, the Pittsburgh Reduction Company, which was later named the Aluminum Company of America (Alcoa), was established and employed a commercial process for producing aluminum in large enough quantities to generate economical prices. This electrolytic process was called the Hall-Heroult process and the same method is still utilized today.[114] By establishing itself early and using this method, the Alcoa Company essentially pioneered the commercial production of aluminum in the United States. There was no purer expression of the company's high-reaching pursuits than a skyscraper clad in aluminum.

Construction

Like the previous high-rises, the Alcoa Building is framed in steel. In this case the steel is fireproofed with foam concrete.[115] Its frame is protected and sheathed in oxford-gray aluminum panels, finished with a clear, liquid plastic coating. Pivoted porthole-like aluminum windows penetrate the aluminum panels (see *Figure 6.6*). The exterior cladding is all panelized construction. The aluminum cladding and pivoted window assembly was prefabricated and assembled off-site then anchored to the structural frame one panel at a

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[113] Stephen J. Kelley, "Aluminum," Twentieth-Century Building Materials: History and Conservation, ed. Thomas C. Jester (Washington, D.C.: McGraw Hill, 1998) 47.
[114] Ibid., 47.
[115] "Alcoa Building: Innovations in Aluminum," Architectural Record Aug. 1952: 123.

time. The Alcoa Building was one of the first buildings to use prefabricated curtain wall panels.[116]

The technology of the Alcoa Building in many ways defines its style. In fact, Alcoa marketed aluminum by proclaiming that it was adaptable to decoration.[117] The prefabricated, pressed aluminum panels on the building decorate the facade in a waffle-like pattern. As the clients intended, the construction method employed to make the skin, such as pre-stamping, is celebrated on the exterior. In an article from *Architectural Forum* published in July 1952, author Jack Holmes said of the new high-rise:

> For this tower is more than a handsome piece of architecture. It is also a testing laboratory, erected almost regardless of cost, to try out every possible use for aluminum in building. And, it is, perhaps the greatest challenge ever thrown down to the copper industry, which normally sells 30% of its total production to the building industry largely for which aluminum is here substituted.[118]

It is true that the Alcoa Company was taking a gamble on many fronts. If their building failed to impress architectural critics, their workers, and their customers, Alcoa's $20 million investment (the building) could be a catastrophic failure for their thriving business in aluminum manufacturing. Yet they put it all to the test.

In addition to the aluminum cladding, the Alcoa Building was also the first to use pivoted air-inflated gasketed windows. These windows are double-glazed with heat resistant exterior panes. The synthetic rubber tubing around each window is pneumatically filled with air. It was not until later in the mid-1950s that another form of rubber sealant, butyl rubber

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[116] Kelley, "Aluminum" 49.

[117] Ibid., 46.

[118] Jack Holmes, "Facet Metal Wall for Alcoa in Pittsburgh Sets New Style in Tall Buildings," Architectural Forum July 1952: 135.

sealant, was available to the construction industry. Butyl rubber was developed to provide a synthetic alternative to natural rubber, which was in high demand before and during World War II.[119] Instead of using concrete block as the back-up wall for the aluminum panels, a new cementitious material called Perlite was sprayed on aluminum lath to provide the infill between the steel frame. Perlite-concrete is a lightweight concrete that was developed in the late 1940s and early 1950s.[120] Perlite is not a proprietary name; rather, it is an aggregate added to a concrete mixture to effectively reduce its weight. The resultant composite is distinguished for its sound deadening, thermal insulating, and fireproofing properties. The use of Perlite-concrete and aluminum cladding was an attempt to make the high-rise a lighter weight structure.

In relation to all components employed in the Alcoa Building, the use of aluminum is intentionally pervasive. Along with Alcoa's premier product, aluminum, how were the components in the building's vertical enclosure projected to endure given the prefabrication methods employed and the innovative qualities of the components? To test this question, service life analysis attempts to measure the lifespan of the Alcoa's components.

Service Life Analysis

The following outlines each component that comprises the Alcoa Building's vertical enclosure and explains the service life value assigned to each.

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[119] Michael J. Scheffler and James D. Connolly, "Building Sealants," Twentieth-Century Building Materials: History and Conservation, ed. Thomas C. Jester (Washington, D.C.: McGraw Hill, 1998) 274.
[120] Perlite.info, 19 April 2007, <http://www.perlite.info/hbk/0031443.html>.

Stamped Aluminum Panels
Service Life = 30 years

There is no provision for a metal-paneled cladding system in the HAPM Manual. Therefore, the service life of the aluminum panels is based on another exterior metal application, that of Coping Systems. For an aluminum coping system, the HAPM Manual recommends a 20-year service life.

The diamond-shaped geometry of the panels makes them self-cleaning in the sense that water should naturally shed from the panel rather than linger and cause residual damage. Any moisture that hits the building will be directed to the joint. However, the interlocking joint between panels should provide for adequate drainage.[121] It is assumed that the 20-year value factors in a harsh exterior condition that a coping system typically endures. Since the aluminum panels are part of a curtain wall system, Kesik's 32-year minimum estimate for a curtain wall is also considered in conjunction with the 20-year value. Factoring both the joint design and the 32-year estimate, the total service life of the aluminum panels in the Alcoa Building is adjusted to 30 years.

Aluminum Center-Pivot Windows
Service Life = 35 years

The service life of Alcoa's center-pivoted aluminum windows is based on the 30-year base value provided by the HAPM Manual's class C1 for aluminum windows. The design intent for the Alcoa Building's fenestration was to employ a window that was capable of being cleaned from the inside.[122] Because the pivot function allows the windows to be accessed for maintenance and repair when necessary, five years are added to the service life

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[121] There is no sealant between the aluminum panels. Further investigation is necessary to augment the existing information and to fully understand how moisture drains from the interlocking joint between panels.

[122] "Office Buildings: Fenestration," Architectural Record Apr. 1955: 207.

of the center-pivot windows. The windows also incorporate heat-absorbent glass, which reduces thermal expansion and extends the life of the entire window system. Thus, the total adjusted service life for Alcoa's aluminum windows is 35 years.

Aluminum Sheet Lath
Service Life = 20 years

Aluminum sheet lath is the surface to which the Perlite concrete is sprayed (see *Drawings 6.4, 6.5* & *6.6*). The service life of the lath is based on the HAPM's Render Lath section, class E2 that describes an aluminum mesh. For this category, the suggested service life is 20 years.

Perlite-Concrete Sprayed Back-up Wall
Service Life = 35 years

Since Perlite-concrete acts like a concrete block back-up wall in this installation, the concrete block base value from the HAPM guide is utilized to estimate its service life. Five years are deducted from the 40-year base value because at the time it was installed in the Alcoa Building it remained an unproven technology. Therefore the total adjusted service life of the Perlite-concrete back-up wall is 35 years.

Pneumatic Synthetic Rubber Tubes
Service Life = 20 years

The pneumatic synthetic rubber tubes used to seal the pivoted windows are a more substantial sealant than a simple rubber caulk described in the HAPM Manual. In lieu of an adjusted value derived from the HAPM guide, an article on the Alcoa Building states that the Alcoa Company originally estimated the pneumatic gaskets to last at least 20 years. Thus, the service life used for this analysis is 20 years.

Steel Fasteners
Service Life = 25 years

In the Alcoa Building, steel bolts and fasteners are positioned within the Perlite-concrete back-up wall to anchor it back to the reinforced concrete steel structure (see *Drawing 6.6*). The fasteners' service life is derived from the HAPM Manual's class D1 for steel threaded, galvanized components, which assigns a 25-year service life. Since they are embedded within and anchored to the concrete structure, the threat of a galvanic reaction between the steel fasteners and the adjacent aluminum lath is diminished. Therefore, the base value is not adjusted and remains at 25 years.

Metal Flashing
Service Life = 25 years

Although the drawings do not explicitly call out aluminum as the flashing material, given the client and the pervasiveness of aluminum in the building it is assumed that the flashing is of aluminum. Based on the roof flashing section of the HAPM Manual, the service life given for commercial grade aluminum flashing for a flat roof is 20 years. Five years are added to the base value because of its use within the wall construction. Therefore, the total service life is adjusted to 25 years.

Conclusion

Graph 6.2 shows the service life values of all components employed in the vertical enclosure of the Alcoa Building. Only two of the seven components scored a service life of 35 years or more. Two components are estimated to have a 25 to 30-year service life while the remaining two components share a 20-year service life value. The total service life values range from 20 to 40 years. Unlike Lever House, which was completed only one year prior to the Alcoa, the outermost components have higher service lives at a 30-year service life for the aluminum panels and a 35-year service life for the center-pivot aluminum windows.

SEAGRAM BUILDING

Situated diagonally across from the Lever House on Park Avenue in New York City, the Seagram Building (Seagram) joined its modern skyscraper cousin when ground broke for construction on the building in 1954 (see *Figure 6.7*). This high-rise was a realized form of the all glass skyscraper prototype conceived of forty years prior by its architect Mies van der Rohe. Although Mies van der Rohe is most often credited with the design, it was a collaborative effort with rising New York architect Philip Johnson. Once the building was completed in 1958, its final form became a testament to the majesty modern design could achieve and the potential outcome that proponents of modern architecture had been advocating for the past few decades.

At the time Seagram was built, the New York zoning code allowed a tower of unlimited height if it did not consume more than 25% of its site. The Seagram Building's footprint used 50% of the site, reaching the highest permissible height within zoning restrictions at 39 stories and 516 feet.[123] The Seagram Companies, a distiller of alcoholic beverages, commissioned the modern structure to serve as their new corporate headquarters and ended up occupying a quarter of the office space upon its completion.

Just like the Alcoa Building and Lever House from the same decade, the Seagram Building employed numerous innovative technologies. Adding to the ongoing emphasis on innovation in high-rise design, the title of an article from *Engineering News-Record* stresses that

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[123] Peter Carter, Mies van der Rohe at Work (London: Phaidon Press Limited, 1999) 38-63.

characteristic of the Seagram: "A Skyscraper Crammed with Innovations."[124] Despite the common factor of technological innovation, author Stanley Tigerman suggests that Mies achieved an elegant and harmonious proportion in the Seagram facade that is lacking in the earlier Lever House.[125]

Mies van der Rohe's view that architecture was an autonomous aesthetic practice also manifested itself in the design of the Seagram Building. Mies felt that a singular building did not necessarily need to be individualized; its expression and technology could be applied and mass-produced. Many subsequently adopted the building's aesthetic and technologies even in design projects that may not have had as generous a budget as did the Seagram Building. Tigerman contends that Mies's intention that architecture be capable of emulation was, when applied by others, only simulation. Many architects who attempted to copy Mies fell short of the philosophical rigor, fundamental understanding of technology, aesthetic sensibility, and structural logic that Mies had mastered.[126]

Finally, Tigerman asserts, "Even as Madison Avenue manipulated new trends and tailored taste, Mies buildings continued to demonstrate not only intrinsically good taste, but also permanence – a commodity longingly sought but sparingly achieved."[127] This service life analysis tests the permanence that Tigerman suggests the Seagram Building possesses and attempts to assess how long the original building components were projected to last before requiring replacement or renewal.

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[124] "A Skyscraper Crammed with Innovations," Engineering News-Record, [Date unknown]: 8-9. David Guise Collection. Architectural Archives of the University of Pennsylvania, Philadelphia, Pennsylvania.
[125] Stanley Tigerman, "Mies van der Rohe: A Moral Modernist Model," Perspecta 22 (1986): 123.
[126] Ibid., 123.
[127] Ibid., 121.

Construction

The Seagram is a bolted steel framed building with its steel columns encased in concrete fireproofing. Congruous with its structural frame, the exterior skin is also constructed in a stick-like manner. The so-called sticks of the frame are bronze and compose a fixed curtain wall system with bronze plates at the spandrels. Topaz-tinted heat-absorbing plate glass is installed within the bronze frame (see *Figure 6.8*).

One of the Seagram Building's touted innovations is the choice of bronze for the mullions and spandrel plates. In an article about the building's innovative qualities, the author explains the decision: "Bronze was selected for the exterior because of its color, both initially and after aging; its corrosion resistance and its extrusion properties, which permit extruding the mullions with sharp edges – an effect desired by the architect."[128] It was intended that the bronze be rubbed occasionally with oil, which would make the bronze darken and become a richer color.[129] Moreover, the use of the extruded mullion was an architectural aesthetic that Mies pioneered. He essentially used a structural component, the I-section, for exterior adornment rather than for a structural purpose.

In addition to the innovative I-section bronze mullion, the Seagram Building does not have walls in the conventional sense. Some contend that this was a groundbreaking achievement, but Lever House has a similar condition wherein the exterior cladding is essentially a framework of metal and glass. In the Seagram Building, back-up walls between the steel frame are, in effect, eliminated. Its curtain wall system was installed in sections of prefabricated grills. By the late 1950s prefabrication had generated much attention and

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[128] "A Skyscraper Crammed with Innovations."

[129] Drexler, 142.

garnered a respectable amount of reverence and widespread acceptance. Prefabrication was viewed as the wave of the future for building technology. Its proponents argued that it effectively reduced time and costs for the client and the builder.

According to architectural magazine articles of the period, the prefabricated technology in the Seagram Building did not compromise the integrity of the workmanship. In an article of 1958, architectural curator of New York's Museum of Modern Art, Arthur Drexler praised the materials and the craft: "It is also his [Mies's] first large building in the United States to be executed with the fine materials and craftsmanship characteristic of his European work."[130]

With regard to Mies' vertical articulation on the exterior actually complementing the structure rather than revealing the it, architectural critic Lewis Mumford remarked:

> This is however a logical treatment of the curtain wall, for the very nature of a curtain wall is to be detached from the structure, not to support it; if anyone should doubt this detachment, the barely visible segmentation of those vertical fins, to allow for the expansion and contraction of the metal they are made of, should settle the matter.[131]

Previous discussions on the Guaranty and Woolworth buildings exposed how in the first period of skyscraper design architects and critics struggled to define the relationship between the steel structure and the exterior cladding. With the design of the Seagram Building, Mumford implies that skyscraper design had come closer to achieving a harmonious, and perhaps more acceptable, condition between structure and exterior cladding. Mies may have been more successful in achieving this condition than contemporary architects because he

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[130] Arthur Drexler, "The Seagram Building," Architectural Record July 1958: 141.

[131] Lewis Mumford, "The Lesson of the Master," Architecture: AIA Journal Jan. 1959: 20.

understood the possibilities and limitations of American industrial production. In the 1957 article, "Machine Made America," McCallum says of Mies's machine-inspired architecture: "He (Mies) has produced a lyricism of two constituent US psychological facts – unlimited space and unmitigated technology – in a form that is neither provincial nor crude, and can be held up to the rest of the world as an example of a convincing machine-age architecture."[132]

Tigerman said of the material decisions for the Seagram and other Mies buildings of the same era: "The materials used in these buildings were clearly meant for the long term: stainless steel, bronze, hard-coated and anodized aluminum, verde antique marble, travertine, and terrazzo."[133] If the long-term intention of the bronze material in the Seagram is accepted, does an estimate for the building's service life coincide with the long-term intention rooted in the material choice?

Service Life Analysis

The following outlines each component that comprises the Seagram Building's vertical enclosure and explains the service life value assigned to each.

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[132] Ian McCallum, ed. "Machine Made America," Architectural Review May 1957: 339.
[133] Tigerman, 121.

Fixed Bronze Curtain Wall
Service Life = 40 years

The HAPM Manual makes no provisions for bronze as a building material or for a fixed glass and metal curtain wall system. As such, two alternative sources were consulted: Hope's Windows and Kesik's website on durability.[134]

For a bronze and glass system, Hope's Windows provides a mere 5-year warranty. This coverage is five years fewer than the warranty the company provides for a comparable system in steel. Without knowing the reasoning behind the discrepancy, the relationship seems counterintuitive. Since bronze is more corrosive resistant and performs better than steel in an urban environment, one would reason that when used in an exterior application, it would have greater durability.[135]

Like the method used for Lever House, the information published on Kesik's website suggests an average 35-year service life for a curtain wall system and is used as a base value. This is deducted by 5 years due to the lack of thermal breaks needed to prevent internal condensation. On the other hand, the exceptional durability and corrosive resistant properties of the bronze material adds 10 years to its base service life. Thus, the total adjusted service life is 40 years.

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[134] Ted Kesik, Enclosure Durability, Architectural Science Forum: 2002. <http://www.canadianarchitect.com/asf/enclosure_durability/>.

[135] Part II: Metals Systems and Architecture, 14 Mar 2007, <http://ocw.mit.edu/NR/rdonlyres/Architecture/4-461Fall-2004/46D31163-F862-461F-B314-D0E7506860C8/0/lect17b.pdf>.

Pressed Bronze Spandrel Panel
Service Life = 35 years

The service life estimate for the Seagram's bronze panels employs the same method used to approximate the serviceable lifespan of the aluminum panels in the Alcoa Building. The base value stems from the HAPM Manual's section on Coping Systems. Since this section does not include bronze as a possible coping material, an aluminum coping system is assumed to generate a base value for which a 20-year service life is recommended. This value is then adjusted by adding 10 years for the exceptional corrosion resistant properties of bronze. In addition to the base value, Kesik's 32-year minimum estimate for a curtain wall is considered since the bronze panels are employed within a curtain wall system. In this way, the total adjusted value for the bronze panels is adjusted up to a 35-year service life.

Neoprene Spacers
Service Life = 20 years

Since neoprene is not included in the HAPM Manual's list of sealants, the base service life value of the neoprene spacers is derived from the lifespan suggested for polyurethane. The polyurethane sealant is used because its chemical compounds are most similar to those of neoprene. Therefore, the service life of the neoprene spacers is 20 years.

Stainless Steel Bolts
Service Life = 25 years

The service life of the stainless steel bolts is based on the HAPM Manual's class D1 for stainless steel bolts and fasteners, which recommends a 25-year service life.

Copper Flashing/Condensation Channel
Service Life = 40 years

Like the flashings of the previously discussed buildings, the HAPM Manual's category for roof flashing is used to estimate the service life value of copper flashing in the Seagram. For copper flashing installed on a flat roof, the HAPM assigns a 30-year service life. Because copper is highly corrosive resistant and, in this application, it is installed within the vertical enclosure, 10 years is added to its service life. Thus, total adjusted service life is 40 years.

Conclusion

Graph 6.3 illustrates the total service lives of all components in the Seagram Building's vertical enclosure. By studying the relationships of all components displayed in the graph, it is revealed that two of the five components have a service life in the uppermost range of values with a 35-year and 40-year lifespan. The remaining three components fall within the 20-year and 30-year service life range. The range of service life values of the Seagram Building's vertical enclosure spans from 20 years to 40 years.

Within this range, the neoprene spacers have the lowest estimated lifespan at 20 years and the copper flashing/condensation channel score the highest service life at 40 years. Both these components serve an important purpose within the façade. The copper flashing is recessed from the face and is positioned to drain any trapped moisture to prevent it from lingering within the curtain wall assembly. The neoprene spacers seal the glass within the bronze frame of the curtain wall. One could argue that since the neoprene spacers are exposed to the most weathering, they should have a service life equal to that of the copper flashing, at a minimum. In this case, the service life of neoprene spacers is half that of the copper flashing.

The bronze curtain wall, however, has the highest service life value at 40 years. This is largely attributable to its construction in bronze, a highly durable material. The lack of thermal breaks in the system suggests that the thermal properties of the wall might require improvement. Future adjustments or additions to the original curtain wall might be necessary to increase its thermal performance.

Chapter 7: High-rises c. 1975

CITICORP CENTER

Hugh Stubbins and Associates designed the Citicorp Center in association with Emery Roth & Sons. Upon its completion in 1977, the Manhattan high-rise was immediately recognizable by its slanted top (see *Figure 7.1*). At the street level, the form of the high-rise is a response to unusual site constraints whereby the former owner of the site, St. Patrick's Church, required a corner of the block to build a new church and would not allow columns of the new building to invade its area. Needing to clear space for the new church, the Citicorp Center stands on four massive, nine-story high columns positioned at the center of each side rather than at the corners (see *Figure 7.2*). The skyscraper appears to achieve its status as a "proud and soaring thing" by defying gravity and appearing weightless on its nine-story stilts. Reaching its peak at 59 stories and 914 feet, the Citicorp became the seventh tallest building in the world.[136] In his article on skyscrapers, architect Cesar Pelli claims that Citicorp was among the buildings that marked the termination of the third period of skyscraper design with their emphasis on accommodation and, in the case of Citicorp, creating a distinguishing object-like profile.[137]

In a letter to his client, First National City Bank (later named Citicorp), Hugh Stubbins expressed his first thoughts about the design:

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[136] Joe Morgenstern, "The Fifty-Nine Story Crisis," The New Yorker 29 May 1995: 45.

[137] Pelli, 146.

> The new, thick slab buildings that march up the avenues of New York and other U.S. cities are symbolic expressions of the Machine. They are anonymous – cool and inhumane. We must use these resources of big business, reinforced by moral and social ideas, to develop a new generation of office buildings planned for the community and expressive of the humanity of the individuals who use them.[138]

By this time, the high-rises of the previous decades had disenchanted Stubbins. For the design of the Citicorp, Stubbins was not inspired by the 1950s designs of Lever House and the Seagram Building, which embraced Le Corbusier's machine aesthetic philosophy.

Between completion of the Seagram Building (1958) and construction on the Citicorp Center (1974-78) notable advancements were made in building technology. In particular, the first silicone sealant was manufactured by Dow-Corning around 1960. Two years later, in 1962, the first American company, Pittsburgh Plate Glass, was the first to adopt the float process for plate glass production, which eliminated the need for grinding and polishing.[139]

Following the energy crisis in 1973, the Citicorp Center was the only major project under construction in New York City between 1974 and 1975. Ludman suggests that construction of the Citicorp Center was thus an act of optimism in the environment of economic uncertainty.[140] Based on the increased energy consciousness at the time, the Citicorp Center implemented systems that were intended to reduce the building's energy consumption.

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[138] Mildred F. Schmertz, "Citicorp Center: If You Don't Like its Crown, Look at its Base," Architectural Record June 1978: 114-116.

[139] Konrad, et al., "Plate Glass," Twentieth-Century Building Materials: History and Conservation, ed. Thomas C. Jester (New York: McGraw-Hill, 1995) 185.

[140] Dianne M. Ludman, Hugh Stubbins and His Associates: the First Fifty Years (Cambridge, MA: Stubbins Associates, 1986) 85.

Construction

The Citicorp Center's structure is a steel frame with sprayed fireproofing that incorporates diagonal bracing to protect against high wind loads. The building's curtain wall is comprised of a reflective pale, natural-colored aluminum paneled skin (at 4'-9" modules) penetrated with horizontal bands of fixed aluminum windows with double pane insulating glass.[141] Both the metal panels and the reflective glass help the building reflect a significant amount of heat that would be absorbed by a darker structure. The aluminum paneling and the glass are flush at the exterior.

One of the most distinctive features of the high-rise is its angled crown, which also serves as a solar energy collector. Although the solar collector was later deemed economically infeasible because the operational costs were greater than the cost savings, it marks a shift in high-rise design in which environmental and energy conscious issues are recognized through curative measures incorporated into the design.

One critical flaw in the structural design should be noted. Failure suddenly fell upon the owner and design team when the originally designed welded joints were value-engineered to be bolted joints. The steel contractor believed that welded joints, which were more labor-intensive and therefore more expensive, were often stronger than necessary and bolted joints were technically sound and equally safe.[142] The structural engineer, William J. LeMessurier, was not convinced. LeMessurier's concern prompted him to run check calculations on the bolted joints and consult a fellow engineer who tests wind forces on high-rises as a profession. LeMessurier's due diligence proved to him that the bolded joints at the

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[141] "A Tower with a Distinctive Top," Architecture: AIA Journal Mid-May 1979: 174.

[142] Joe Morgenstern, "The Fifty-Nine Story Crisis," The New Yorker 29 May 1995: 46.

thirteenth floor were potentially catastrophic. After LeMessurier notified the architect and the client of the hazardous situation, a band-aid method was approved as a no-option solution. At an approximate cost of four million dollars, two-inch-thick steel plates were welded to approximately 200 bolted joints after hours and under the shelter of the dark night sky in 1978.[143]

Since the building's completion, and subsequent structural fix, the Citicorp Center was sold and the office space was converted into residential condominiums while retail was retained on the bottom floors. In Schmertz's article of June 1978, she said of the Citicorp Center:

> The tower, surrounded by buildings which age (some of them not so gracefully), stands ageless, its brightness bisecting midtown like a shaft of sky. It is a building that must be kept clean and is easy to keep clean and shining because its glass windows and aluminum spandrels are on the same plane.[144]

No building is immune to aging; the service life analysis in the following section estimates the first service life of the components in the Citicorp Center's vertical enclosure.

Service Life Analysis

Due to the difficulties encountered in gathering the exterior envelope drawings mentioned previously, the only drawing obtained for the Citicorp was in the form of a slide from the David Guise Collection. The slide shows a portion of a full size architectural drawing that includes a plan section drawing cut through the shaft of the building and the top portion of an exterior envelope section. Although not ideal, these two drawings pieced together provide the exterior envelope information for this analysis. The following outlines

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[143] Ibid.

[144] Schmertz, 115.

each component that comprises the Citicorp Center's vertical enclosure and explains the service life value assigned to each.

Aluminum Insulated Panel (at spandrel)
Service Life = 30 years

As mentioned in the analysis of the Alcoa Building, there is no provision for a metal-paneled cladding system in the HAPM Manual. Therefore, the service life for the aluminum panels is based on an exterior metal application, that of Coping Systems. For an aluminum coping system, the HAPM Manual recommends a 20-year service life. Because the base value assumes a harsh exterior condition that a coping system typically endures, the service life seems applicable to the exterior application of the aluminum panels. However, 10 years are added to the 20-year base value so that the value more closely aligns with that of the building's curtain wall. Therefore, the total adjusted service life is 30 years.

Fixed Natural-Colored Aluminum Curtain Wall with Reflective Glass
Service Life = 30 years

The service life of Citicorp's fixed aluminum curtain wall system is based on the 35-year service life estimate from Kesik's website. Unlike earlier systems, the Citicorp's curtain wall assembly appears to have incorporated appropriately designed thermal breaks. Unlike the condition in the Seagram Building, which shows no insulation behind its bronze spandrel panel, the section drawing of the Citicorp shows rigid insulation placed directly against the aluminum spandrel panel. In the late 1970s, it was common practice to incorporate thermal breaks of low conductivity materials, traditionally polyurethane and more recently nylon, for improved thermal performance. Beneficial to the Citicorp Center, aluminum has very high thermal conductivity. Despite these positive factors, aluminum is more corrosion resistant than steel but is susceptible to pitting in urban environments. Therefore, 5 years are deducted from the base service life, adjusting the total service life to 30 years.

Thermafiber Insulation
Service Life = 40 years

The 40-year service life for thermafiber insulation is based on the HAPM Manual's lifespan estimate for cellulose fiber insulation. The HAPM includes two categories for insulation: one for masonry cavity walls and one for timber frame walls. Both categories are assigned a 40-year service life. Even though in the Citicorp Center application the insulation is installed against an aluminum panel, the same type of fibrous insulation was used for wood studwork and masonry walls.

Fasteners
Service Life = 30 years

Since the drawings do not specify the type of metal fasteners, it is assumed that the bolts and fasteners employed in the Citicorp façade are aluminum alloy fasteners. The HAPM Manual suggests a 30-year service life for anodized aluminum alloy bolts and fasteners.

Metal Flashing
Service Life = 25 years

Because the exterior is largely comprised of aluminum and because the drawings do not call out the type of metal, it is assumed the Citicorp's flashing is aluminum. As applied to the analysis of previously discussed buildings, the service life for aluminum flashing is derived from the roof flashing category of the HAPM Manual. Thus, the service life for commercial grade aluminum flashing is 20 years. Five years are added to the base value because the flashing is installed within the wall and is therefore less vulnerable to the harsh weathering conditions of a roof location. The total adjusted service life is 25 years.

Conclusion

Two of the five components are estimated to have a service life above 35 years (see *Graph 7.1*). Like the Seagram Building, the service life values range from 20 years to 40 years. In the case of the Citicorp Center, both of the lowest values belong to components situated at the innermost portion of the vertical envelope. These components are the metal fasteners with a 20-year service life and the metal flashing with a 25-year service life. In the Citicorp Center, the distribution from a high service life to a low service life generally occurs from the outermost to the innermost portion of the enclosure. Since the components closest to the exterior typically endure the most weathering, this distribution seems to be a reasonable and appropriate condition.

AT&T BUILDING

Designed by Philip Johnson during his partnership with John Burgee, the AT&T Building was a deliberate departure from the glass and metal-sheathed box typified by the Seagram Building. The AT&T Building became a prominent example for the new era of postmodern design, which looked back at traditional and classical architecture. In an attempt to incorporate historical design elements, a broken pediment crown distinguishes the high-rise (see *Figure 7.3*). This defining feature is allegedly based on a Chippendale chest popular in the 18th century. The unique roofline peaks at 648 feet and 37 stories above ground level.

After breaking ground in 1978, New York City's AT&T Building was finally completed in 1984. AT&T eventually left the building they had commissioned for a new headquarters when the high-rise was leased to Sony in 1991.

The design of the AT&T Building not only intentionally departs from the Seagram Building, on which Johnson collaborated with Mies van der Rohe, it also departs from the International Style, the idiom of the earlier PSFS Building (1932) (refer to Chapter 5 - High-rises c. 1925). In fact, Philip Johnson co-invented the term "International Style" when he introduced the modern style to America as a key curator of the 1932 MoMA exhibition. Thus, in the design of the AT&T, Johnson consciously rejected the modern styles he promoted in previous eras and introduced a new approach by resurrecting traditional masonry finishes and articulation for tall office design. In this way, he established himself as a "spokesman of new architectural attitudes."[145]

Johnson did not singularly author this shift in paradigm. The client, AT&T Chairman DeButt, commanded Johnson: "Now, look, I don't want just another building. We'd like to make the next step in tall building architecture since the Seagram Building – just go to it."[146] Rather than borrowing from the designs of glass and metal high-rises like Lever and Seagram, which deliberately broke from the aesthetics and technologies of traditional building design, for inspiration Johnson looked back at early Romanesque architecture and the designs of McKim, Mead, and White.[147] The firm McKim, Mead, and White emerged at the turn of the 20th century and became highly regarded for their Beaux-Arts/Neo-classical

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[145] Benjamin Forgey, "Towers of Excellence: Manhattan's AT&T & Seagram Skyscrapers," The Washington Post 7 Apr. 1984, final ed.: C1.
[146] Hilary Lewis and John O-Connor, Philip Johnson: The Architect in His own Words (New York: Rizzoli, 1994) 104.
[147] Ibid., 104.

masonry clad buildings. One of their buildings, the Racquet Club (1919), sits directly across from the Seagram Building and four blocks away from the AT&T Building. After approximately eighty years of high-rise design in the United States, a marked shift occurred wherein there was a reappraisal and endorsement of construction techniques employed in the first period of skyscraper design, especially that of masonry cladding.

Authors Lewis and O'Connor remarked on what the AT&T Building meant for Johnson's career and the design of corporate America:

> The building that put Johnson back at the forefront of American architectural discussion is the AT&T Building, which has become an icon of postmodernism. What makes this building so special is that it was designed at a time when corporate headquarters were indisputably being built on the model of the sleek glass and metal Seagram Building. Johnson rejected all that was then conventional wisdom in corporate architecture by proposing to build a stone-clad structure in pink granite with bronze details, amid a veritable sea of marble.[148]

Although *New York Times* critic Ada Louise Huxtable, who was known as a proponent of modern architecture, scorned the new edifice, many welcomed Johnson's return to traditional materials and design.[149]

Construction

The AT&T Building is a steel structure with sprayed fireproofing. Rather than a steel and glass enclosure, the AT&T is sheathed in 13,000 tons of pink-grey granite. The 2" thick granite panels are tied back to the structure with metal clips glued to the stone. Fixed aluminum windows with insulating glass provide light to the largely granite-clad building.

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[148] Lewis and O'Connor, 104.

[149] Ada Louise Huxtable, "Ada Louise Huxtable Surveys Principal Architectural Achievements…," New York Times 31 Dec. 1978: 21.

Like many of the previously discussed high-rises, the construction budget for the AT&T was ample. With regard to the chosen materials Johnson remarked: "I think that if you've got money and you want to make an important statement, use good material."[150] Therefore it is assumed that the exterior envelope materials such as the granite and the aluminum windows were of substantially high quality.

Although the AT&T Building incorporated masonry clad construction typical in early skyscrapers such as the Guaranty and the Woolworth, advancements in prefabrication and panelized construction made earlier in the 20th century informed the construction details of the AT&T and differentiated the cladding system from the earlier models. In a book on Johnson and Burgee's architecture published in 1985, the building's construction was described as follows:

> False joints are incorporated along with real ones to simulate traditional masonry construction, and refinements of moldings and other details were worked out with the aid of Styrofoam models. To guard against the risks of attaching tons of granite to a steel skeleton, each piece was anchored separately and each mount was engineered to withstand the weight of two panels to avoid a domino effect if one should fall.[151]

The granite panels used in the AT&T Building incorporated false joints to create the illusion of an actual joint. The Guaranty Building (1896), for instance, had no such false joints; they were all true joints sealed with mortar. Even though the joint system employed in the AT&T Building was not authentic to the earlier models, the relative novelty of the cladding material triggered a rediscovery of stone as a high-rise building material.

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[150] Ibid., 110.

[151] Philip Johnson/John Burgee: Architecture 1979-1985 (New York: Rizzoli, 1985) 42.

Authors of a book on Johnson and Burgee published in 1985 argue that the AT&T Building's granite curtain wall was designed to suggest the sculptural detail and play of light and shadow evident in stone clad building throughout history.[152] By contrast, the same effect would not have been achievable if Johnson had chosen to integrate the granite panels within a stick-frame curtain wall.

Moreover, in his book on Johnson, Blake states that Johnson brought back traditional stone finishes after witnessing decades of thin glass and metal curtain walls that did not always wear very well.[153] In a 1979 article about the comeback of granite as a building material, Johnson said that glass and metal curtain walls were no longer practical due to heat loss and the high price of aluminum.[154] The following service life analysis strives to assess whether the materials used in the AT&T Building are estimated to be as durable as those employed in the Guaranty and Woolworth Buildings to which the AT&T was paying tribute.

Service Life Analysis

The following outlines each component that comprises the AT&T Building's vertical enclosure and explains the service life value assigned to each.

Granite Veneer
Service Life = 40 years

Based on the HAPM Manual's category for natural stone, the granite veneer is assigned a 40-year service life.

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[152] Ibid., 42.
[153] Blake, 192.
[154] Robert E. Tomasson, "Granite is Making Major Comeback as Building Material in Manhattan," New York Times 15 Sept. 1979: 22.

Fixed Aluminum Windows with Insulating Glass
Service Life = 30 years

The service life of the fixed aluminum windows is derived from the HAPM Manual's subsection for aluminum windows. Under class C1 for anodized aluminum windows, fixed or operable, the manual suggests a 30-year service life. For this service life value, the HAPM Manual makes the optimistic assumption that the window system is regularly maintained by renewing weatherstripping and gaskets every 10 years.

Generally, aluminum is a moderate performing metal. Aluminum is not as corrosion resistant as bronze or stainless steel and performs moderately in an urban environment such as New York City.[155] The insulating properties of the glass, however, help protect against condensation on the inside of the glass.

Neoprene Gasket
Service Life = 15 years

Since neoprene gaskets are also implemented into the construction of the Seagram Building, the same service life estimate method is applied to the AT&T Building. In this case, the 20-year base value must be adjusted for the assumption embedded in the service life value for the AT&T Building's aluminum windows. The HAPM Manual assumes that gaskets in aluminum windows are renewed every 10 years. By taking the average of the 10-year and 20-year values, the total adjusted service life of the neoprene gaskets is 15 years.

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[155] Part II: Metals Systems and Architecture, 14 Mar 2007, <http://ocw.mit.edu/NR/rdonlyres/Architecture/4-461Fall-2004/46D31163-F862-461F-B314-D0E7506860C8/0/lect17b.pdf>.

Metal Angle Support System for Granite Veneer
Service Life = 25 years

The drawings indicate a framework of a light metal angle support system for the granite veneer. This system is not labeled and it is not clear exactly how the system is attached to the granite and then anchored back to the structure. Despite the lack of detailed information, the system of angles is most similar to a mild steel section described in the category for hot rolled steel lintels in the HAPM Manual. Class C1 describes a mild steel section, hot dipped galvanized after any cutting, welding, or drilling steel to 2mm – 2.9 mm. This is about 1/10 to 1/5 inches, which approximates the thickness of the metal angles shown in the section drawings of the AT&T Building. This class assigns a 30-year service life, which is reduced by 5 years because the coating on the angles is unknown. The total adjusted service life is 25 years. Additional knowledge, such as the on-site condition of this assembly, would inform the soundness of this anchoring system.

Rigid Insulation
Service Life = 35 years

Unlike the Citicorp Center, the rigid insulation in the AT&T Building is placed a few inches inside the surface of the exterior granite veneer. This placement provides an air cavity to allow the granite to breathe and it also insulates the rest of the wall system. Rigid insulation is included in the HAPM Manual and the suggested service life is 35 years.

Stick-clips
Service Life = 10 years

The service life of the stick-clips is based on the Bolts and Fasteners category in the HAPM Manual. The 10-year base value is derived from the recommend default value for steel screws. Since the type of metal is not known, it is assumed that the clips are constructed of steel. Because glue is used to anchor the stick-clips to the granite veneer, the integrity of the connection between the clips and the stone is questionable. The natural forces of expansion and contraction could weaken the adhesive properties of the glue.

Metal Flashing
Service Life = 25 years

Using the same method employed in the Citicorp Center, the service life of metal flashing in the AT&T Building is based on a commercial grade aluminum flashing. Thus, an adjusted 25-year service life is used for this analysis.

Conclusion

The analysis of all components' service lives in the AT&T Building's vertical enclosure reveals that only two of the seven components have a service life of 35 years or more (see *Graph 7.2*). The range of values spans from 10 years to 40 years. While the granite veneer and the rigid insulation bear a 40-year and 35-year service life the neoprene spacers and the stick-clips have the lowest service life values at 15 years and 10 years, respectively. The graph (*Graph 7.2*) showing the service lives of the components within the AT&T Building's vertical enclosure exhibits a spread of high and low values from the exterior to the interior. This may indicate that a component with a low service life, such as the neoprene spacers, will ultimately shorten the service life of another components, such as the aluminum windows.

Chapter 8: High-rises c. 2000

NEW YORK TIMES TOWER

Designed by premier contemporary architect Renzo Piano in collaboration with New York architecture firm FxFowle, construction on the New York Times Tower broke ground in 2005 (see *Figure 8.1*). This new high-rise is the biggest and most ambitious project unveiled in Manhattan since the devastation of the World Trade Center Towers on September 11, 2001.[156] Construction is still in progress and the new high-rise is slated for completion sometime this year (2007). The New York Times (NYT) Tower joins a collection of recently constructed high-rises that emphasize their sustainable features, and have consequently been termed "green towers." In 2006, the tower was included in a New York City exhibit sponsored by the Skyscraper Museum, which showcased green towers that "propose radically new ways of being environmentally friendly."[157]

The New York Times Company will locate its headquarters in the lower half of the tower and the balance of the office space will be leased to office tenants. Although the building itself rises 52-stories to 748 feet, the tower's mast reaches 1,142 feet.

Construction

Steel pervades the palate of materials used in the New York Times Tower. Not only is the building a steel framed structure, but the entire curtain wall and storefront systems are also constructed of steel (see *Figure 8.2*). Dan Kaplan, the senior principal at FxFowle Architects, remarked: "For The New York Times, we're putting the structural frame of the

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[156] Paul Goldberger, "Spiffing up the Grey Lady," The New Yorker 7 Jan. 2002: 20.
[157] "Green Towers for New York: From Visionary to Vernacular," The Skyscraper Museum, 8 Feb 2007 <http://www.skyscraper.org/EXHIBITIONS/GREEN_TOWERS/gt_walkthrough_corphq_nyt.htm>.

building on display."[158] In the same article of 2003, Kaplan compared the building to a sailboat mast, saying, "It's totally structurally derived, but it's very light and expresses lightness and elegance."[159] Steel provided the designers and engineers the indispensable ability to detail and sculpt the building's form in a way that would not have been possible with an alternative material like concrete.

In order to meet current building codes and to maintain the lightness and transparency the design team desired, the steel is finished with a particular paint that can maintain fire integrity for the columns and beams while providing a cosmetically acceptable exterior surface finish. To compensate for wind loads and undesirable swaying inherent in very tall buildings, diagonal tie rods were integrated into the structure. Rather than concealing the bracing as Stubbins chose to do in the Citicorp Center, the designers remained true to their initial design philosophy of transparency and exposed the bracing on the exterior.

Juxtaposed against the strength of massive amounts of steel, a portion of the New York Times Tower's elegance is attributed to the high-rise's simple, yet intricate double skin. The outermost skin is a network of horizontal ceramic tubes in a steel frame while the innermost skin is a curtain wall of transparent glass in a steel frame (see *Drawing 8.1*). The ceramic tubes are white, one and five-eighths inches in diameter, and composed in screens suspended one and a half feet from the face of the first layer of glass and steel (see *Figures 8.3*

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[158] Amy Choi, "Designing the New York Times: Steel Grid Visible Inside and Out," New York Construction Sept. 2003: 59.
[159] Ibid.

& *8.4*). The tubes are spaced at various intervals to allow people inside the offices to see out and vice versa, but they also provide a lightness that Kaplan mentioned.[160]

The double skin has a dual purpose: while the first layer of steel and glass encloses the interior and protects the building from general weathering, the second layer of ceramic tubing provides a protective sunscreen, which in turn reduces energy costs. Shades, lighting, and heating will automatically adjust relative to the amount of sunlight that permeates the screen. By controlling light and heat in this way, the Times Company estimates they will save 50 percent on lighting costs alone.[161] The framework of ceramic tubes is one of the sustainable components of the structure and highlights the current era of environmental consciousness and emphasis on energy efficiency in high-rise design.

The New York Times Tower represents advancements in the contemporary era of high-rise design in two ways in particular: 1) it incorporates sustainable design practices; and 2) it has a double skin that also functions as an active envelope system. With the scares of global warming and fear of depleting our natural resources, sustainability has been increasingly endorsed in the building industry. Although the service life analysis does not specifically address sustainability, it does attempt to estimate the maintainable lifespans of each component in the tower's vertical enclosure. In general terms, a longer lifespan indicates a more sustainable component because less energy is expended for its repair or replacement.

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[160] David W. Dunlap, "Times Goes Forward on Plan for Tower on Eighth Avenue," New York Times 14 Dec. 2001, late ed.: D3.

[161] Jack Rosenthal, "Insolation," The New York Times Magazine 16 July 1006, late ed.: 18.

Service Life Analysis

Because of its dual exterior layers, the New York Times Tower has a greater number of components in its exterior enclosure than the previously analyzed high-rises. The following outlines the service life values attributed to two layers of the New York Times Tower's vertical enclosure.

Ceramic Tubes in Steel Frame
Service Life = 40 years

The 40-year service life estimate for reconstituted stone is used as the base value for the ceramic tubes.

Steel Frame for Ceramic Tubes
Service Life = 30 years

The steel frame provides the structural framework for the ceramic tubes. Though the dimension of the steel is not known, the sections are likely ¼" thick or less. Therefore, the service life of the steel frame is based on the hot rolled steel lintels section in the HAPM manual. Class B2 describes mild steel sections, hot dipped galvanized after any cutting, welding, or drilling to at least 5 mm thick. The 35-year base service life value for this class is then reduced by five years because the steel frame in the NYT Tower is painted rather than galvanized. The total adjusted service life is 30 years.

Steel Curtain Wall with Thermal Pane Glass
Service Life = 40 years

Like the other curtain wall systems analyzed in this thesis, the 35-year service life gleaned from the data presented on Kesik's website is applied as the base value for the NYT Tower's curtain wall. The base value is increased by 5 years because steel is a stronger, more durable material than, for instance, the aluminum employed in the Citicorp.[162] As a result, the total adjusted service life of the steel curtain wall system is 40 years.

Steel Panel (at Spandrel)
Service Life = 35 years

The service life estimate for the NYT Tower's steel panels employs the same method used to approximate the service life of the metal panels in the Alcoa and Seagram Buildings. This method is uses the HAPM Manual's section on Coping Systems. For a stainless steel coping system, the HAPM Manual recommends a 25-year service life. Like a coping system, steel panels integrated into the vertical enclosure must also endure exterior weathering. Since the New York Times Tower's steel panels are integral to the curtain wall system, Kesik's 32-year minimum estimate for a curtain wall is also considered. The total service life of the building's steel curtain wall is 40 years. Based on Kesik's 32-year estimate and the 40-year service life of the building's steel curtain wall, total adjusted service life for the steel panels is 35 years.

Insulation (at Spandrel)
Service Life = 35 years

The service life estimate for the fibrous insulation is derived from the HAPM Manual's recommendation of a 35-year service life for glass fiber insulation.

Steel Tie-backs and Fasteners
Service Life = 30 years

The service life of NYT Tower's steel fasteners is based on the HAPM's 25-year lifespan estimation for galvanized steel threaded components. Five years are added to the

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[162] Part II: Metals Systems and Architecture, 14 Mar 2007, <http://ocw.mit.edu/NR/rdonlyres/Architecture/4-461Fall-2004/46D31163-F862-461F-B314-D0E7506860C8/0/lect17b.pdf>.

base number because the fasteners are thicker steel sections than described in the HAPM Manual. Therefore, the total adjusted service life is 30 years.

Conclusion

Viewed together in *Graph 8.1*, the components in the New York Times Tower's vertical enclosure have impressively high service life values. Four of the six components have a service life equal to or greater than 35 years. The two remaining components have a 30-year service life. In total, the range of service life values extends from 30 years to 40 years – only a 10-year difference from the lowest value to the highest value. Unlike many of the other high-rises analyzed in this thesis, the service life difference between the fasteners and the curtain wall in the New York Times Tower is only five years. While the fasteners have a 30-year service life, the steel curtain wall has a 40-year service life.

Chapter 9: Comparative Analysis

Following analysis of the individual service lives of the components of each high-rise's vertical enclosure, this chapter will provide a collective comparison of the results. To do this, graphs were produced in an attempt to reveal the trends over a period of approximately 100 years and furthermore illustrate how the different technologies employed in each high-rise might have ultimately affected service life values. To assess the differences in service life values among the high-rises for the same component type generally common to all buildings, three graphs were produced: 1) Vertical Enclosure: Glazing and Cladding Systems; 3) Glazing Systems: Operable and Fixed; 2) Bolts and Fasteners.

VERTICAL ENCLOSURE – GLAZING AND CLADDING SYSTEMS

The first comparison considers the service lives of the glazing and cladding systems in the vertical enclosure, as illustrated by *Graph 9.1*. As building construction techniques and design practices evolved over the past century, the glazing and cladding systems have become less distinct and more integral. For instance, the Guaranty Building's double-hung wood windows are a distinct system from its terra cotta cladding. Comparatively, the glazing and the cladding are one in the same in Lever House's enclosure. The glazing and the cladding functions merge in the form of one continuous glass and steel system. Because of this evolutionary change in curtain wall construction, this comparison distinguishes between the cladding and the glazing system, where possible. The exterior cladding value is indicated by a triangle while the glazing system value is symbolized by a dot. Irrespective of the component type, components belonging to the same building are displayed in the same color.

The graph also illustrates the lifespan relationship between the cladding and the windows, or, in effect, the solid and the void. With regard to service life, most of the relationships between the two systems within a given building fall within a 5-year service life range independent of the year in which the building was constructed. The PSFS Building is an exception to this common relationship.

While the granite and brick veneers in the PSFS Building have a 40-year service life, the single-hung aluminum windows have a 25-year service life – 15 years lower than that of the veneer. What is the reason for this gap in service life values? One explanation might be that when the PSFS was constructed, between 1929 and 1932, aluminum windows were a nascent technology. Aluminum was not used for window sash until after World War I (1914-1918).[163] In addition, the anodizing process for aluminum, which is a finishing method that helps protect the aluminum from atmospheric corrosion, was first developed in the 1920s. Yet, the method was not available for architectural application until after World War II (1939-1945). Since the anodizing process was not available in 1932, the PSFS windows did not have the benefit of a protective, anodized finish. An anodized finish may add a maximum of five years to the windows' service life. Both these conditions, the developmental characteristic of aluminum windows and the lack of an anodized finish, may explain the low service life of the aluminum windows relative to the building's masonry veneers.

The low range of service life values for both the glazing and cladding systems is between 30 and 35 years. A cluster of high-rises constructed between 1952 and 1984 (Lever

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[163] Stephen J. Kelley, "Aluminum," Twentieth-Century Building Materials: History and Conservation, ed. Thomas C. Jester (Washington, D.C.: McGraw Hill, 1998) 48.

House, Alcoa Building, Seagram Building, Citicorp Center, and AT&T Building) fall within this range. In the Seagram Building, for example, the glazing system has a 40-year service life while the bronze panels bear a 35-year service life. The bronze panels and the glass are integrated into a bronze frame and prefabricated as a panelized system. This is to say that even though the components are broken into two categories for estimating their service lives, the components were assembled into a composite system before being anchored to the building's structural frame.

The glazing and cladding systems that scored in the high range, a 35-year or 40-year service life, belong to high-rises built in the early and current period of high-rise design: the Guaranty Building (1896), the Woolworth Building (1913), and the New York Times Tower (2007). Since these buildings share high service life values for their glazing and cladding systems, one might conclude that so-called traditional curtain wall construction and contemporary glass and metal systems can attain the same high values. However, the maintainability analysis discussed below sheds light on additional issues affecting the lifespan of vertical enclosures and may not make the two periods of high-rise construction so comparable.

GLAZING SYSTEMS – OPERABLE AND FIXED

This comparison examines operable and fixed glazing systems independent of the cladding, as illustrated in *Graph 9.2*. Operable systems are indicated with a solid column while fixed systems are shown as an open column. The emergence of fixed window systems highlights a shift in aesthetic and technological practices. This change from operable to fixed windows generally occurs in the United States sometime in the 1940s. In this analysis, the shift occurs between the construction of the PSFS Building (1932) and Lever House (1952) and is indicated on the graph with a gray dashed line. Whereas the Lever House's glass and metal system is fixed, the Bauhaus (1925), which served as an international prototype for glass and metal curtain walls, incorporated operable components within its early curtain wall. Since the completion of the Bauhaus in 1925 and its subsequent impact on modern design in America, the glass and metal curtain wall system transformed from an operable to a fixed system.

Looking back to earlier operable hung windows employed in the Guaranty, Woolworth, and PSFS Buildings, the service life values vary from 25 years to 40 years. While the windows in the Guaranty Building (1896) bear a 35-year service life, the windows in the later Woolworth Building (1913) have a longer service life at 40 years. Although both buildings employ hardwood double-hung windows, the Woolworth's windows have an extra layer of protection with their exterior copper cladding. This accounts for the additional 5 years indicated for the Woolworth Building's glazing system. Though the PSFS windows are an operable, hung system, they are constructed of aluminum rather than wood. As explained in the previous section, the primary factors that affect the windows' low 25-year service life are the lack of a protective coating and the experimental nature of their aluminum construction.

The glazing systems in the three oldest buildings in this analysis, the Guaranty, the Woolworth, and the PSFS, illustrate that between 1896 and 1932 operable hung windows dominated the glazing systems employed in high-rise construction. It is furthermore evident that within this time frame, metal was increasingly integrated into the window systems.

Whereas the Guaranty Building's windows are all wood, the Woolworth's windows have an added layer of copper cladding, and ultimately, the PSFS's windows are constructed exclusively of aluminum.

As mentioned above, Lever House's glazing system marks a transition from an operable system to a fixed system. The glass and steel system's 25-year service life suggests that the shift to a fixed, continuous enclosure system had a negative impact on the system's projected lifespan. Chapter 6 discusses specific inadequacies of Lever House's glass and steel system that eventually led to its recent replacement. These include a lack of thermal breaks and the system's high reliance on multiple fasteners, both of which make the curtain wall system more susceptible to deterioration and ultimately require major repair or replacement.

The Alcoa Building, completed in 1953, is an exception to the notable shift from operable to fixed glazing systems. As mentioned previously, the design of the Alcoa was a reaction against the trend toward glass and steel. In addition to the all-metal exterior cladding, the high-rise also features operable pivoted-windows. While not operable, the service life of Seagram Building's fixed curtain wall system is estimated to be 40 years, which is 5 years greater than the 35-year service life of Alcoa's operable aluminum windows. This curious proximity in service life values of a fixed system and operable system is further analyzed through the maintainability of the glazing systems and elucidates the maintenance factor affecting a component's lifespan (see section - Maintainability Analysis and *Table 9.3*).

Despite the durable properties of bronze, the service life of the Seagram's glazing system remains susceptible to deterioration due to a lack of thermal breaks. Although the adjustment factor strives to compensate for conditions in the system such as this, the Seagram's glazing system demonstrates that existing methods for service life analysis are not comprehensive enough and require more development.

The high-rises built within the past thirty years, the Citicorp Center, the AT&T Building, and the New York Times Tower, have fixed glazing systems. Both the Citicorp and the AT&T's glazing systems indicate a 30-year service life while the New York Times Tower's glazing system is estimated to last 10 years longer at a 40-year service life. Both the Citicorp and the AT&T's glazing systems are constructed in aluminum. By this time the anodizing process for aluminum had become common and although it is not explicitly called out on the drawings, it is assumed that the aluminum glazing systems in both the AT&T and Citicorp Buildings had this protective finish. Alternately, the New York Times Tower's glazing system is framed in stainless steel, a stronger and more corrosive resistant material than aluminum. While aluminum performs well in urban environments, steel performs only moderately in urban environments.[164] Yet the coefficient of thermal expansion of steel is half that of aluminum. These properties of steel indicate that although on the whole its performance in a harsh urban environment such as New York City may not be as great as aluminum, it is particularly less susceptible to deterioration caused by changes in temperature. Therefore, of the high-rises built within the last thirty years, the glazing systems of the earlier ones (the Citicorp Center and the AT&T) have a lower estimated service life than that of the New York Times Tower, which is currently under construction.

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[164] Part II: Metals Systems and Architecture, 14 Mar 2007, <http://ocw.mit.edu/NR/rdonlyres/Architecture/4-461Fall-2004/46D31163-F862-461F-B314-D0E7506860C8/0/lect17b.pdf>.

In sum, the year a high-rise was built has no direct impact on the service life of its glazing system. Rather, the way in which the components are assembled and the component's material properties are intricately tied to the system's service life estimate. The year constructed, however, indicates prominent building technologies and materials used at the time that in turn affect a glazing system's service life.

When viewed collectively, the service lives of the glazing systems are distributed as follows:

Table 9.1 - Comparative Analysis: Glazing Systems.

Glazing System Service life (in years)	High-rise	Year Constructed
40	Woolworth	1913
40	Seagram	1958
40	NYT Tower	2007
35	Guaranty	1896
35	ALCOA	1953
30	Citicorp	1977
30	ATT	1984
25	PSFS	1932
25	Lever	1952

The glazing systems with the highest estimated service lives at 40 years are two different types of systems and installed in buildings built approximately 50 years apart. One system is operable double-hung windows and incorporated into a high-rise design that exemplifies the early period of skyscraper design, the Woolworth Building, while the other two are fixed glass and metal curtain wall systems installed in both the Seagram Building and the New York Times Tower. The second highest ranking service life at 35 years includes operable glazing systems from buildings of different vintages and both operable and fixed glazing systems. Whereas the Guaranty Building was built in the first period of skyscraper design and its windows are operable, the Alcoa was built in the 1950s and also employs operable windows. The fixed glazing systems incorporated into the Citicorp Center and the AT&T Building, both built in the late 1970s, early 1980s, share a 30-year service life. The lowest ranking glazing systems belong to the PSFS Building (1932) and Lever House (1952). As mentioned previously, the PSFS has operable hung windows constructed of aluminum and Lever House has a fixed glass and steel curtain wall.

The above synopsis indicates that service life analysis does not necessarily discriminate against the operational component of glazing systems. While some operable glazing systems have a 40-year service life, one operable system has a 25-year service life. The maintainability analysis, however, will determine the "repairability" or "replaceability" of a building's vertical envelope (see following section - Maintainability Analysis).

BOLTS AND FASTENERS

In addition to the cladding and glazing systems, the bolts and fasteners that tie the components together and anchor them back to the structure are examined as a separate comparative analysis. Similar to the previous graphs, a color-filled column represents the anchors of a given building in *Graph 9.3*. Where two types of fasteners are incorporated in a building's vertical enclosure, the average service life of both values is used.

All together, the service lives of bolts and fasteners for all high-rises range from 15 years to 30 years. The range is much lower than the range of the cladding and glazing systems, which spans from 25 years to 40 years.

While the bolts and fasteners in the PSFS Building and the New York Times Tower have the highest service life value in the range at 30 years, the lowest service life values, at 17.5 years and 15 years, belong to the AT&T, Guaranty, and Woolworth Buildings. These three high-rises are clad with a masonry veneer and the anchors tie the veneer back to the structure. While both the Guaranty and Woolworth Building use iron anchors, the AT&T Building employs a metal angle support system to anchor its veneer back to the steel structure. Both types of anchors are problematic, but for different reasons. The iron anchors are embedded within the terra cotta and are susceptible to corrosion by moisture. The movement and corrosion of the anchors over time affect the entire enclosure. Little is known, however, about the integrity of the metal angle system in the AT&T Building. Yet, the stick-clips used to hold the rigid insulation in place are particularly of concern because of their reliance on an adhesive. Therefore, the anchorage system in the AT&T Building requires further investigation to adequately understand the integrity of the connections.

The bolts and fasteners incorporated in four of the nine buildings analyzed are clustered together with 20-year and 25-year service lives. These four high-rises, Lever House, the Alcoa Building, the Seagram Building, and the Citicorp Center, were built between 1952 and 1977.

Table 9.2 - Comparative Analysis: Bolts and Fasteners.

Bolts/Fasteners Service Life (in years)	High-rise	Year Constructed
30	PSFS	1932
30	NYT Tower	2007
25	ALCOA	1953
25	Seagram	1958
20	Lever	1952
20	Citicorp	1977
17.5	ATT	1984
15	Guaranty	1896
15	Woolworth	1913

In some cases, the service life values for bolts and fasteners share the type of curtain wall construction in which they are employed. For instance, the AT&T, Guaranty, and Woolworth Buildings are masonry-clad structures with punched windows. They also share low service lives with the AT&T at an average 17.5-year service life and the Guaranty and Woolworth Buildings at 15-year service lives.

On the whole, the bolts and fasteners in each high-rise have varying service life relationships to the other components of the building. While in some cases a fastener's service life is closer to that of the rest of the vertical enclosure, in other cases a 20-year gap exists between them. The low range of service life values for the bolts and fasteners causes concern because of their importance in tying together all the components in a vertical enclosure. Deterioration and failure of bolts and fasteners can send a ripple effect through the entire enclosure and potentially cause damage to multiple components.

MAINTAINABILITY ANALYSIS

In addition to the service life analysis, maintainability analysis was conducted to assess 1) availability of access to components; 2) ease of installation and changing of parts; 3) modular coordination. These three factors for assessing maintainability are adopted from the AIJ's 1992 publication on service life planning. The maintenance aspect of high-rises' vertical enclosures captures attributes of each enclosure that are not adequately measured through service life analysis. While the service life analysis offers a more objective approach for assessing the components' lifespans, the maintainability analysis attempts to elucidate and account for the shortcomings of this formulaic approach. Specifically, the section drawing of each building's vertical enclosure offers information that informs considerations such as accessibility and ease of installation.

Based on the above outlined 3-part criteria, each building is assigned a ranking of *excellent*, *moderate*, or *difficult* to maintain. The analysis is primarily based on studying the building section drawings with respect to the criteria. For instance, where the cladding and glazing systems were more intertwined and the modular coordination is high, the more difficult will be accessibility and installation of replacement parts. Table 9.3 below illustrates the results for each high-rise and provides remarks for the justification of the assigned ranking of each building.

Table 9..3 – Comparative Analysis – Maintainability Analysis.

Maintainability Analysis				
	Excellent	Moderate	Difficult	Remarks
Guaranty	X			operable windows, separate cladding and glazing systems
Woolworth		X		operable windows, separate cladding and glazing systems
PSFS	X			operable windows, separate cladding and glazing systems, more distinct components than in the Woolworth Building
Lever			X	fixed system, cladding and glazing in one integral system
ALCOA	X			operable windows, panel limited to (1) window and (1) story
Seagram		X		fixed system, panelized
Citicorp		X		fixed system, easier to repair aluminum panels than the glazing system
ATT	X			fixed system, cladding and windows are separate components
NYT Tower			X	(2) fixed exterior systems: the curtain wall and the frame of ceramic tubes

The maintainability analysis reveals that although some high-rises might have relatively long service lives compared to their 20th-century counterparts, they may be difficult to maintain beyond their serviceable lifespans. The New York Times Tower is a prime example. Whereas the service lives of all components in the NYT Tower hover at a high range of 30 to 40 years, their maintainability is deemed difficult.

On the other hand, the maintainability analysis also reveals the inverse relationship is true where the components' have short service lives in comparison to their excellent maintainability. For instance, two of the AT&T Building's components, the stick-clips and the neoprene gaskets, have very short service lives at 10 years and 15 years respectively. Yet the building is deemed much easier to maintain than the New York Times Tower because the components are not intricately tied to one another.

It should be noted that although operable glazing systems allow for easier access, they might also compromise the structure's ability to resist wind forces for buildings that reach a certain height. Furthermore, neither the service life analysis nor the maintainability analysis in this thesis account for the economic factor that drives any maintenance program. In addition to the availability of funding, extensive repairs often require elaborate and costly scaffolding. Such measures can facilitate or prohibit the necessary renewal of a vertical enclosure system.

CONCLUSION

Both service life analysis and maintainability analysis show the correlations that can be made between high-rises of varying time periods and building technologies. The comparative analysis shows that there is no single trend line for approximately one hundred years of high-rise design. Rather, the resultant service lives and maintainability rankings are very much unique to the individual building. Nevertheless, trends by period can be extrapolated from both the service life analysis and maintainability analysis.

For the service life analysis, the high-rises built between 1952 and 1977 seem to cluster within the mid-level of the service life range in all comparative graphs. In contrast, the high-rises constructed earlier in the century, from 1896 to 1932, are more volatile. While some components have high service life values, others are extremely low. The AT&T Building and the New York Times Tower stand alone in the contemporary period of high-rise design. While the service lives of components in the AT&T Building (1984) are more volatile like those of the earlier high-rises, the service lives of the components in the New York Times Tower are consistently high.

For the maintainability analysis, the rankings were highly sensitive to whether the glazing systems in each building were operable or fixed and how easily the components in the building's enclosure could be accessed or disassembled for maintenance purposes. The enclosures of the New York Times Tower and Lever House ranked as the most difficult to maintain while those of the Guaranty, the PSFS Building, the Alcoa Building, and the AT&T Building ranked as the most adaptable and conducive to maintain. Falling in between, the envelope systems of the Woolworth Building, the Seagram Building, and the Citicorp Center were determined moderately maintainable.

When viewed together, the service life analysis and maintainability analysis indicate that a vertical enclosure's maintainability can reduce or extend its service life. If the service life value is high, a maintainable and flexible design can extend the enclosure's lifespan and make the system more resilient to future repairs or replacements. On the other hand, if the service life is low, an inflexible and difficult to access design might further reduce the overall service life of the vertical enclosure system.

Chapter 10: Philosophical Issues Affecting the Preservation of 20th-Century High-rises

This chapter probes whether a different philosophical approach should be applied to high-rises from distinct periods of building design and construction. After having measured the serviceable life of each high-rise's vertical enclosure, how do the results of service life and maintainability analyses inform a long-standing preservation question of how to treat historic fabric: retain, repair, or replace? The answers to this question are multi-faceted and will continue to garner much debate. The analysis of a building's service life and maintainability will stimulate a philosophical discussion about high-rises that face the need for restoration. This is especially timely for modern high-rises that will confront issues of deterioration in the near future.

For decades, most jurisdictions with the power to regulate preservation apply a general preservation philosophy to historic buildings of all vintages. As dictated through the enabling legislation from the National Park Service and additionally when tax credit programs are applied towards a historic building's renovation, jurisdictions enforce *The Secretary of the Interior's Standards for Rehabilitation* ("the Standards") or some version of it. Since these have become the baseline standards by which most historic buildings are rehabilitated, this thesis explores and challenges their applicability to high-rise buildings.

All buildings examined in this thesis are locally or nationally registered as historic structures except for those built most recently; these include: the Citicorp Center, the AT&T Building, and the New York Times Tower. Due to their innovative design features and because they were designed by highly regarded architects, it is expected that by the time these three high-rises reach 50 years of age, they will be designated historic structures and then be subject to preservation regulations. Since the three buildings are located in New York City, it is quite possible that if there is enough interest and support, the Landmarks Preservation Commission could designate both the Citicorp Center (1978) and the AT&T Building (1985) within the next ten years. For example, the New York City Landmarks Preservation Commission designated Lever House an official landmark when it turned 31 years old in 1983.[165] Given its designation, Lever House's recent restoration campaign required adherence to preservation guidelines.

The preservation guidelines outlined in *The Secretary of the Interior's Standards for Rehabilitation* dissuade against sacrificing any historic fabric and recommend that all historic fabric be *retained*. If followed in absolute terms, this policy would dictate that glazing systems in neither the PSFS Building nor in Lever House could be replaced, despite limited service lives of 25 years and 30 years, respectively. Not only is this policy unreasonable when viewed in this light, but it also contradicts the 50-year minimum age requirement for listing on the National Register of Historic Places. Although the service life estimates are conservative and used as a comparative measure, they indicate that the glazing systems would likely have to be sacrificed and replaced prior to the building receiving designation under which regulation would strongly discourage, and perhaps prevent replacement. In practice, officials who enforce the regulations would probably not be so rigid, but the scenario illustrates that high-rises built in 1932 as well as in 1952 might not comply with such an unyielding rule.

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[165] In New York City, a building must be 30 years old to be locally designated an historic landmark while at the national level a building must be 50 years old.

Recognizing that retaining historic fabric in every case is impractical and idealistic, the Standards suggest *repair* as the next preferred level for rehabilitating historic fabric. The Standards define repair as "augmenting or upgrading individual parts of features."[166] Because it is less rigid, this strategy is more attainable than the former. Following repair in the hierarchy of rehabilitation approaches, the guidelines allow for *replacement* under the following conditions: "Where the severity of deterioration requires replacement of a distinctive feature, the new feature shall match the old in design, color, texture, and other visual qualities and, where possible, materials."[167] This approach to replacement is largely focused on aesthetic features. To test the applicability of both repair and replacement approaches, the PSFS Building and Lever House will be used to illustrate the approaches relative to the glazing technologies of two different time periods.

With regard to a repair approach, the single-hung aluminum windows in the PSFS Building, with a nominal 25-year service life, could be retrofitted to extend the windows' service life. To improve their thermal properties, the existing single glazing could be modified to incorporate double glazing, deteriorated sealant joints could be re-caulked to prevent moisture and air infiltration, and thermal breaks could be added. The glass, sealants, and sections necessary to accommodate thermal breaks would be the only portions of the window system sacrificed for new material. Thus, this approach would retain a large percentage of the original fabric of the aluminum windows.

If a repair approach were applied to Lever House's glazing system, the entire vertical enclosure would be subject to repair. To mitigate thermal and moisture issues affecting the

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[166] Morton, 50.
[167] Ibid., vii.

façade, a retrofit of the curtain wall system would be extremely invasive and difficult. The interconnectedness of the system's components would likely require each component to be removed, repaired, and then re-installed. Where modifications require integration, portions of the system would likely have to be removed and taken to an off-site location for retrofit. Because repair would cause disturbance to the entire system, panes of glass would likely break and be sacrificed in the process.

As part of the 2000 renovation of the PSFS Building for its new use as a hotel, the replacement approach was employed and the building's original aluminum hung windows were replaced with "in-kind" hung windows.[168] According to the renovation architect, Arthur Jones of Bower Lewis Thrower Architects, the original windows were constructed of raw aluminum, which had turned black and exhibited extensive pitting. After trying to clean the original windows in attempt to repair them, it was determined that the deterioration was beyond repair and the windows were replaced.[169] The new windows are anodized finished to protect the aluminum from corrosion and incorporate double-paned glass and higher performing sealants to compensate for the original system's inadequate thermal properties. Though newer technologies of the replacement windows do not guarantee a service life longer than the original windows, the replacement windows attempt to improve upon the inadequacies of the original. The replacement of the windows alone would affect only a portion of the entire vertical enclosure. Replacement recommenced the service life of the PSFS Building's glazing system whereas repair would have extended the service life of the existing.

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[168] It is believed that the aluminum windows were replaced as part of the building's renovation for conversion to a hotel in 2000.

[169] Arthur Jones, telephone interview, 17 April 2007.

In the 2002 restoration of Lever House, the replacement approach was executed and its entire curtain wall system was replaced. Replacement in this case was extensive and large scale, affecting the entire vertical enclosure. In designing the new curtain wall, the designers attempted to correct failures of the original system while adhering to the guidelines outlined in the Standards with respect to replacement. As noted previously, these guidelines are particularly sensitive to aesthetic features. Therefore, in addition to improving upon the thermal properties of the curtain wall, the designers were careful to match the dimensions, color, and finish of the components that constitute the aesthetic of the building.

By comparing the repair and replacement approaches, it is evident that the two rehabilitation methods affect the service lives of the vertical enclosure systems in the PSFS and Lever House differently. A repair approach in the PSFS Building would extend the service life of the windows only, which is a percentage of the entire enclosure. By contrast, a repair approach for Lever House's glazing system would extend the service life of 100% of the enclosure. Likewise, a replacement approach to the glazing systems in both buildings affected the percentage of each building's façade consumed by glazing. Whereas only a portion of the PSFS Building's vertical enclosure was provided a new service life, the entire enclosure of Lever House was given a clean slate service life.

On the whole, the windows in the PSFS Building (1932) seem to accommodate a more conservative repair approach while the curtain wall in Lever House (1952) is not as adaptable. When these two approaches, repair and replacement, are applied to two different types of glazing systems, they demonstrate that 1) the same rehabilitation approach is not uniformly applicable to two different glazing systems; and 2) service life of a vertical enclosure can be extended component by component or as a whole system. To elaborate on the first point, each rehabilitation approach must respond to the unique technologies of the system. The PSFS Building and Lever House illustrate that the same rehabilitation approach cannot be uniformly applied to two very distinct glazing systems. Thus, in addition to an aesthetic value, *The Secretary of the Interior's Standards for Rehabilitation* should acknowledge a technological value to account for the technologies unique to specific periods of design and construction.

When considering the values that embody a building's significance, Lever House illustrates a tension between the technical and the aesthetic. Because Lever House is an icon of the modern movement, its curtain wall replacement sparked apprehension along with some discontent among the architecture and preservation communities. Preservationists, in particular, questioned the total loss of historic fabric and, in reaction to the replacement, they questioned the new curtain wall's strict compliance to the original. The concerns vocalized about the curtain wall's replacement lead one to question whether such a radical approach was justifiable. The issues faced in the preservation of the Lever House façade demonstrate a schism between architecture and technology, a condition that Giedion discusses in his book of 1941. Giedion argues that architecture grows out of technological innovation. In the case of the Lever House, it can be argued that its architecture essentially outgrew, or even outlived, its technology. The new curtain wall design attempted to *maintain* the aesthetic, yet *improve* upon the technology.

A better understanding of this schism may lie in a discussion of the two competing values: an aesthetic value and a technological value. The notion of an aesthetic value, or *artistic value*, in architecture has been around for centuries while the concept of a technological value is less widely acknowledged, if at all. In his 1903 publication, Alois Riegl contends that artistic value is not timeless. If this is accepted, then the aesthetic of a monument, or a work of architecture that is monumentalized, has a contemporary value that is defined by its modern, daily value. Riegl suggests that a monument's historical past, or historical value, can be acknowledged and integrated into its contemporary value. Ultimately, a building's contemporary value is the most enduring and becomes a combination of many values, including its aesthetic and historical values.

Riegl discusses an additional value, called *newness value* that is particularly applicable to buildings of the modern movement, such as Lever House. In exploring the meaning of modernity and modern architecture, Hilde Heynen examines the etymology of the word *modern*. She explains that the word has three meanings: the first and oldest meaning is *present* or current; the second meaning is *new*, as opposed to old; and the third meaning has a connotation of being *momentary*, of the transient.[170] Signifying new, the second meaning of modern, in particular, relates to Riegl's discussion on *newness value*. Riegl argues that newness character in a building can only be preserved by means that are in direct contradiction to age value. In this way, he says, "Newness value is indeed the most formidable opponent of age value."[171] The newness inherent in the definition of modern architecture presents a conflict when preserving a building conceived with a newness value. Preservation presupposes that a building has aged and experienced decay. Since disharmony exists between the values of

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[170] Heynen, Architecture and Modernity 8-9.

[171] Riegl, 80.

newness and age, it is particularly challenging to integrate a newness value into a building's contemporary value, especially in the context of preserving modern buildings.

As noted previously, the technology of Lever House's curtain wall aged quickly and its aesthetic eventually outlived its technology. At the time Lever House was built in the early 1950s, the curtain wall's technology was new and progressive, and in this sense, it was consistent with the newness inherent in modern architecture. Its replacement, however, demonstrates that the technological component of its newness eventually aged and led to complete removal of the original curtain wall.

In his writings of 1963, Italian theorist Cesare Brandi argues that a work's original form as the work of man is what interests us and the deterioration of its components does not.[172] One could reason that since technology is also the original work of man, with its origin as an idea or as physical labor, it is also part of a building's significance. Yet, if it is accepted that a building's technology has value but we are not interested in its deterioration, the preservation of technology is placed in question. It is pertinent to note that Brandi's theory was published in 1963 when the modern movement was waning, but still had significant influence on architectural design. At that time, buildings of the modern movement were still considered new and wanted to appear new. Their deterioration was not a concern.

A recent concept called *values-based preservation* builds upon Riegl's writings that acknowledge multiple values in cultural heritage buildings. In his article of 2006 about values-based preservation, Randall Mason contends that cultural change over the past

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[172] Brandi, 233.

century demonstrates that Riegl's values should be augmented to include social, political, and economic values. This thesis argues that an additional value should be acknowledged: a technological value. The evolutionary nature of technology and the effect it has on a building's preservation gives merit to recognizing such a value. While technology might have both positive and negative effects on a building, its role is inextricably linked to preservation issues evident in buildings such as Lever House.

The evolutionary nature of building technology speaks to the change buildings endure over time. Riegl argues: "The modern viewer of old monuments receives aesthetic satisfaction not from the statis of preservation but from the continuous and unceasing cycle of change in nature."[173] This statement echoes and underscores that of John Allan in his essay, "A Challenge of Values." In addressing the philosophical issues of preserving buildings from all eras, one must accept that buildings *must* sustain change and that it is impossible to freeze the state of a building.[174] A preservation philosophy that acknowledges change and a technological value will better align with the forces that affect durability of high-rises and will in turn inform rehabilitation approaches necessary for a long lifespan.

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[173] Riegl, 73.

[174] Allan.

Chapter 11: Conclusion

EVOLUTION OF THE VERTICAL ENCLOSURE IN HIGH-RISES

As building technology evolved over the past century, the high-rise vertical enclosure transformed generally from a monolithic system to a system with discreet, articulated components forming distinct layers with different purposes. In the early period of skyscraper design, structures like the Guaranty Building employed a masonry-dominant curtain wall in which the cladding, anchorage, back-up wall, windows, and structure were combined in one thick wall section. Despite the high level of bonding, the system still acts as a non-loadbearing curtain wall in the way that the dead load of the cladding, windows, and back-up wall is transferred to a structural steel framework. By the 1950s, this prototypical system, which integrated the structure and the cladding, evolved into two distinct systems, one comprised of the structure and one comprised of the cladding.

Lever House clearly exhibits the fragmentation of the composite wall into a two-layered system wherein its glass and steel cladding becomes separated from its structure by a 2 to 3-inch air space. While the glazing system remains tied to the structure, the anchors are no longer embedded in a masonry wall such as they are in the Guaranty Building. By contrast, the anchors in Lever House bridge an air space, tying the cladding and structural systems together.

Over the next fifty years, from 1950 to 2000, the vertical enclosure evolved in such a way that the cladding system and the vertical structural system grew further apart in distance and a third layer with an additional purpose was added. This condition is illustrated in the New York Times Tower's exterior envelope section. While the building's glass and steel curtain wall represents an improved iteration of the earlier curtain wall prototypes of the Seagram Building and Lever House, the structural column grid is freed from the exterior, being separated by a distance of approximately 6'-0" from the curtain wall surface. Therefore, the buildings examined show that after fifty years the distance between exterior enclosure and vertical structure has increased from a few inches to potentially as much as 6'-0." The New York Times Tower embodies yet another development: a third layer of the vertical enclosure. This layer takes the form of a network of ceramic tubes as solar filters. At 1'-6" outboard of the curtain wall surface, the additional layer has a sustainable purpose: to manage the amount of sunlight that enters the building in order to reduce energy costs.

The buildings used to illustrate the major changes in vertical enclosure construction, the Guaranty Building, Lever House, and the New York Times Tower, reveal that the most distinct shifts occur at approximately 50-year intervals: 1900, 1950, and 2000. The high-rises in this thesis exhibit an evolution of the vertical enclosure as follows:

- one layer - c. 1900 (or since its emergence in the late 19th century) to c. 1950;
- two layers - c. 1950 to c. 2000; and
- three layers - c. 2000.

While the 50-year intervals show distinct changes, the vertical envelopes of the buildings constructed between the two major shifts, c. 1925 & c. 1975, incorporate technologies from earlier models and also begin to show the development of technologies realized in later envelope systems.

The PSFS Building, constructed between 1929 and 1932, after the Guaranty Building and before Lever House, is an example of this phenomenon. While its enclosure remains dominated by masonry cladding common to the first period of skyscraper design, the cladding is thinner than previous cladding materials and the enclosure also incorporates a horizontal window of expansive glass. These two characteristics, expansive glass and thinness, were eventually magnified in scale in Lever House's enclosure. Lever House's glass and steel curtain wall unites the concepts of transparency and thinness by expanding the glass and steel framework to encompass the entire vertical enclosure. The enclosure, in effect, is comprised of multiple glazing units positioned within a grid system and expanded across the building's vertical envelope.

While the appearance of the AT&T Building (1978-84) may have been inspired by the aesthetic of a turn-of-the-century skyscraper, its construction incorporated building practices from later eras. This ultimately produced an exterior envelope section most comparable to that of the PSFS Building, built approximately 30 years into the 20th century. Common to both the PSFS Building and the AT&T Building is the steel frame, cladding with a thin stone veneer, and the employment of aluminum windows. The AT&T Building developed beyond the technology of the PSFS to incorporate technologies that were current to its construction period, such as neoprene gaskets, the stick-clips, insulating glass, and granite panels with false joints.

As a heavy and compact vertical enclosure transformed into a largely transparent and multi-layered system over the 20th century, new technologies greatly influenced the relationship of the solid and the void. In the context of much technological advancement, the use of the steel frame and the development of plate glass technology were instrumental to the realization of a transparent façade. As one might expect, the transformation from solidity to transparency is best illustrated through the evolution of glazing systems. Whereas the vertical enclosure generally evolved from integration to separation, glazing systems evolved from a system of separate units (e.g. double-hung windows) to an integrated system (e.g. glass and metal curtain wall). In effect, the development of integrated glazing systems was an evolutionary process inverse to that of the whole vertical enclosure that developed a larger number of discreet components.

The enclosures of the Guaranty Building, the PSFS Building, and Lever House represent the first fifty years (c. 1900 to c. 1950) of the trend whereby the solid is gradually reduced and the void is increased. This transformation is evident in both the section and elevation representations of these buildings. While the glazing systems expand to encompass the entire elevation, they also become more integrated in section and are separated from the structural layer. Earlier high-rises employed multiple glazing units in the form of double-hung windows, as evident in the Guaranty Building. By using an expansive glass wall, the PSFS Building shows that by 1932 a higher percentage of transparency was being added to high-rise vertical enclosures. However, the expansive glass was only a portion of the glazing in the façade with the remainder incorporating the earlier established double-hung windows. The glass wall in the PSFS Building was a precursor to the glass and steel curtain wall that was realized in Lever House by 1952. In this way, one can see the transformation from distinct units, a combination of distinct units and an expansive glass wall, and finally to an entire vertical enclosure defined by glass and metal. Thus, as glazing slowly dominated the façade, the masonry cladding is diminished and eventually disappears.

THE EFFECT OF TECHNOLOGY ON DURABILITY

Technology that enabled the vertical enclosure's evolution also affected the enclosure's durability. In some buildings, the effect extends the enclosure's lifespan while in others it shortens the lifespan. The buildings examined show that experimental technologies, those that were still in the developmental stages, are more likely to have a shorter lifespan. The evolution of technology demonstrates that manufacturers attempt to improve upon the shortcomings of prototypes and, as a result, the lifespan of that technology is oftentimes lengthened. The effect technological developments have had on individual building components, however, is not as easily defined. In this thesis, service life was used to analyze the first lifespan (and durability in the broad sense) of the components in each building's vertical enclosure. As outlined in Chapter 9: Comparative Analysis, the service life of each component was highly sensitive to its material properties and did not adequately capture the integrity (or lack thereof) of its integration within the enclosure system. In order to effectively assess a building's durability, service life must be viewed in combination with the enclosure's maintainability. After the service life of each component was determined, the building's enclosure was then analyzed with regard to its maintainability. The results were varied and did not mirror those of the service life analysis.

The maintainability analysis showed that while the service lives of an enclosure's components might be high, the enclosure's maintainability might be difficult because it is highly dependant upon proper integration of the components to allow for easy access. The maintainability analysis executed in this thesis reveals that operable windows and removable components indicate excellent maintainability. Along with the service life of the components, their juncture and integration into the building enclosure becomes critical to the enclosure's durability. This suggests that easy access for repairs and replacement is necessary to extend a component's lifespan and in turn improve the durability of the vertical enclosure on the whole. Thus, ensuring that an enclosure system employs flexible joint design is crucial to achieving the long-term goal of maintaining buildings as valuable and adaptable resources.

Many have written about the concept that a higher level of technological experimentation might decrease a building's lifespan. This high level of experimentation is most evident in buildings of the modern movement. Certainly, Lever House's curtain wall is an example of how the inadequacies of a highly experimental system ultimately led to its complete replacement. On the other hand, the New York Times Tower's curtain wall is an example of a system that evolved from Lever House's innovative prototype and seems to have improved upon the inadequacies of the earlier one. With that said, time will tell how well the NYT Tower's curtain wall lasts before it requires repair or replacement. Service life analysis predicts that the NYT Tower's curtain wall will require renewal in 40 years, yet the analysis also predicts that Lever House's curtain wall required renewal after 25 years.[175] In actuality, it was replaced 50 years after construction was completed.

Although the service life analysis has provided a means to compare the lifespans of 20-century high-rise vertical enclosures, the method remains quite theoretical. While the analysis might be valid when comparing buildings, such as Lever House and the NYT Tower, through a common method, the resultant data is not proven applicable to actual

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[175] The history of repairs to Lever House's curtain wall prior to its replacement is not known. Attempts many have been made to correct the shortcomings of the system before the decision was made to replace the entire system.

conditions and outcomes. To compensate for the disparity, factual data on the history of each building's rehabilitation campaigns should be gathered and applied to the service life analysis of each building. Furthermore, the recommended approaches to service life analysis, such as those put forth by the *HAPM Component Life Manual*, AIJ's *Principal Guide for Service Life Planning of Buildings*, and information published on Ted Kesik's website on enclosure durability, should be synthesized and used to codify an applicable approach for predicting service lives of all building types, not only those of high-rises.

Because the majority of service life research originates in foreign countries, such as Japan, the United Kingdom, and Canada, the United States must become more involved in research efforts. One plausible reason for the United States' lack of involvement is because this country does not generally treat real estate as a long-term asset.[176] The United States should also recognize the economic advantage tied to predicting a building's service life as a tool to reduce capital expenditures and in turn free up funds that can be applied towards another purpose or investment. As part of a global cause and as an economic motivation, the United States must engage the sustainable objective of maintaining real estate assets for the long-term.

APPLICATION OF PRESERVATION PHILOSOPHY

Given the evolutionary nature of building technology and the positive and negative effect the changes can have on a building's durability, preservation philosophy must acknowledge a technological value. As the most commonly implemented preservation guideline, *The Secretary of the Interior's Standards for Rehabilitation* must recognize the role

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[176] Bernard Camins, telephone interview, 7 Mar. 2007.

technology plays in a building's durability. The Standards should adjust the guidelines to allow for methods of renewal consistent with the technological environment in which a building was constructed. For instance, it is unreasonable to call for the retention of experimental technologies that are failing and adversely affecting the durability of other building components. Because the Standards are enforced in registered buildings and compliance is required for the use of historic tax credits, such a revision to the Standards has a greater chance for actual implementation.

The Standards must also learn from John Allan who asserts that we must embrace the change buildings endure. In order to perform their fundamental function to provide shelter and be able to adapt to the needs of society, buildings must change. Therefore, preservation philosophy must accept that change is part of a building's historical significance and is oftentimes crucial to its long-term durability. Especially for buildings of the modern movement, accepting change is intricately tied the original design intent of progress and emancipation from traditional building practices. While the preservation of buildings from the modern movement, in particular, remains complex and paradoxical, technology will continue to evolve and challenge the preservation of high-rises and other building types.

It should be recognized that the majority of the high-rises studied in this thesis are notable exceptions to the rest of the building stock of their respective eras in several ways. They are icons, they benefited from generous construction budgets, and as high-rises they were designed to have a total lifespan of 60 to 100 years, which is longer than many other building types.

As icons, they have been protected from serious threats of demolition simply due to their significance. On the other hand, as registered buildings (or those expected to be registered in the future), they must also comply with preservation regulations and are often the subject of debate when disputes ensue over radical changes proposed to their fabric. Since people develop a sense of ownership of iconic buildings, they are often more reluctant to accept changes to these buildings, especially when those changes come in the form of drastic interventions.

Generous construction budgets also enable choices for materials and systems that cost more, and are oftentimes more durable. In this way, the buildings studied have an advantage over other buildings with more modest budgets. Since high-rises are typically designed for longer lifespans than other building types, one can argue that high-rises start with a higher service life than other building types.

In sum, the high-rises studied in this thesis have unique characteristics and the analysis cannot be uniformly applied to all building types. However, these buildings do reveal that a relevant preservation philosophy should acknowledge a technological value to compensate for the evolutionary nature of building technology that is likely found in other building types. A balance must be struck between the level of intervention necessary to extend building's lifespan while accepting change and remaining true to the origin of the idea behind the building's architecture, technology, and its purpose.

FUTURE CHALLENGES

Since technology in high-rise vertical enclosure design has evolved to a multi-layered system that integrates with a sustainable, energy-conscious design component, these new types of systems with new purposes will present preservation challenges for the next generation. As the current trend suggests, energy consciousness will continue to be at the forefront of discussions on buildings' sustainability and must also be considered with regard to buildings' durability.

Similar its purpose, modern architecture incorporated concepts of progress and emancipation, and many technologies in buildings from the modern movement were experimental and have proven to be ephemeral. In this way, the purpose aligns with the outcome. As illustrated in the New York Times Tower, the current movement in architecture has a sustainable, energy-conscious purpose. The next fifty years should prove whether the purpose in fact breeds more durable technologies. Like the buildings from the modern movement, will the origin of sustainable design align with the outcome?

Although one architect foresees a time when buildings will be able "to 'recharge' themselves," building technology has not yet evolved to that level of efficiency.[177] While a break-through is not eminent, professionals and preservation guidelines must acknowledge the evolving nature of building technology to maximize buildings' durability and their useful lifespans.

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[177] Vuk Vujovic and Douglas J. Ogurek, "The Metal Panel Deconstructed: Future Applications of Composite Metal Wall Systems," Eco-Structure Mar. 2007: 63-64.

Bibliography

(Categorized by theme)

MODERN MOVEMENT

Bronson, Susan D. and Thomas C. Jester. "Conserving the Built Heritage of the Modern Era: Recent Developments and Ongoing Challenges." APT Bulletin. 28. 4 (1997): 4-12.

"The Case of 2 Columbus Circle." Editorial. New York Times. 29 June 2005: A22.

Cunningham, Allen, ed. Modern Movement Heritage. London; New York: E & FN Spon, 1998.

Goldhagen, Sarah Williams. "Something to Talk About: Modernism, Discourse, Style." Journal of the Society of Architectural Historians. 64. 2 (2005): 144-167.

GSA. Growth Efficiency and Modernism: GSA Buildings of the 1950s, 60s, and 70s. Washington, DC: U.S. General Services Administration, Office of the Chief Architect, Center for Historic Buildings, 2003.

Henket, Hubert-Jan. "The Icon and the Ordinary." Modern Movement Heritage. Ed. Allen Cunningham. London; New York: E&FN Spon, 1998. 13-17.

Henket, Hubert-Jan and Hilde Heynen. Back From Utopia: the Challenge of the Modern Movement. Rotterdam: 010 Publishers, 2002.

Heynen, Hilde. Architecture and Modernity: a Critique. Cambridge, MA: MIT Press, 1999.

Heynen, Hilde. "Transitoriness of Modern Architecture." Modern Movement Heritage. Ed. Allen Cunningham. London; New York: E&FN Spon, 1998. 29-35.

Jester, Thomas C. and Susan D. Bronson. "Mending the Modern: A Selected Bibliography." APT Bulletin. 28. 4 (1997): 59-60.

Kelley, Stephen and Dennis K. Johnson. "The Metal and Glass Curtain Wall: The History and Diagnostics." Modern Movement Heritage. Ed. Allen Cunningham. London; New York: E&FN Spon, 1998. 77-87.

Kinney, Leila W. "Fashion and Fabrication in Modern Architecture." The Journal of the Society of Architectural Historians. 58. 3 (1999): 472-481.

Longstreth, Richard. "The Significance of the Recent Past." APT Bulletin. 23.2 (1991): 12-24.

Perspecta 32: Resurfacing Modernism. Eds. Ann Marie Brennan & Brendan D. Moran. Cambridge, MA: The MIT Press. 2001.

Pogrebin, Robin. “2 Columbus Circle Makes Group’s List of Threatened Sites.” New York Times. 21 June 2005: E1.

Pogrebin, Robin. “In Preservation Wars, a Focus on Midcentury.” New York Times. 24 Mar. 2005.

Pogrebin, Robin. “Permit Issued for Long-Disputed Work at 2 Columbus Circle.” New York Times. 30 June 2005: B4.

Pogrebin, Robin. “Wrecking Ball Dashes Hopes for a Lapidus Work.” New York Times. 9 Mar. 2005.

Rappaport, Nina. “Preserving Modern Architecture in the US.” Modern Movement Heritage. Ed. Allen Cunningham. London; New York: E&FN Spon, 1998. 59-65.

Sharp, Dennis and Catherine Cooke, eds. The Modern Movement in Architecture: Selections from the DOCOMOMO Registers. Rotterdam: 010 Publishers, 2000. 266-272.

Traub, James. “The Towering Problem.” New York Times Magazine. 15 May 2006: 23-24.

TECHNOLOGY

Allen, William. Envelope Design for Buildings. Oxford: Architectural Press. 1997.

Brookes, Alan J. Cladding of Buildings. 3rd ed. London: E & FN Spon, 1998.

Brookes, Alan J. and Chris Grech. The Building Envelope: Applications of New Technology Cladding. London; Boston: Butterworth Architecture, 1990.

Clark, W.C and J.L. Kingston. The Skyscraper: A Study in the Economic Height of Modern Buildings. New York; Cleveland: American Institute of Steel Construction, Inc., 1930.

Davison, Robert L. “Progress in Prefabrication.” Architecture: AIA Journal. May 1944: 234-242.

“The “Flatiron” or Fuller Building.” Architectural Record. Oct. 1902: 528-536.

Gatz, Konrad. Curtain Wall Construction. New York: Washington: Frederick A. Praeger, Inc., 1967.

Giedion, Sigfried. Space, Time and Architecture: The Growth of a New Tradition. 5th ed. Cambridge, MA: Harvard University Press, 1997. 163-617.

Girard, Ann, and George M. Bleekman III, Karin Link, et al. Twentieth-Century Buildings Materials 1900-1950: An Annotated Bibliography NPS Reading List. Washington, DC: U.S. Department of the Interior, 1993.

Hart, Franz, W. Henn, and H. Sontag. Multi-storey Buildings in Steel. Trans. G. Bernard Godfrey. New York: Nichols Pub Co., 1985.

Herzog, Thomas. Facade Construction Manual. Basel; Boston: Birkhauser-Publishers for Architecture, 2004.

Hindrichs, Dirk U. and Winfried Heusler, Eds. Facades: Building Envelopes for the 21st Century. Basel; Boston: Birkhauser, 2004.

Hornbostel, Caleb and William J. Hornung. Materials & Methods for Contemporary Construction. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1982.

Jester, Thomas C., ed. Twentieth-Century Building Materials: History and Conservation. New York: McGraw-Hill, 1995.

Kaskel, Bruce S. "The Metal and Glass Curtain Wall." 14 Feb 2007. <http://crm.cr.nps.gov/archive/18-8/18-8-7.pdf>.

Kelley, Stephen J. "The Glass and Metal Curtain Wall: History, Diagnostics and Treatment." Preserving Post-War Heritage: The Care and Conservation of Mid-twentieth Century Architecture. Ed. Susan Macdonald. Shaftesbury, Dorset: Donhead Publishing, 2001. 150-166.

Kelley, Stephen J. and Dennis K. Johnson. "Metal and Glass Curtain Wall: History and Diagnostics." Modern Movement Heritage. Ed. Allen Cunningham. London; New York: E&FN Spon, 1998. 77-87.

Knobloch, Philip G. Architectural Details from the Early Twentieth Century: A Book of Traditional Details. 1931. 2nd ed. Washington, D.C.: American Institute of Architects Press, 1991.

Lewis, James. "Lugs, Stubs, Brackets, Clamps, and Dowels-and Bolts into the Concrete: Window Fixings and the Bauhaus." DOCOMOMO 28, Mar. 2003: 83-93.

McCallum, Ian, ed. "Machine Made America." Architectural Review. May 1957: 293-393.

Mumford, Lewis. This City in History. San Diego; New York: Harcourt, Inc., 1961: 430.

Pelli, Cesar. “Skyscrapers.” Perspecta.18 (1982): 134-151.

Sands, Herman. Wall Systems: Analysis By Detail. New York: McGraw-Hill, 1986.

Savage, Bernard A. “Post-War Expectations in New Materials and Methods of Construction.” Architecture: AIA Journal. May 1944: 215-221.

Starrett, W.A. Skyscrapers and the Men Who Build Them. New York; London: Charles Scribner’s Sons, 1928.

“Technical Department.” Architectural Record. Jan. 1902: 104-128.

“Trends in the Development of Building Materials.” Architectural Record. May 1939: 78-83.

Vujovic, Vuk and Douglas J. Ogurek. “The Metal Panel Deconstructed: Future Applications of Composite Metal Wall Systems.” Eco-Structure. Mar. 2007: 63-64.

Wilson, Forrest. Building Materials Evaluation Handbook. New York: Van Nostrand Reinhold Company, 1984.

Wiseman, Carter. Shaping a Nation: Twentieth-Century American Architecture and Its Makers. New York; London: W.W. Norton & Company, 1998. 1-182.

Yeomans, David. Construction Since 1900: Materials. London: BT Batsford Ltd. 1997.

Yeomans, David. “The Origins of the Modern Curtain Wall.” APT Bulletin. 32.1 (2001): 13-18.

SERVICE LIFE

Architectural Institute of Japan. The English Edition of Principal Guide for Service Life Planning of Buildings. Architectural Institute of Japan: 1993.

Baker, J.M., ed. Durability of Building Materials and Components. Proc. of Fifth International Conference, Nov. 7-9 1990, Brighton, UK. London; New York: E. & F.N. Spon, 1991.

Bourke, Kathryn and Hywel Davies. “Factors Affecting Service Life Predictions of Buildings: A Discussion Paper.” Building Research Establishment Laboratory. London: 1997.

Camins, Bernard. Telephone Interview. 7 Mar. 2007.

Construction Audit, Ltd. HAPM Component Life Manual. London; Glasglow: E & FN Spon, 1994.

Fischetti, David C. "The Montague Building and Watauga Hall: A Comparison of Predicted Service Life Based on Building Materials." Service Life of Rehabilitated Buildings and Other Structures. Eds. Stephen J. Kelley and Philip C. Marshall. Philadelphia, PA: ASTM, 1990. 117-124.

Frohnsdorff, G.J. and J.W. Martin. "Towards Prediction of Building Service Life: The Standards Imperative." Durability of Building Materials and Components: Proceedings of the 7th International Conference, Stockholm, Sweden, 19-23 May 1996. Ed. C. Sjostrom. New York: E & FN Spon, 1996. 1417-1428.

Fuller, Sieglinde. "Life-Cycle Cost Analysis." World Building Design Guide. <http://www.wbdg.org/design/lcca.php?r=use_analysis>.

Johnson, Paul G. Performance of Exterior Building Walls. West Conshohocken, PA: ASTM International, 2003.

Kesik, Ted. Enclosure Durability. Architectural Science Forum: 2002. <http://www.canadianarchitect.com/asf/enclosure_durability/>.

Lacasse, M.A. and C. Sjostrom. "Recent Advances in Methods for Service Life Prediction of Building Materials and Components – An Overview." (2004) National Research Council Canada. 22 Sept. 2006 <http://irc.nrc-cnrc.gc.ca/pubs/fulltext/nrcc47030/nrcc47030.pdf>.

Mora, Eduardo Peris. "Life Cycle, Sustainability and the Transcendent Quality of Building Materials." Building and Environment. 42 (2007): 1329-1334.

Part II: Metals Systems and Architecture. 14 Mar 2007. <http://ocw.mit.edu/NR/rdonlyres/Architecture/4-461Fall-2004/46D31163-F862-461F-B314-D0E7506860C8/0/lect17b.pdf>.

Sarja, Asko. Integrated Life Cycle Design of Structures. London; New York: Spon Press, 2002.

Sereda, P.J. and G.G. Litvan, eds. Durability of Building Materials and Components. Proc. of First International Conference, Aug. 21-23 1978, Ottawa, CA. Philadelphia: American Society for Testing and Materials, 1980.

Shohet, Igal M. and Monica Paciuk. "Service life prediction of exterior cladding components under failure conditions." Construction Management & Economics, 24.2 (Feb 2006): 131-148, DOI 10.1080/01446190500184535, URL http://dx.doi.org/10.1080/01446190500184535.

Simpson, John W. and Peter J. Horrobin, eds. The Weathering and Performance of Building Materials. New York: Wiley-Interscience. 1970.

PRESERVATION PHILOSOPHY

Allan, John. "A Challenge of Values." Back From Utopia: the Challenge of the Modern movement. Eds. Hubert-Jan Henket and Hilde Heynen. Rotterdam: 010 Publishers, 2002. 20-25.

Bendix, Regina. In Search of Authenticity. Madison: University of Wisconsin, 1999. 3-23.

Brandi, Cesare. "Theory of Restoration (1963)." Historical and Philosophical Issues in the Conservation of Cultural Heritage. Eds. N. Stanley Price, M.K. Talley Jr., and A.M. Vaccaro. Los Angeles: The Getty Conservation Institute, 1996. 230-235, 339-342, 377-379.

Bronson, Susan D. "Authenticity Considerations for Curtain-Wall Buildings: Seminar Summary." APT Bulletin. 32. 1 (2001): 5-8.

Fixler, David N. "The Renovation of Baker House at MIT: Modernism, Materiality, and the Factor of Intent in Preservation." APT Bulletin. 32. 2-3 (2001): 3-11.

Kuhns, Richard. "Criticism and the Problem of Intention." The Journal of Philosophy. 57.1 (1960): 5-23.

Longstreth, Richard. "The Significance of the Recent Past." APT Bulletin. 23.2 (1991): 12-24.

Mason, Randall. "Theoretical and Practical Arguments for Values-Centered Preservation." CRM: The Journal of Heritage Stewardship. 3. 2 (2006): 21-48.

Morton, W. Brown III, et al. The Secretary for the Interior's Standards for Rehabilitation and Illustrated Guidelines for Rehabilitating Historic Buildings. Washington, D.C.: U.S. Dept. of the Interior, National Park Service, Preservation Assistance Division, 1992.

Riegl, Alois. "The Modern Cult of Monuments: Its Essence and Its Development (1903)." Historical and Philosophical Issues in the Conservation of Cultural Heritage. Eds. N. Stanley Price, M.K. Talley Jr., and A.M. Vaccaro. Los Angeles: The Getty Conservation Institute, 1996, 268-274, 358-363.

Schwarzer, Mitchell. "Myths of Permanence and Transience in the Discourse on Historic Preservation in the United States." Journal of Architectural Education. 48. 1 (Sept. 1994): 2-11.

BUILDING SPECIFIC

Guaranty Building

Adler, Dankmar and J.W. Yost. "Influence of Steel Construction and of Plate Glass Upon the Development of Modern Style." The Inland Architect and News Record. Nov. 1896: 33-37.

Aronoff, Jason. "Jack Randall: Preservation on Principle." Western New York Heritage. Fall 2006: 6-14.

Doubilet, Susan. " In the Empire State: The Guaranty Building, Buffalo, N.Y." Progressive Architecture. 65.11 (Nov. 1984): 88-94.

Menocal, Narciso G. Architecture and Nature: The Transcendentalist Idea of Louis Sullivan. Madison, Wisconsin: The University of Wisconsin Press, 1981, 43.

Samuelson, Timothy. Personal Interview. 27 Oct. 2007.

Siry, Joseph. "Adler and Sullivan's Guaranty Building in Buffalo." The Journal of the Society of Architectural Historians. 55.1 (1996): 6-37.

Sullivan, Louis. "The Tall Office Building, Artistically Considered." Louis Sullivan, The Public Papers, electronic version.

"The Prudential (Guaranty) Building." Architectural Record. Aug. 1909: 84, 90, 92, 94.

Twombly, Robert. Louis Sullivan: His Life and Work. New York: Viking, 1986, 281-332.

_______________, ed. Louis Sullivan: The Public Papers. Chicago: University of Chicago Press, 1988.

Woolworth Building

Aus, Gunvald. "Engineering the Design of the Woolworth Building Cass Gilbert, F.A.I.A., Architect." The American Architect. 26 Mar 1913: 157-170.

Gaskie, Margaret F. "The Woolworth Tower: A Technology Revisited, A Material Understood, A Landmark Restored." Architectural Record. Mid-August 1981: 90-95.

Irish, Sharon. Cass Gilbert, Architect: Modern Traditionalist. New York: The Monacelli Press, 1999. 122-136.

Prudon, Theodore H.M. “‘Great Expectations’: Woolworth Building (Cass Gilbert) and Lever House (SOM).” Modern Movement Heritage. Ed. Allen Cunningham. London; New York: E&FN Spon, 1998. 88-95.

___________. “Saving Face: Preservation: Curtain Wall Restoration.” Architecture: AIA Journal. 79. 11 (1990): 105-110, 114.

Schuyler, Montgomery. The Woolworth Building. New York: F.W. Woolworth, 1913.

___________. “’The Towers of Manhattan,’ and Notes on the Woolworth Building.” Architectural Record. Feb. 1913: 99-122.

PSFS Building

Gutheim, Frederick. “Saving Fund Society Building: A Re-appraisal.” Architectural Record. Oct. 1949.

Howe, George, et al. “The PSFS Building, Philadelphia, Pennsylvania, 1929-1932.” Perspecta. 25 (1989): 78-141.

Jones, Arthur. Telephone Interview. 17 April 2007.

Jordy, William H. “PSFS: Its Development and Its Significance in Modern Architecture.” The Journal of the Society of Architectural Historians. 21.2 (May 1962): 47-83.

“A New Shelter for Saving Society.” Architectural Forum. 57.6 (Dec. 1932): 483-507.

Russell, James S. “Altering an Icon.” Philadelphia Inquirer. 17 Nov 1998: E1+.

____________. “PSFS, A Modernist Icon, To Be Converted to a Hotel.” Architectural Record. Jan. 1998: 32.

____________. “Icons of Modernism or Machine-age Dinosaurs?” Architectural Record. June 1989: 142-147.

Lever House

Dixon, John Morris. “Lever House: A Paragon Preserved.” Architecture. 91.12 (2002): 60-67.

Hart, Sara. “A Middle-aged Modernist Icon is Rejuvenated with a New Skin.” Architectural Record. Mar. 2003: 126.

“Lever House Complete.” Architectural Forum. June 1952: 101-111.

"Lever House, New York: Glass and Steel Walls." Architectural Record. June 1952: 130-135.

McCallum, Ian, ed. "Machine Made America." Architectural Review. May 1957: 313.

Prudon, Theodore H.M. "'Great Expectations': Woolworth Building (Cass Gilbert) and Lever House (SOM)." Modern Movement Heritage. Ed. Allen Cunningham. London; New York: E&FN Spon, 1998. 88-95.

___________. "Saving Face: Preservation: Curtain Wall Restoration." Architecture: AIA Journal. 79. 11 (1990): 105-110, 114.

Russel, James S. "Icons of Modernism or Machine-age Dinosaurs?" Architectural Record. June 1989: 142-147.

Stephens, Suzanne. "Analysis: The Restoration of New York City's Lever House is Not So Same-old Same-old, as Architects SOM and William T. Georgis Demonstrate." Architectural Record. Mar. 2003: 122.

Alcoa Building

"Alcoa Building: Innovations in Aluminum." Architectural Record. Aug. 1952: 120-127.

"Alcoa Complete: Pittsburgh's 3-story Aluminum Waffle is America's Most Daring Experiment in Modern Office Building." Architectural Forum. Nov. 1953: 124-131.

"Building Engineering: Aluminum Challenges Copper." Architectural Forum. Aug. 1952: 140-146.

Holmes, Jack. "Faceted Metal Wall for Alcoa in Pittsburgh Sets New Style in Tall Buildings." Architectural Forum. July 1952: 134-135.

McCallum, Ian, ed. "Machine Made America." Architectural Review. May 1957: 319.

"Office Buildings: Fenestration." Architectural Record. Apr. 1955: 198-216.

Seagram Building

Carter, Peter. Mies van der Rohe at Work. London: Phaidon Press Limited, 1999, 38-63.

__________. "Mies van der Rohe." Architectural Design. Mar. 1961: 114-166.

Drexler, Arthur. "The Seagram Building." Architectural Record. July 1958: 141-147.

McCallum, Ian, ed. “Machine Made America.” Architectural Review. May 1957: 315, 339.

“Un Monumento a New York: il ‘Seagram Building.’” Casabella Continuita. Jan. 1959: 3-11.

Mumford, Lewis. “The Lesson of the Master.” Architecture: AIA Journal. Jan. 1959: 19-23.

“Seagram Building, New York, USA: Mies van der Rohe & Philip Johnson.” Architectural Design. Feb. 1961: 72-77.

“A Skyscraper Crammed with Innovations.” Engineering News-Record. [Date unknown]: 8-9. David Guise Collection. Architectural Archives of the University of Pennsylvania, Philadelphia, Pennsylvania.

Tigerman, Stanley. “Mies van der Rohe: A Moral Modernist Model.” Perspecta. 22 (1986): 112-135.

Citicorp Center

Associated Press, “The City; Solar Study Starts on Citicorp’s Roof.” New York Times. 23 Sept. 1983, late ed.: B5.

“At New York’s Citicorp Center, a structure of masterly invention underlies the urbane face of a skyscraper.” Architectural Record. Mid-August 1976: 66-71.

“Citicorp Center: Lexington Avenue, 53rd to 54th Streets, Hugh Stubbins & Associates, and Emery Roth & Sons, 1977.” A + U: Architecture and Urbanism. Dec. 1994, extra ed.: 330-335.

Davis, Douglas. “Brave New Skyscraper.” Newsweek. 31 Oct. 1977: 84.

Egan, Jack. “Citicorp Center Takes Its Place in Manhattan.” 15 Oct. 1977, final ed.: E1.

Ludman, Dianne M. Hugh Stubbins and His Associates: the First Fifty Years. Cambridge, MA: Stubbins Associates, 1986, 84-93.

Morgenstern, Joe. “The Fifty-Nine Story Crisis.” The New Yorker. 29 May 1995: 45-53.

“Photovoltaic System to top 914-ft Tower.” Engineering News-Record. 8 Oct. 1981: 18.

Schmertz, Mildred F. “Citicorp Center: If You Don’t Like its Crown, Look at its Base.” Architectural Record. June 1978: 114-116.

“This High-rise Hardly Sways.” Business Week. 7 Nov. 1977, industrial ed.: 84G.

“A Tower with a Distinctive Top.” Architecture: AIA Journal. Mid-May 1979: 172-174.

AT&T Building

Blake, Peter. Philip Johnson. Basel; Berlin; Boston: Birkhauser, 1996, 192-195.

Forgey, Benjamin. "Towers of Excellence: Manhattan's AT&T & Seagram Skyscrapers." The Washington Post. 7 Apr. 1984, final ed.: C1.

Freedman, Adele. "Jahn Spearheads Battle of the Box." The Globe and Mail. 23 Feb. 1984: E7.

Goldeberger, Paul. "Paul Goldberger Examines New Designs in American Skyscrapers. Notes new…" New York Times. 8 Nov. 1981: 68. Abstract.

Goldberger, Paul. "Paul Goldberger Reviews New Office Building Being Erected Along NYC's…" New York Times. 18 Dec. 1980: 21. Abstract.

"Great Eclectic." Newsweek. 8 Nov. 1982, United States ed.: 76.

Huxtable, Ada Louise. "Ada Louise Huxtable Surveys Principal Architectural Achievements…" New York Times. 31 Dec. 1978: 21. Abstract.

Lewis, Hilary and John O-Connor. Philip Johnson: The Architect in His own Words. New York: Rizzoli, 1994, 104-111.

Philip Johnson/John Burgee: Architecture 1979-1985. New York: Rizzoli, 1985, 40-53.

"Philip Johnson Designs a Post-modernist Tower for AT&T." Architectural Record. May 1978: 34.

Tomasson, Robert E. "Granite is Making Major Comeback as Building Material in Manhattan." New York Times. 15 Sept. 1979: 22.

New York Times Tower

Choi, Amy. "Designing the New York Times: Steel Grid Visible Inside and Out." New York Construction. Sept. 2003: 59.

Dunlap, David W. "Times Goes Forward on Plan for Tower on Eighth Avenue." New York Times. 14 Dec. 2001, late ed.: D3.

Goldeberger, Paul. "Spiffing up the Grey Lady." The New Yorker. 7 Jan. 2002: 20.

"Green Towers for New York: From Visionary to Vernacular." The Skyscraper Museum. 8 Feb 2007. <http://www.skyscraper.org/EXHIBITIONS/GREEN_TOWERS/gt_walkthrough_corphq_nyt.htm>.

Hagberg, Eva. "NY's Green Horizon: With a Spate of New Towers on the Rise, the Future of the City's Skyline Looks Sustainable." Metropolis. May 2006: 52.

"Piano's N.Y. Times Tower Moves Forward." Architectural Record. Jan. 2002: 24.

Rosenthal, Jack. "Insolation." New York Times Magazine. 16 July 2006, late ed.: 18.

Snoonian, Deborah. "Green Grows Up…and Up and Up and Up: Sustainable High-rises are Sprouting from Manhattan's Bedrock." Architectural Record. 1 Nov. 2004: 42.

ARCHIVES

Alcoa Building, Wallace K. Harrison Collection, Avery Architectural Library, Columbia University, New York, New York.

David Guise Collection, Architectural Archives of the University of Pennsylvania, Philadelphia, Pennsylvania.

Mellor, Meigs & Howe Collection, PSFS Building, Architectural Archives of the University of Pennsylvania, Philadelphia, Pennsylvania.

Woolworth Building Collection, Print Room, New York Historical Society, New York, New York.

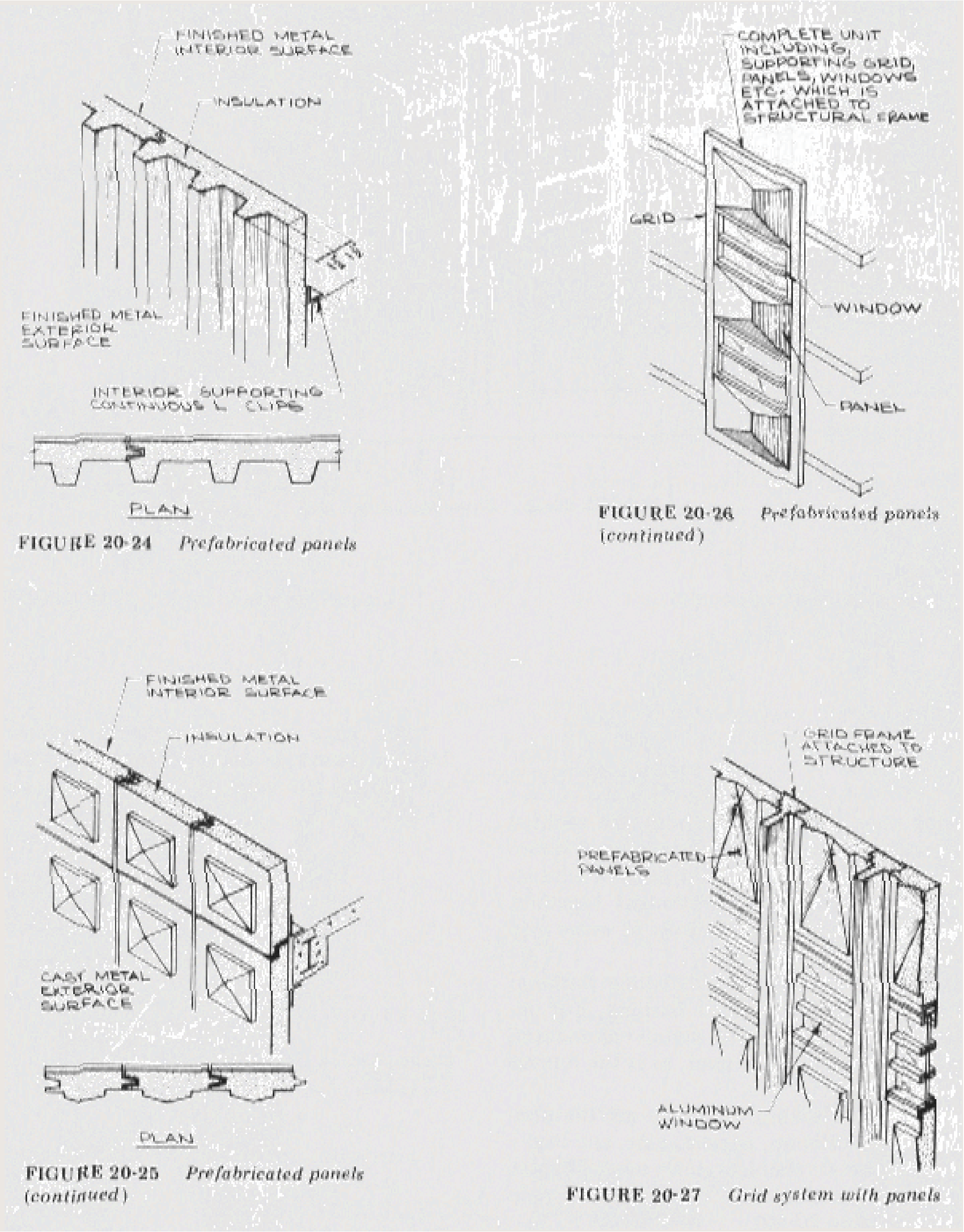


FIGURE 20-24 *Prefabricated panels*

FIGURE 20-26 *Prefabricated panels (continued)*

FIGURE 20-25 *Prefabricated panels (continued)*

FIGURE 20-27 *Grid system with panels*

Figure 2.1 - Illustrations of curtain wall systems, prefabricated panels and grid systems with panels, in Caleb Hornbostel and William J. Hornung, Materials & Methods for Contemporary Construction (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1982) 217.

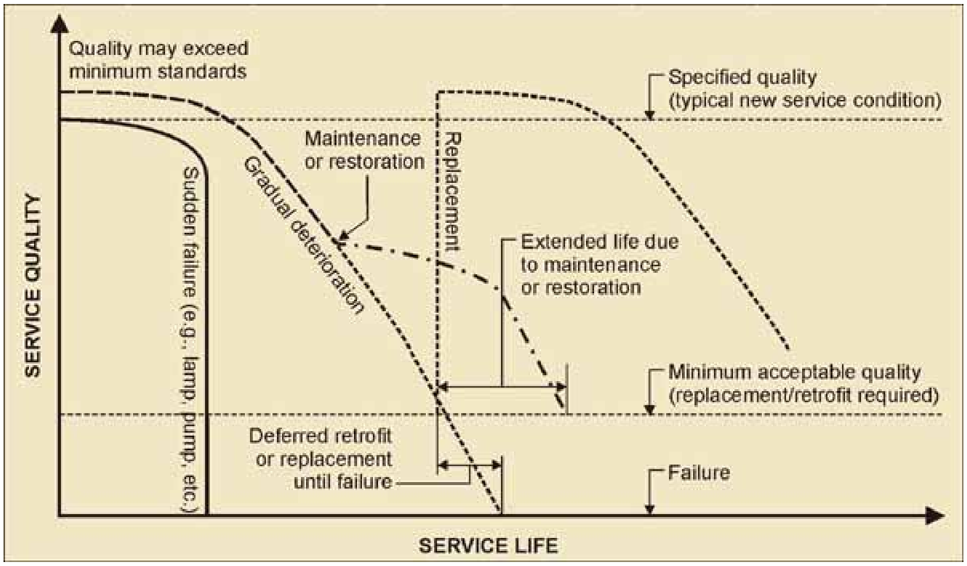
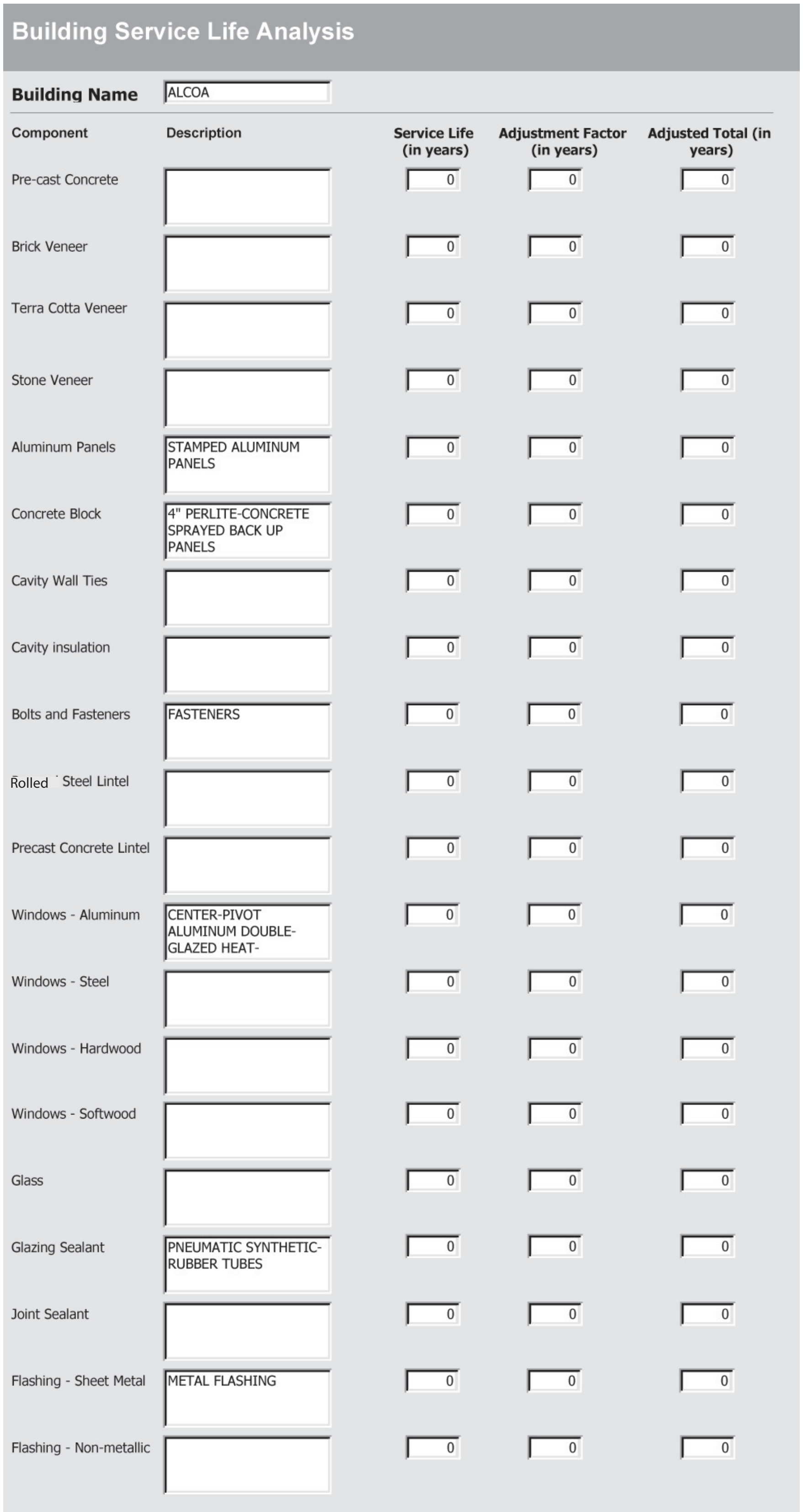


Figure 3.1 - Diagram showing service life. Source: Ted Kesik's website on Enclosure Durability.



Building Service Life Analysis

Building Name ALCOA

Component	Description	Service Life (in years)	Adjustment Factor (in years)	Adjusted Total (in years)
Pre-cast Concrete		0	0	0
Brick Veneer		0	0	0
Terra Cotta Veneer		0	0	0
Stone Veneer		0	0	0
Aluminum Panels	STAMPED ALUMINUM PANELS	0	0	0
Concrete Block	4" PERLITE-CONCRETE SPRAYED BACK UP PANELS	0	0	0
Cavity Wall Ties		0	0	0
Cavity insulation		0	0	0
Bolts and Fasteners	FASTENERS	0	0	0
Rolled Steel Lintel		0	0	0
Precast Concrete Lintel		0	0	0
Windows - Aluminum	CENTER-PIVOT ALUMINUM DOUBLE-GLAZED HEAT-	0	0	0
Windows - Steel		0	0	0
Windows - Hardwood		0	0	0
Windows - Softwood		0	0	0
Glass		0	0	0
Glazing Sealant	PNEUMATIC SYNTHETIC-RUBBER TUBES	0	0	0
Joint Sealant		0	0	0
Flashing - Sheet Metal	METAL FLASHING	0	0	0
Flashing - Non-metallic		0	0	0

Figure 3.2 - Typical form used for Service Life Analysis.

Figure 4.1 - The Guaranty Building, photo by B. Dandona 6 Nov. 2006.

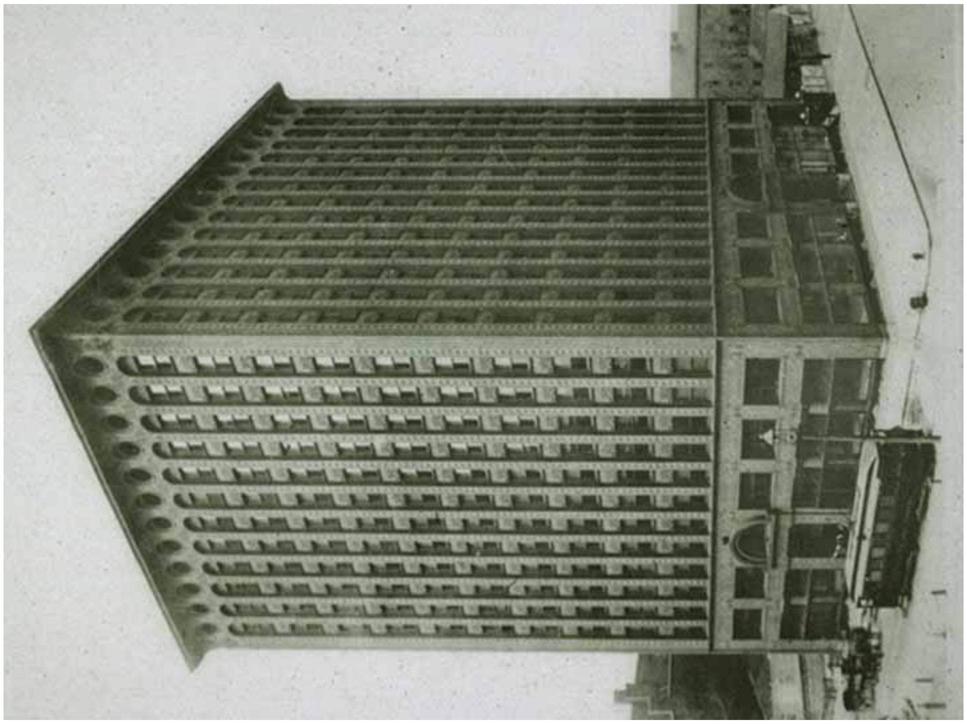


Figure 4.2 - The Guaranty Building, 1901. Source: <www.buffalohistoryworks.com/.../buffalo1901.htm>.

Figure 4.3 - Detail of the Guaranty Building facade, photo by B. Dandona 6 Nov. 2006.

Figure 4.4 - Shaft of the Guaranty Building, photo by B. Dandona 6 Nov. 2006.

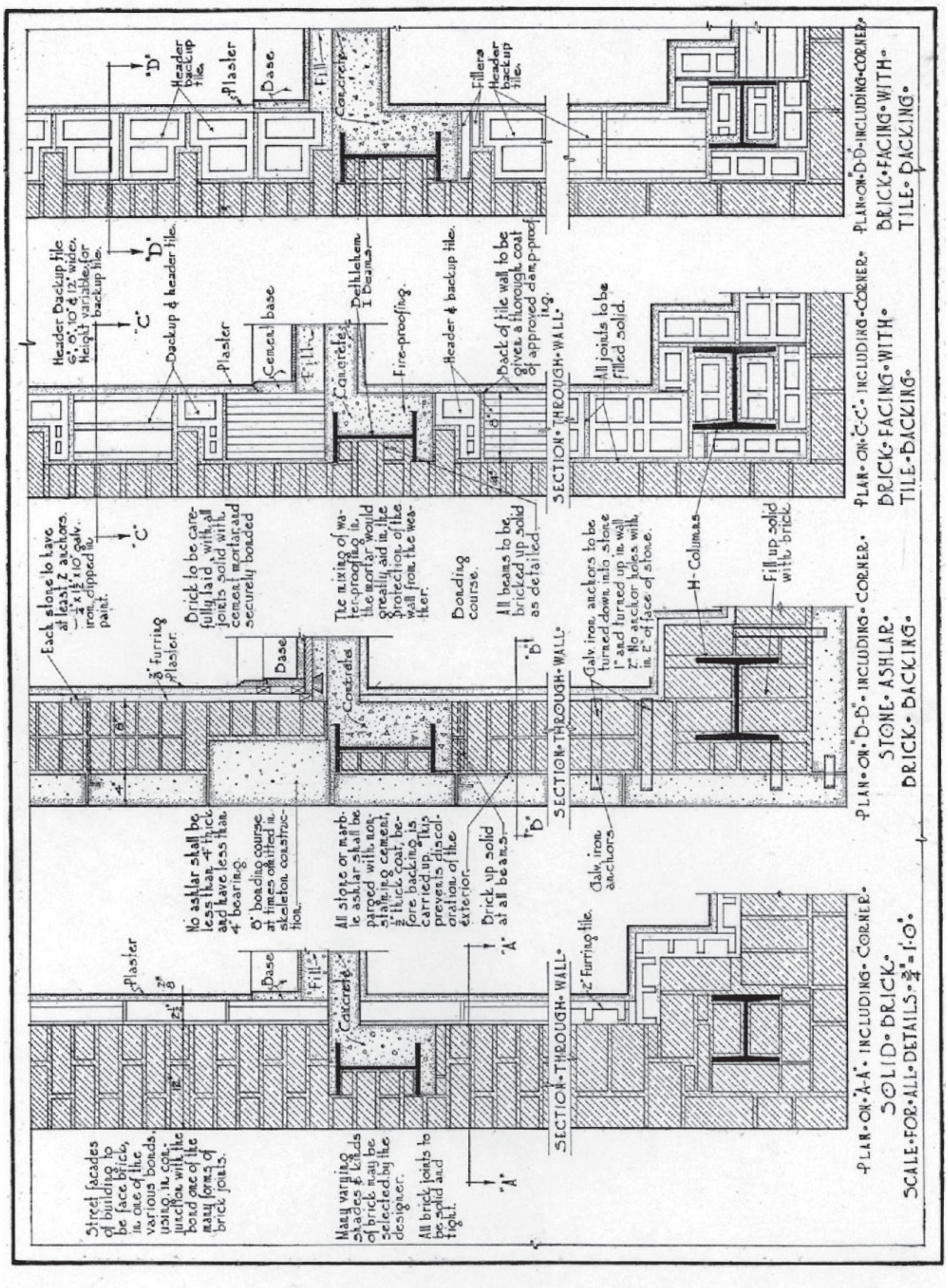


PLATE 7, CURTAIN WALLS

Figure 4.5 - Typical early 20th-century curtain walls in Philip G. Knobloch, Architectural Details from the Early Twentieth Century: A Book of Traditional Details, 1931, 2nd ed. (Washington, D.C.: American Institute of Architects Press, 1991) pl. 7.

Figure 4.6 - The Woolworth Building. Source: <http://www.nyc-architecture.com/SCC/SCC19-woolworth_pc.jpg.>.

Figure 4.7 - Lower portion of the Woolworth Building facade, photo by E. Buckley 19 Dec. 2006.

Figure 5.1 - PSFS Building. Source: <www.thecityreview.com/leblanc.html>.

Figure 5.2 - Base of PSFS Building showing expansive glass window at second floor Banking Level. Source: George Howe, et al., "The PSFS Building, Philadelphia, Pennsylvania, 1929-1932." Perspecta. 25 (1989): 93.

Figure 6.1 - Lever House, photo by E. Buckley 19 Dec. 2006.

Figure 6.2 - Lever House. Source: <www.columbia.edu/.../BT/EEI/C-WALL/c-wall.html>.

Figure 6.3 - Lever House curtain wall after replacement, photo by E. Buckley 19 Dec. 2006.

Figure 6.4 - Lever House curtain wall after replacement, view from interior courtyard, photo by E. Buckley 19 Dec. 2006.

Figure 6.5 - Alcoa Building. Source: Wallace K. Harrison Collection, Avery Architectural Library, Columbia University.

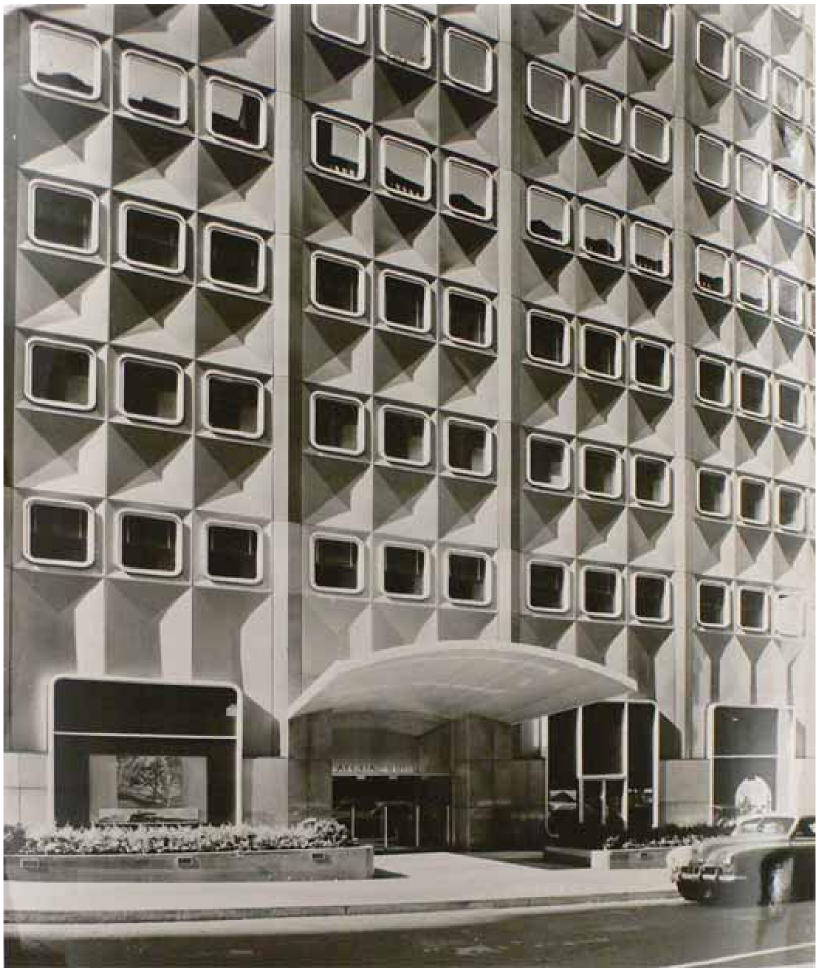


Figure 6.6 - Lower portion of facade at entry - Alcoa Building. Source: Wallace K. Harrision Collection, Avery Architectural Library, Columbia University.

Figure 6.7 - Seagram Building, photo by Ezra Stoller. Source: <www.archpaper.com/.../03_05_philip_johnson.html>.

Figure 6.8 - View of Seagram Building (left) from plaza, photo by E. Buckley 19 Dec. 2006.

Figure 7.1 - Citicorp Center, photo by E. Buckley 19 Dec. 2006.

Figure 7.2 - Citicorp Center and St. Peter's Church, 1977. Source: Dianne M. Ludman, Hugh Stubbins and His Associates: the First Fifty Years (Cambridge, MA: Stubbins Associates, 1986) 93.

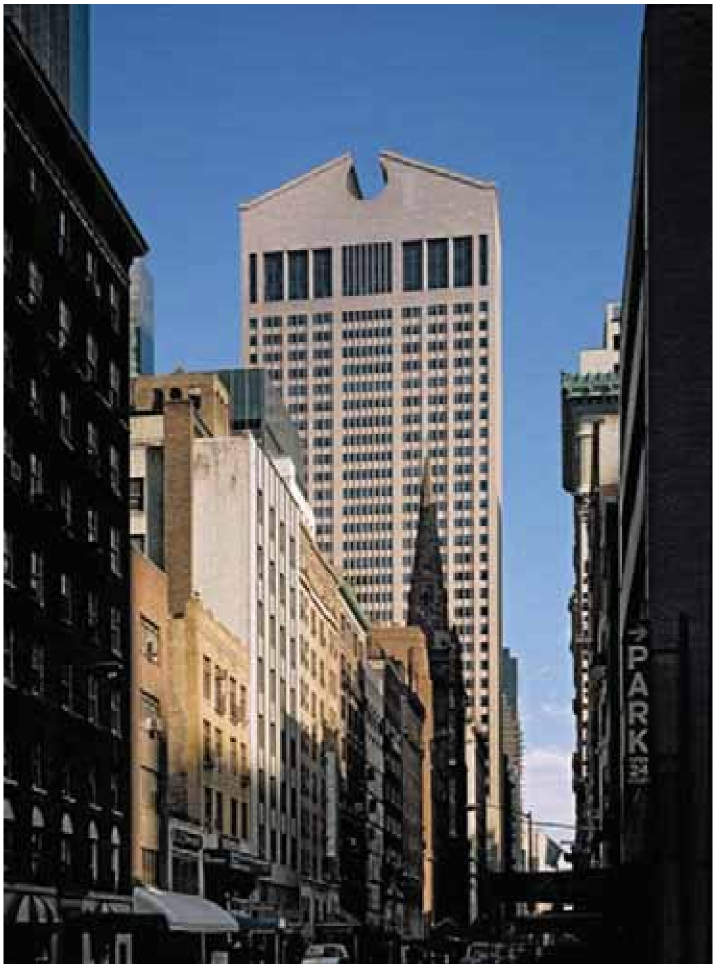


Figure 7.3 - AT&T Building. Source: <www.archpaper.com/.../03_05_philip_johnson.html>.

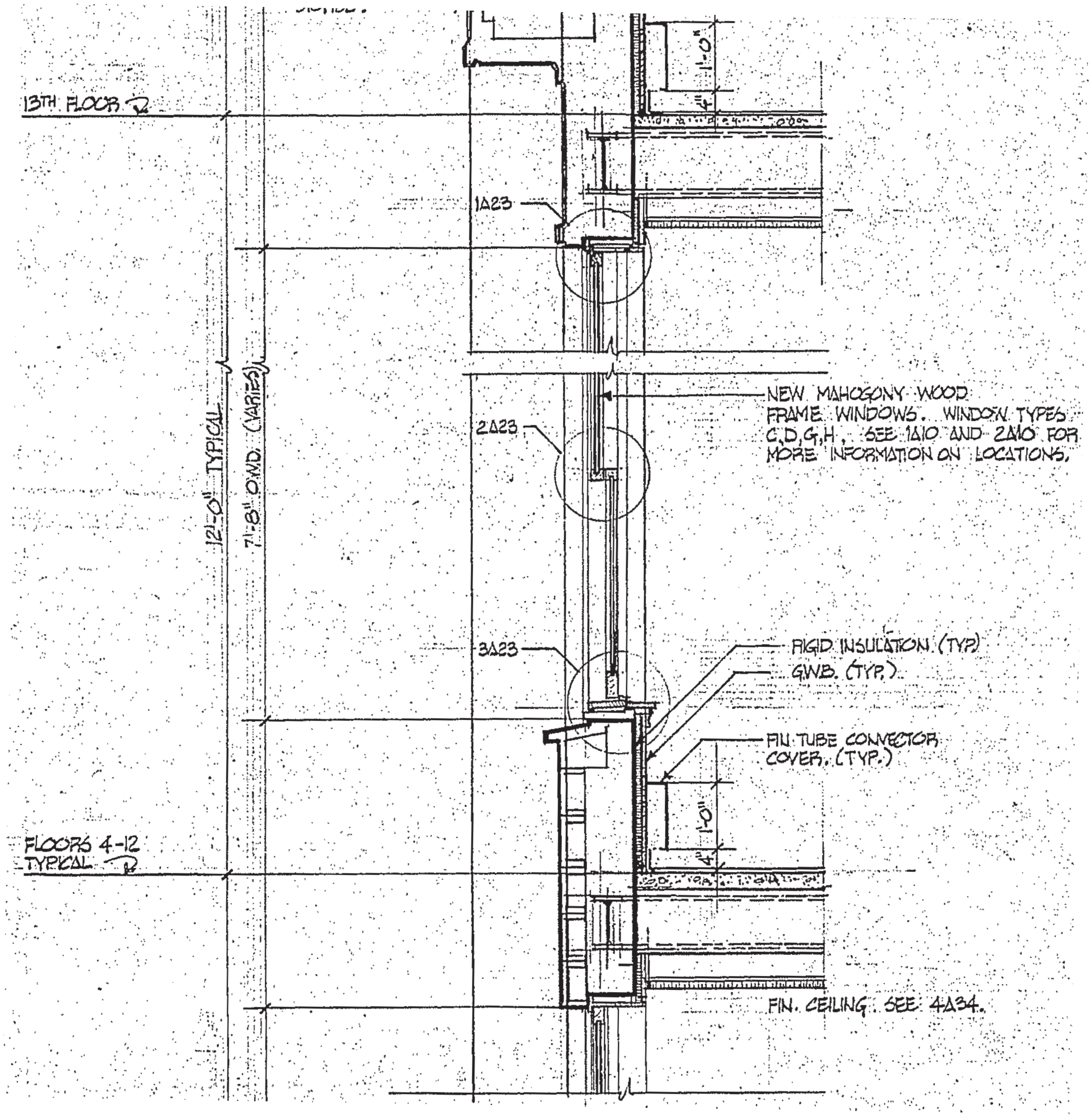
Figure 7.4 - Base of AT&T Building. Source: <www.thecityreview.com/plazas.html>.

Figure 8.1 - New York Times Tower rendering. Source: <http://images.businessweek.com/ss/06/01/greenskyscrapers/image/7_mainnytimesb.jpg>.

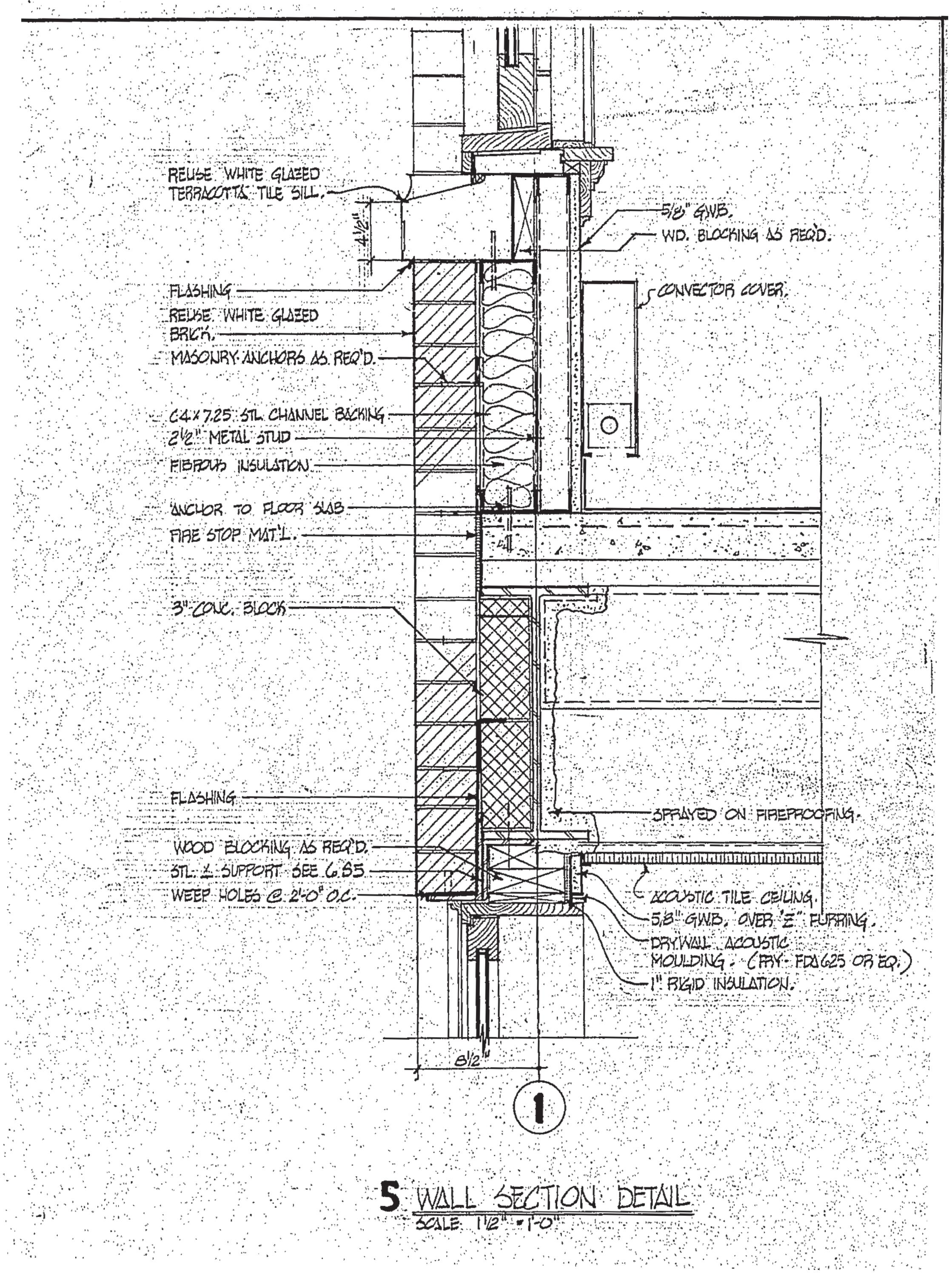
Figure 8.2 - Shaft of New York Times Tower under construction, photo by E. Buckley 19 Dec. 2006.

Figure 8.3 - Mock-up of ceramic tube skin on New York Times Tower. Source: Fx Fowle Architects.

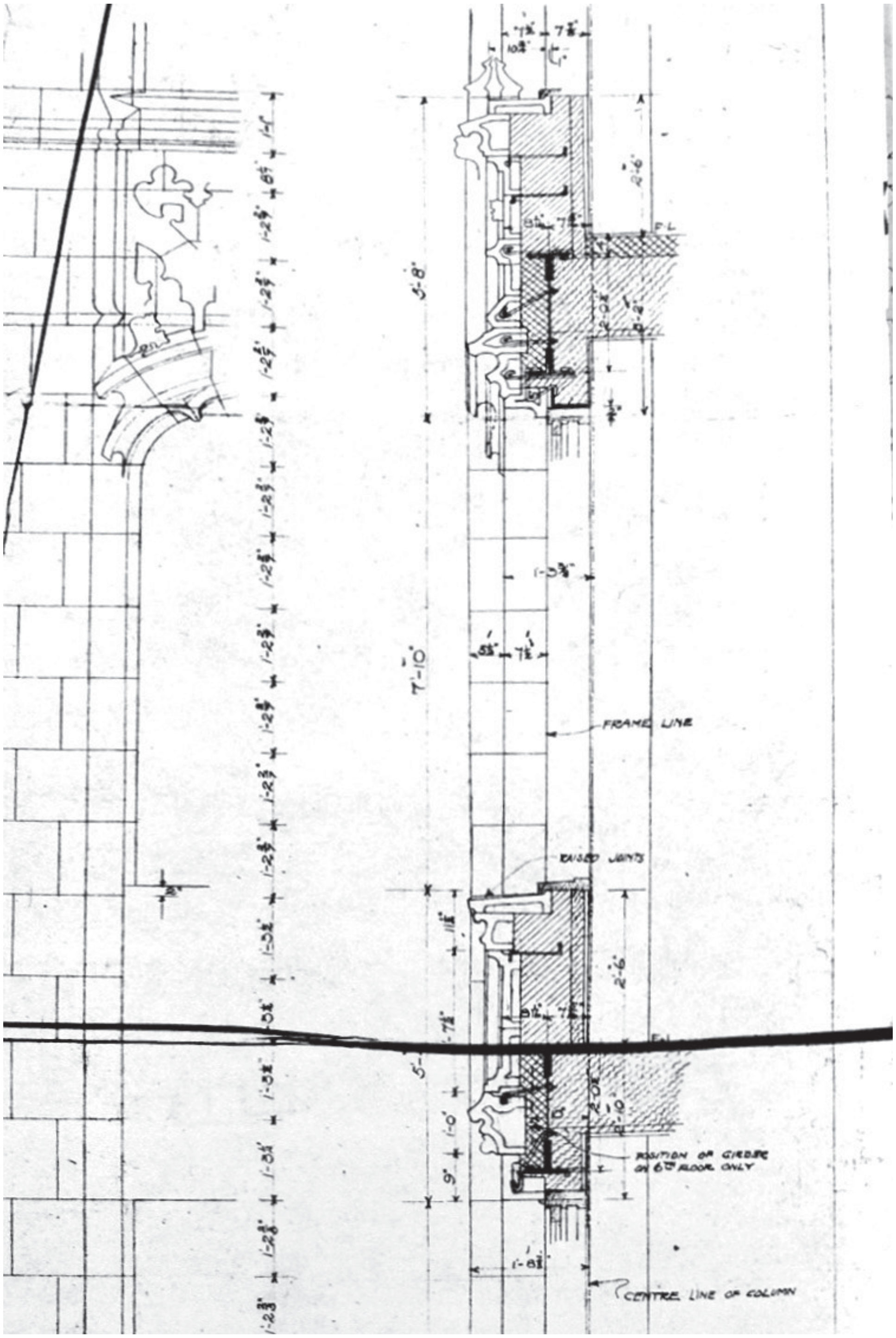
Figure 8.4 - New York Times Tower - network of ceramic tubes under construction, photo by E. Buckley 19 Dec. 2006.



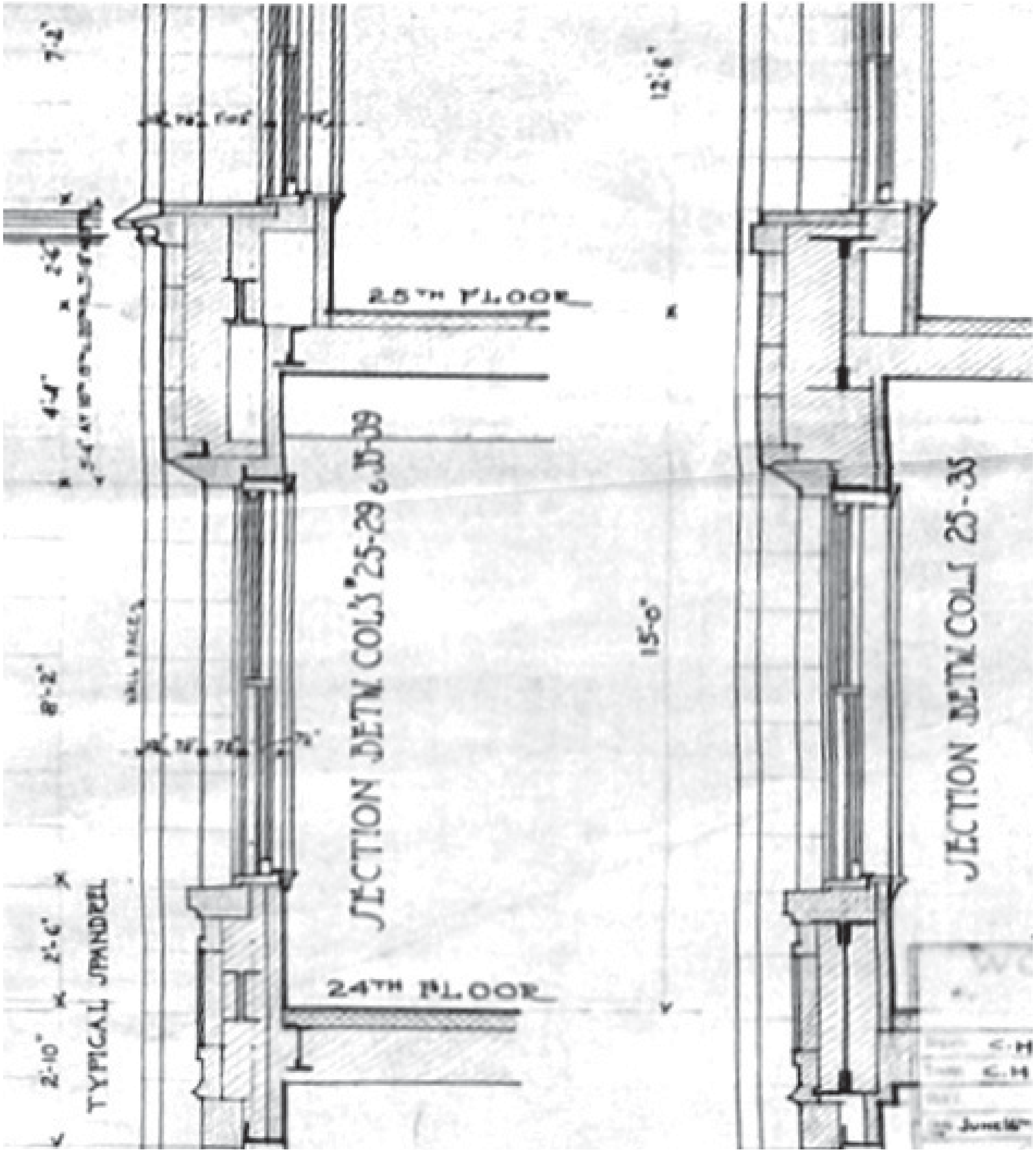
Drawing 4.1 - Exterior envelope section, front facade, Guaranty Building (1895-96), Adler & Sullivan, architects. Source: Cannon Design Renovation Drawings of 1982, received from Flynn Battaglia Architects, Buffalo, New York.



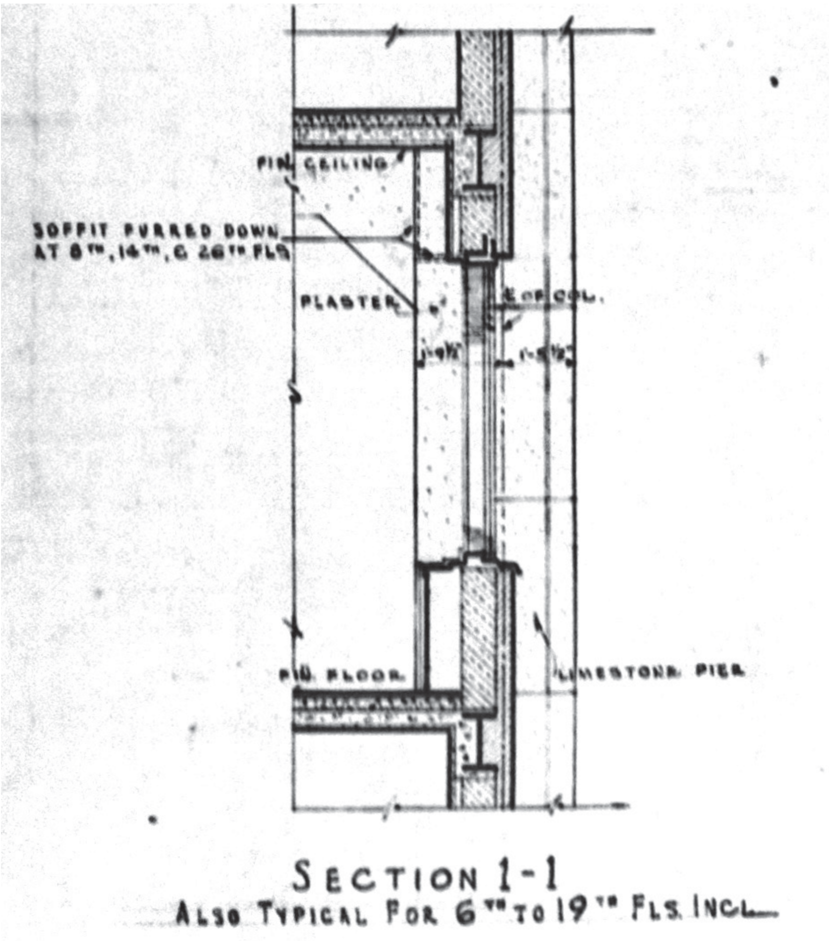
Drawing 4.2 - Exterior envelope section, rear facade, Guaranty Building (1895-96), Adler & Sullivan, architects. Source: Cannon Design Renovation Drawings of 1982, received from Flynn Battaglia Architects, Buffalo, New York.



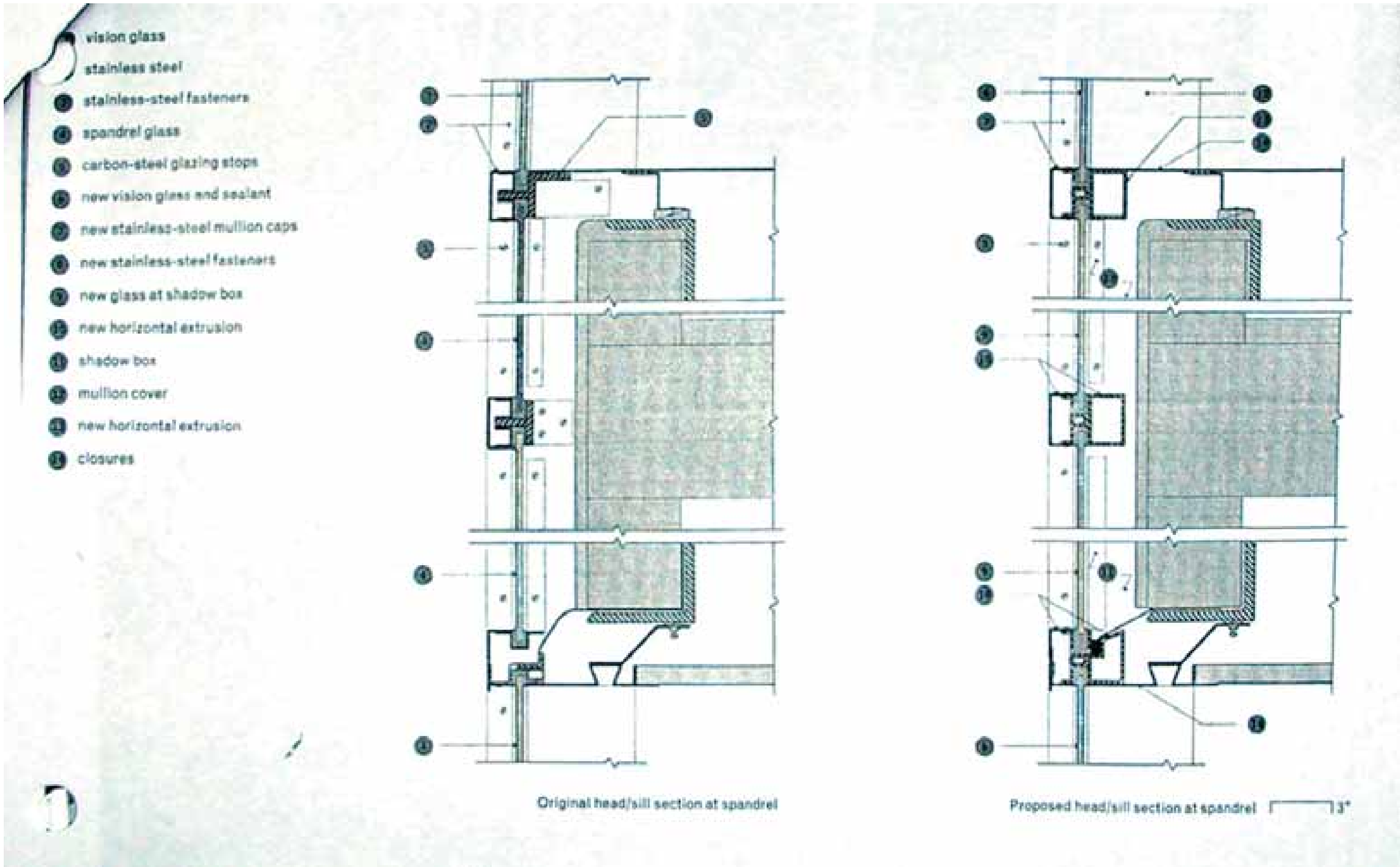
Drawing 4.3 - Exterior envelope section, Woolworth Building (1911-13), Cass Gilbert, architect. Source: Woolworth Building Collection, Print Room, New York Historical Society, New York, New York.



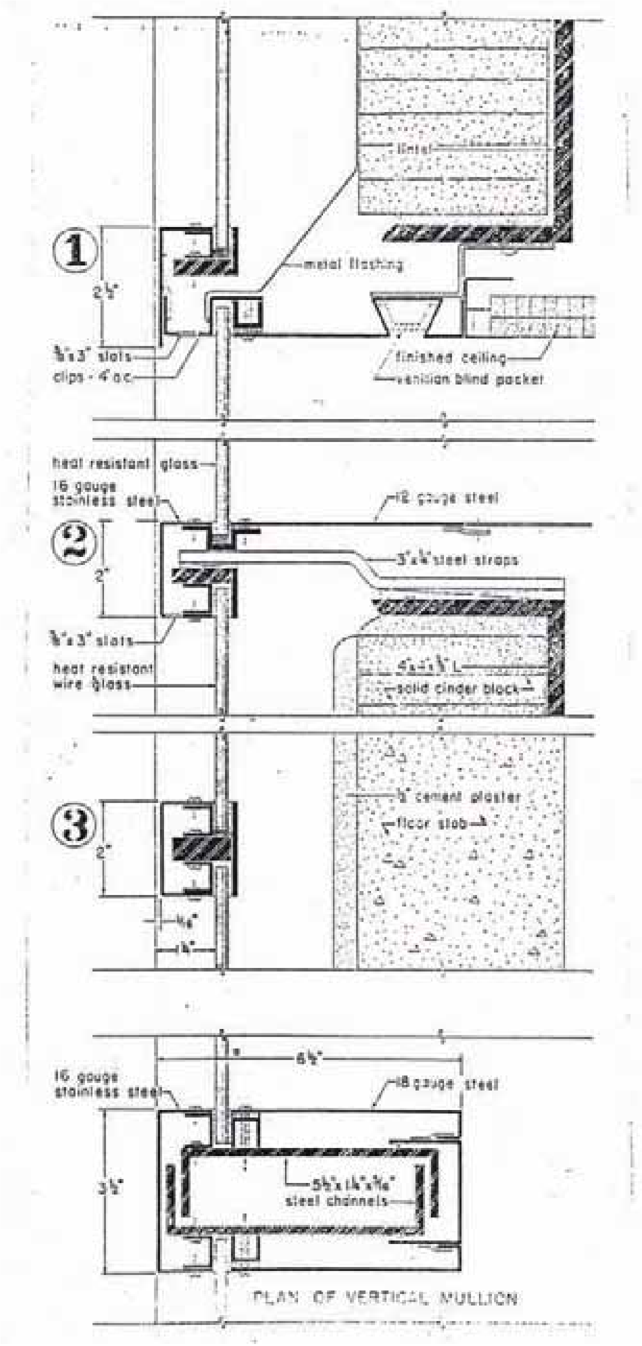
Drawing 4.4 - Exterior envelope section, Woolworth Building (1911-13), Cass Gilbert, architect. Source: Woolworth Building Collection, Print Room, New York Historical Society, New York, New York.



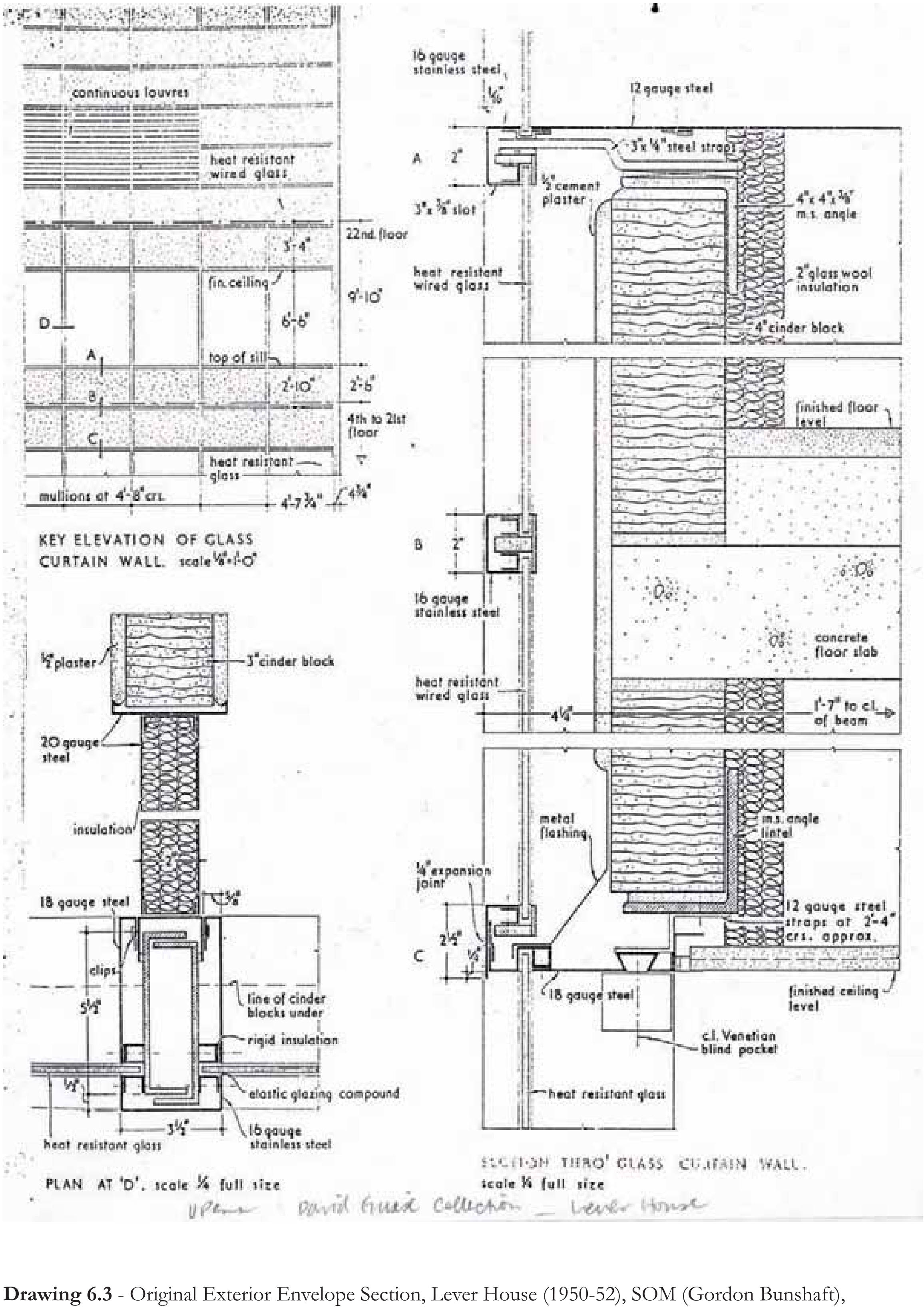
Drawing 5.1 - Exterior envelope section, PSFS Building (1929-32), Howe & Lescaze, architects. Source: Mellor, Meigs & Howe Collection, PSFS Building, Architectural Archives of the University of Pennsylvania, Philadelphia, Pennsylvania.



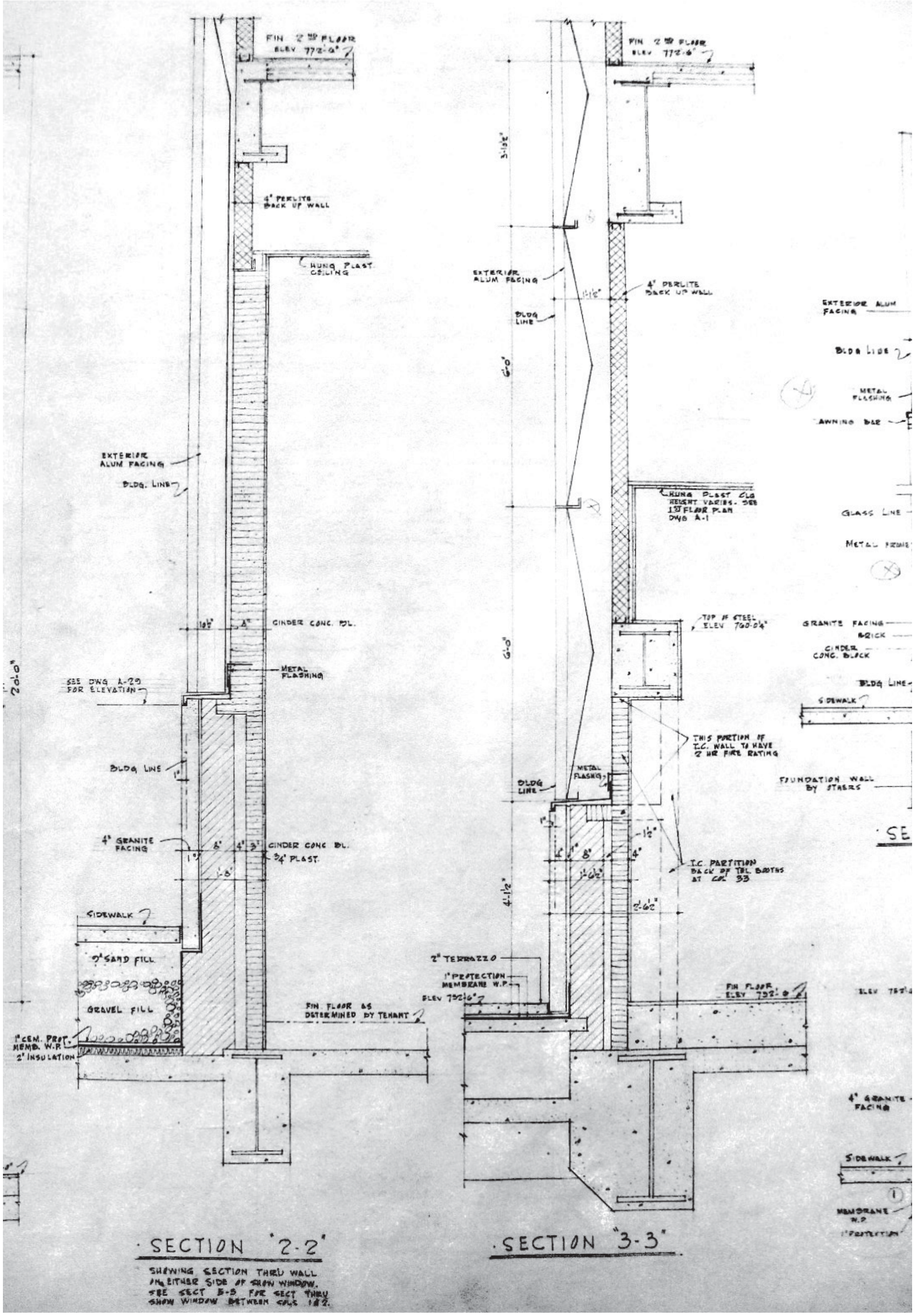
Drawing 6.1 - Exterior envelope sections before and after restoration, Lever House (1950-52), SOM (Gordon Bunshaft), architects. Source: John Morris Dixon, "Lever House: A Paragon Preserved," Architecture 91.12 (2002): 64.



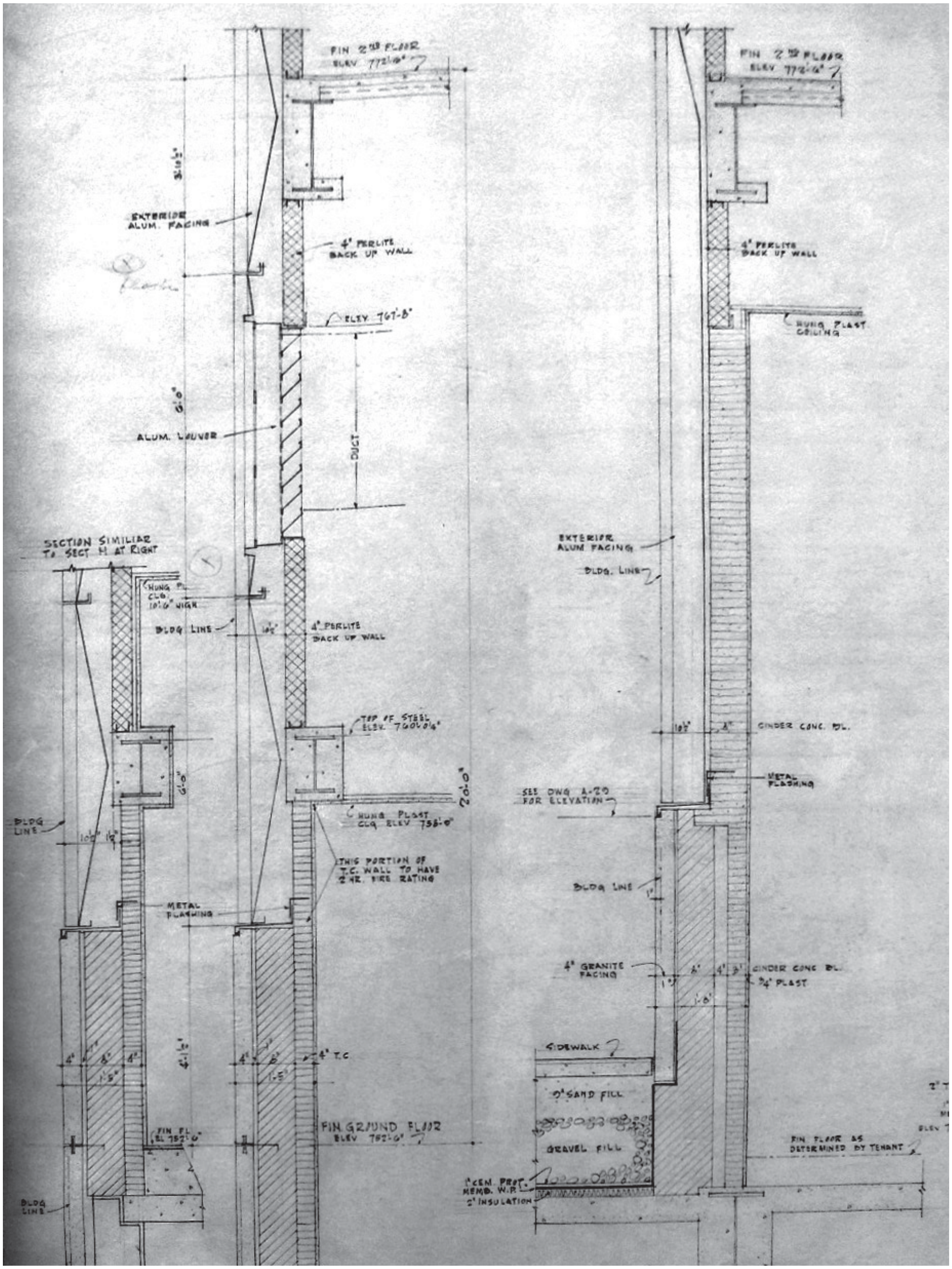
Drawing 6.2 - Original exterior envelope section, Lever House (1950-52), SOM (Gordon Bunshaft), architects. Source: David Guise Collection, Lever House file, Architectural Archives of the University of Pennsylvania, Philadelphia, Pennsylvania.



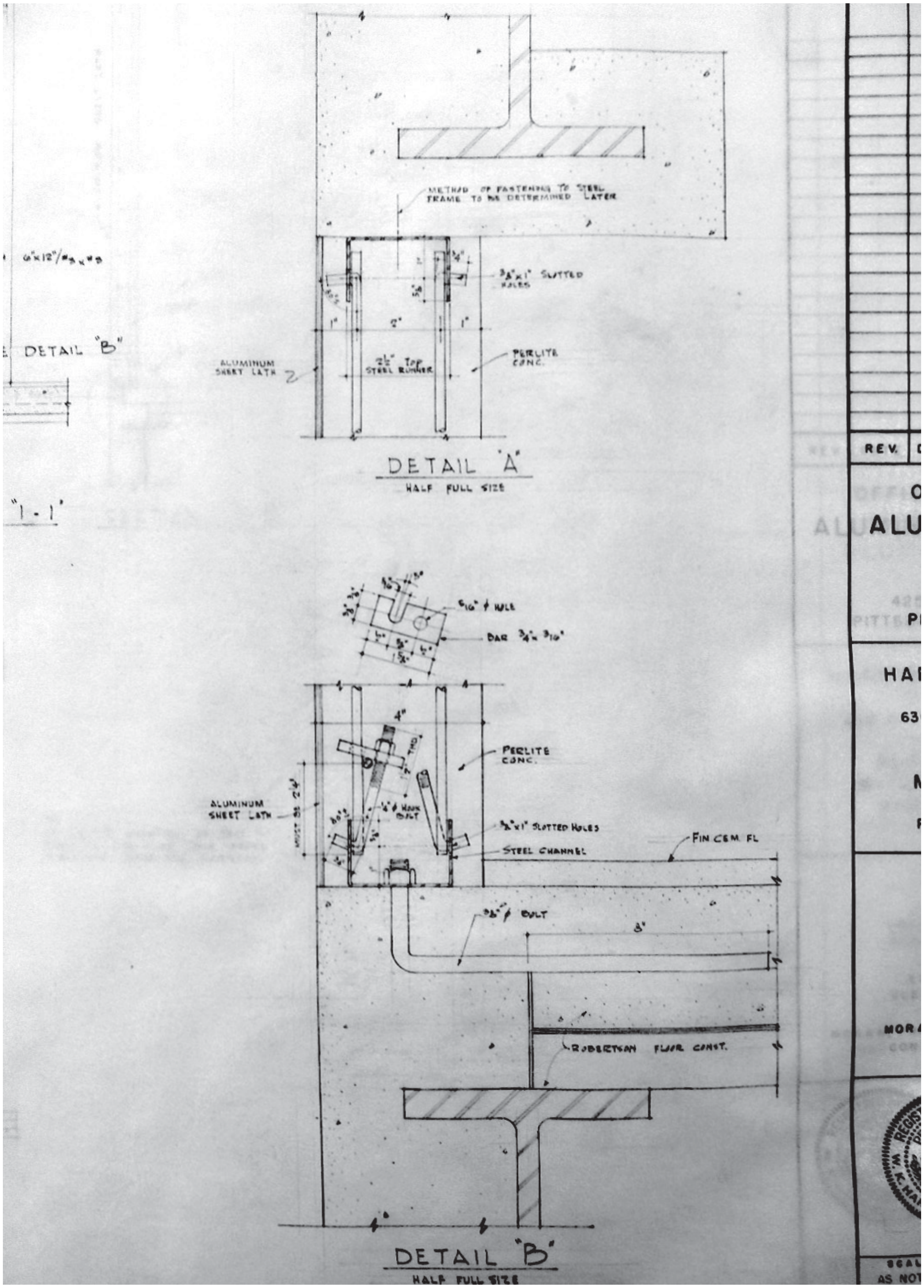
Drawing 6.3 - Original Exterior Envelope Section, Lever House (1950-52), SOM (Gordon Bunshaft), architects. Source: Lever House file, David Guise Collection, Architectural Archives of the University of Pennsylvania, Philadelphia, Pennsylvania.



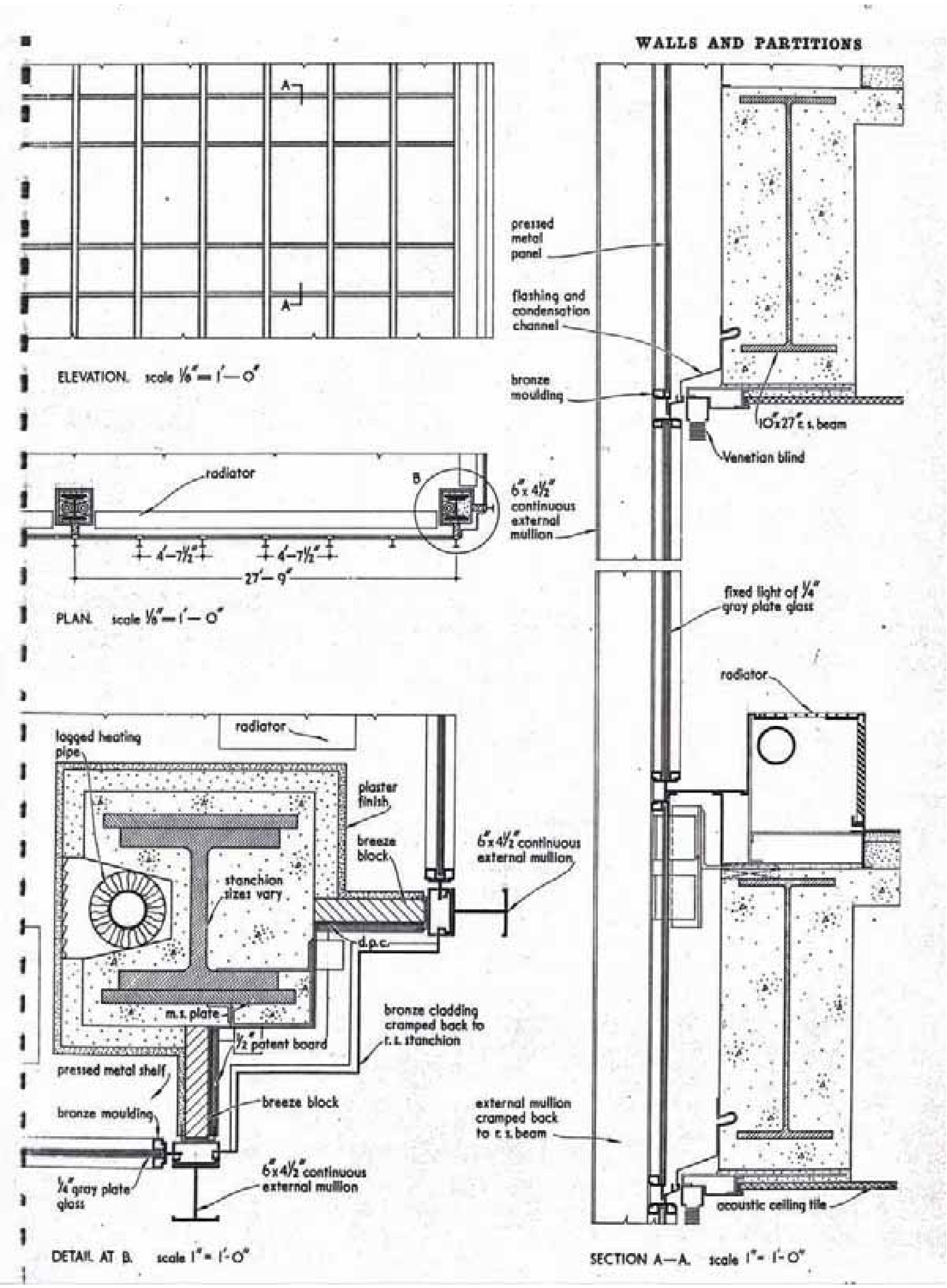
Drawing 6.4 - Exterior Wall Sections, Alcoa Building (1953), Harrison & Abramovitz, architects. Source: Alcoa Building, Wallace K. Harrison Collection, Avery Architectural Library, Columbia University, New York, New York.



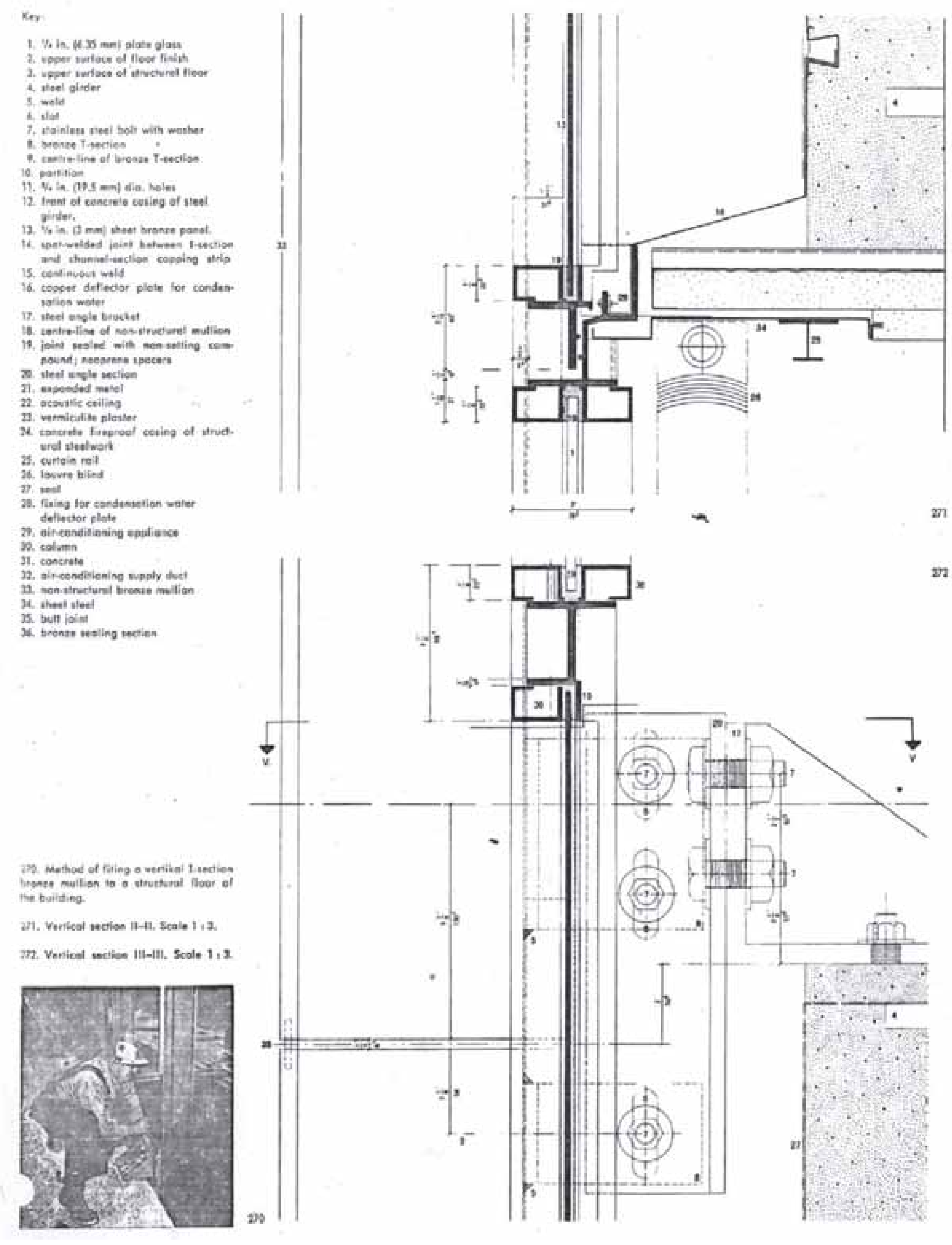
Drawing 6.5 - Exterior Wall Sections, Alcoa Building (1953), Harrison & Abramovitz, architects. Source: Alcoa Building, Wallace K. Harrison Collection, Avery Architectural Library, Columbia University, New York, New York.



Drawing 6.6 - Detail of Perlite-concrete wall, Alcoa Building (1953), Harrison & Abramovitz, architects. Source: Alcoa Building, Wallace K. Harrison Collection, Avery Architectural Library, Columbia University, New York, New York.



Drawing 6.7 - Exterior envelope section and plan section, Seagram Building (1954-58), Mies van der Rohe and Philip Johnson, architects. Source: Seagram Building file, David Guise Collection, Architectural Archives of the University of Pennsylvania, Philadelphia, Pennsylvania.



Key:

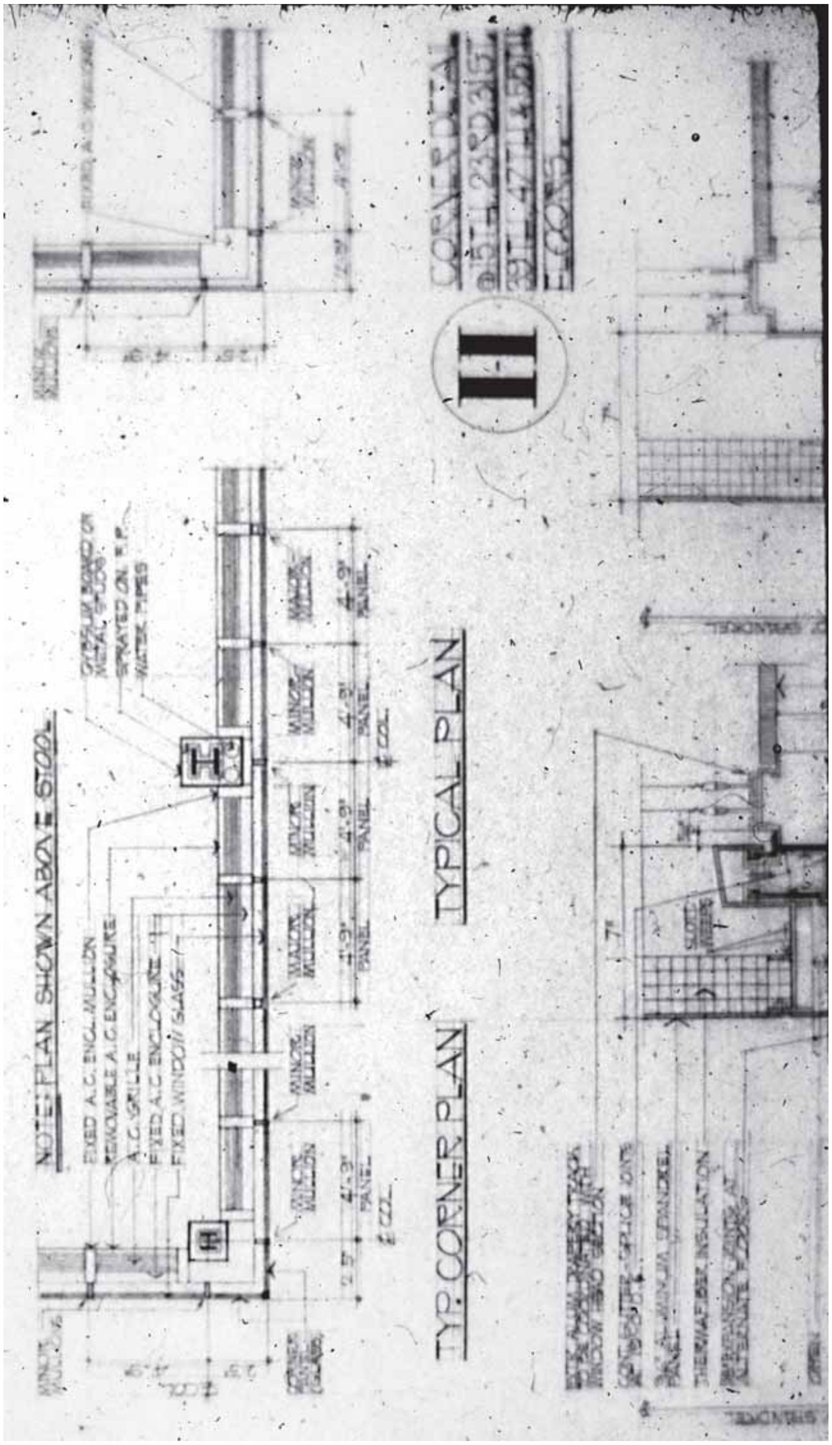
1. ¼ in. (6.35 mm) plate glass
2. upper surface of floor finish
3. upper surface of structural floor
4. steel girder
5. weld
6. slot
7. stainless steel bolt with washer
8. bronze T-section
9. centre-line of bronze T-section
10. partition
11. ¾ in. (19.5 mm) dia. holes
12. front of concrete casing of steel girder.
13. ⅛ in. (3 mm) sheet bronze panel.
14. spot-welded joint between T-section and channel-section capping strip
15. continuous weld
16. copper deflector plate for condensation water
17. steel angle bracket
18. centre-line of non-structural mullion
19. joint sealed with non-setting compound; neoprene spacers
20. steel angle section
21. expanded metal
22. acoustic ceiling
23. vermiculite plaster
24. concrete fireproof casing of structural steelwork
25. curtain rail
26. louvre blind
27. seal
28. fixing for condensation water deflector plate
29. air-conditioning appliance
30. column
31. concrete
32. air-conditioning supply duct
33. non-structural bronze mullion
34. sheet steel
35. butt joint
36. bronze sealing section

270. Method of fixing a vertical T-section bronze mullion to a structural floor of the building.

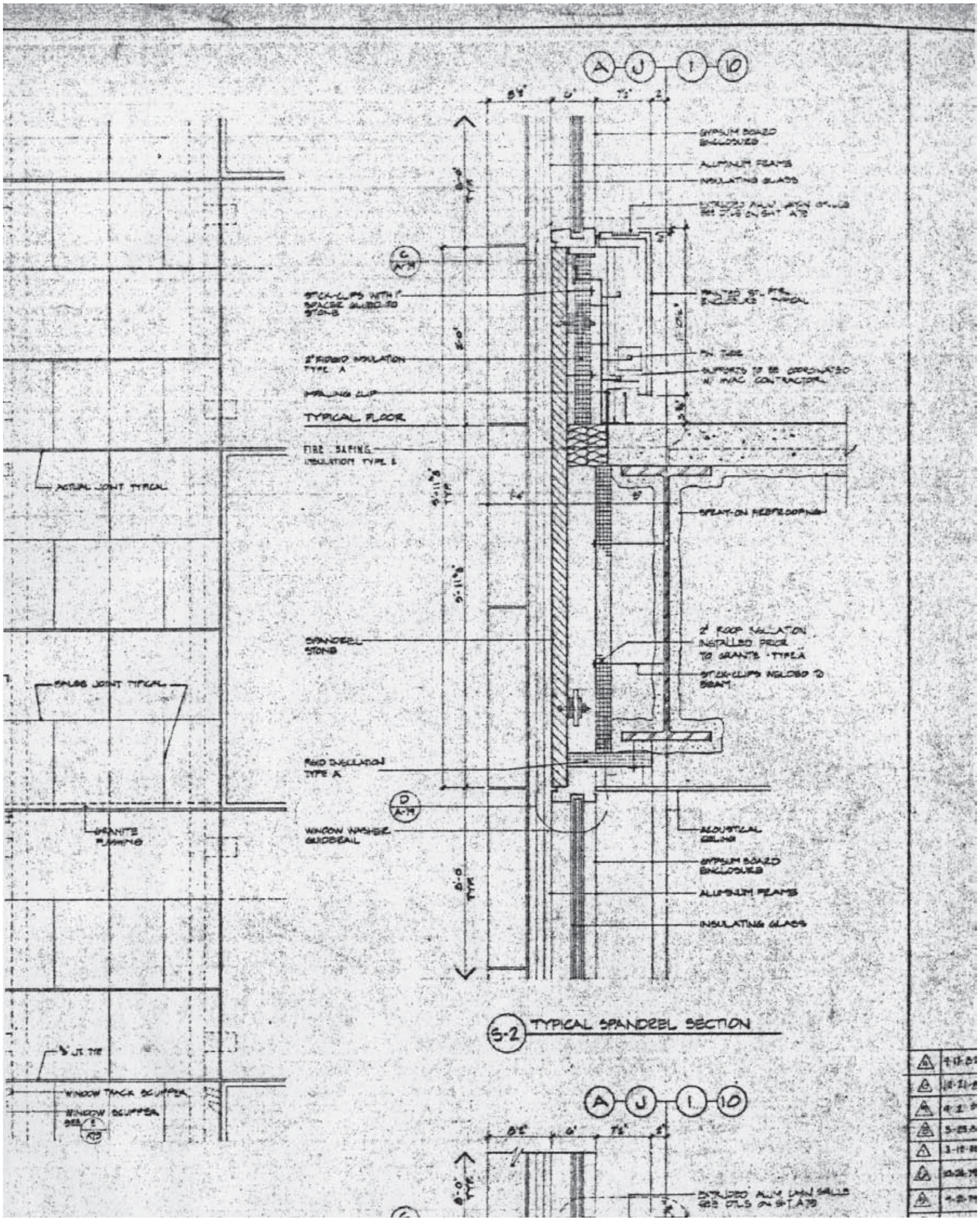
271. Vertical section II–II. Scale 1 : 3.

272. Vertical section III–III. Scale 1 : 3.

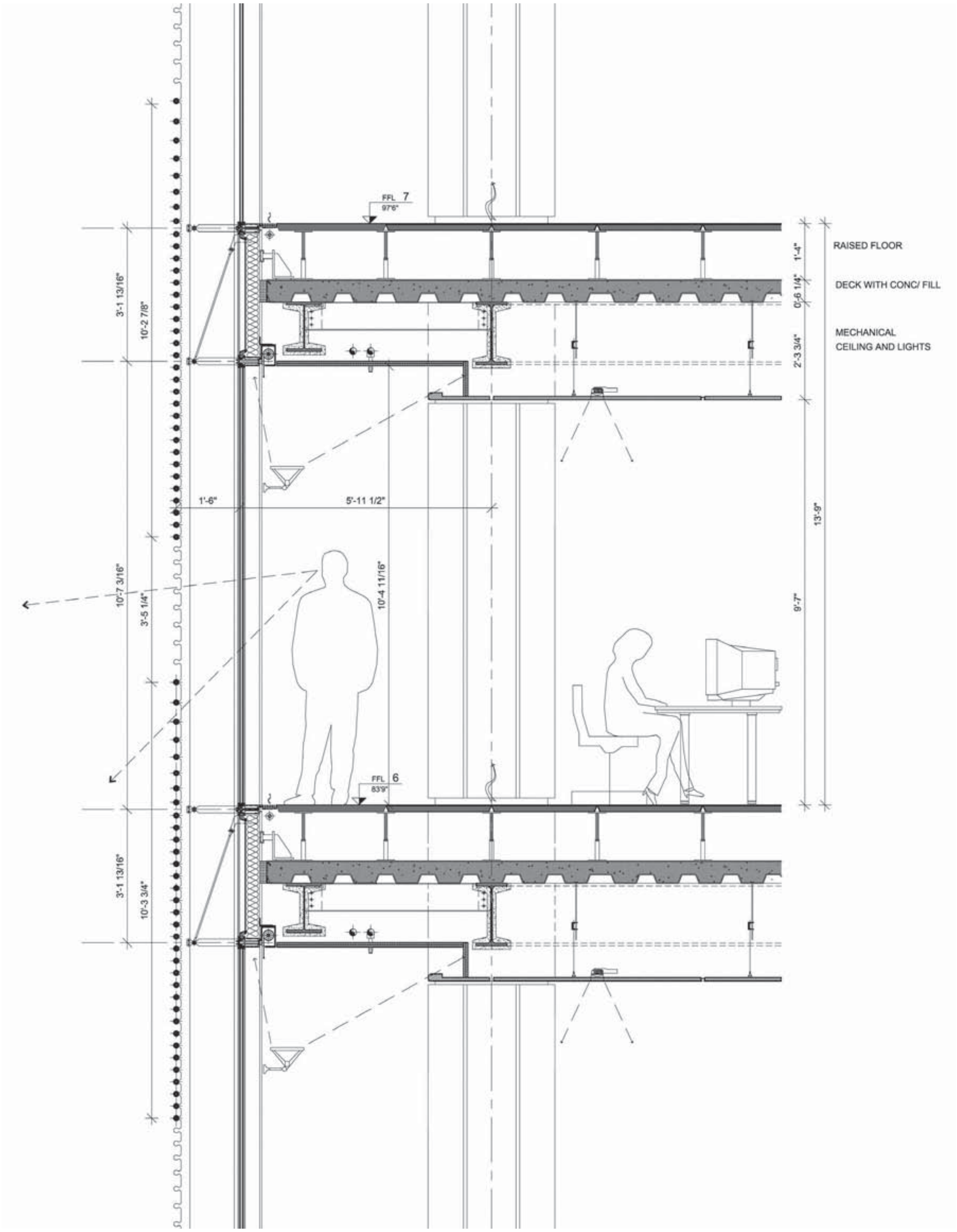
Drawing 6.8 - Exterior envelope section, Seagram Building (1954-58), Mies van der Rohe and Philip Johnson, architects. Source: Seagram Building file, David Guise Collection, Architectural Archives of the University of Pennsylvania, Philadelphia, Pennsylvania.



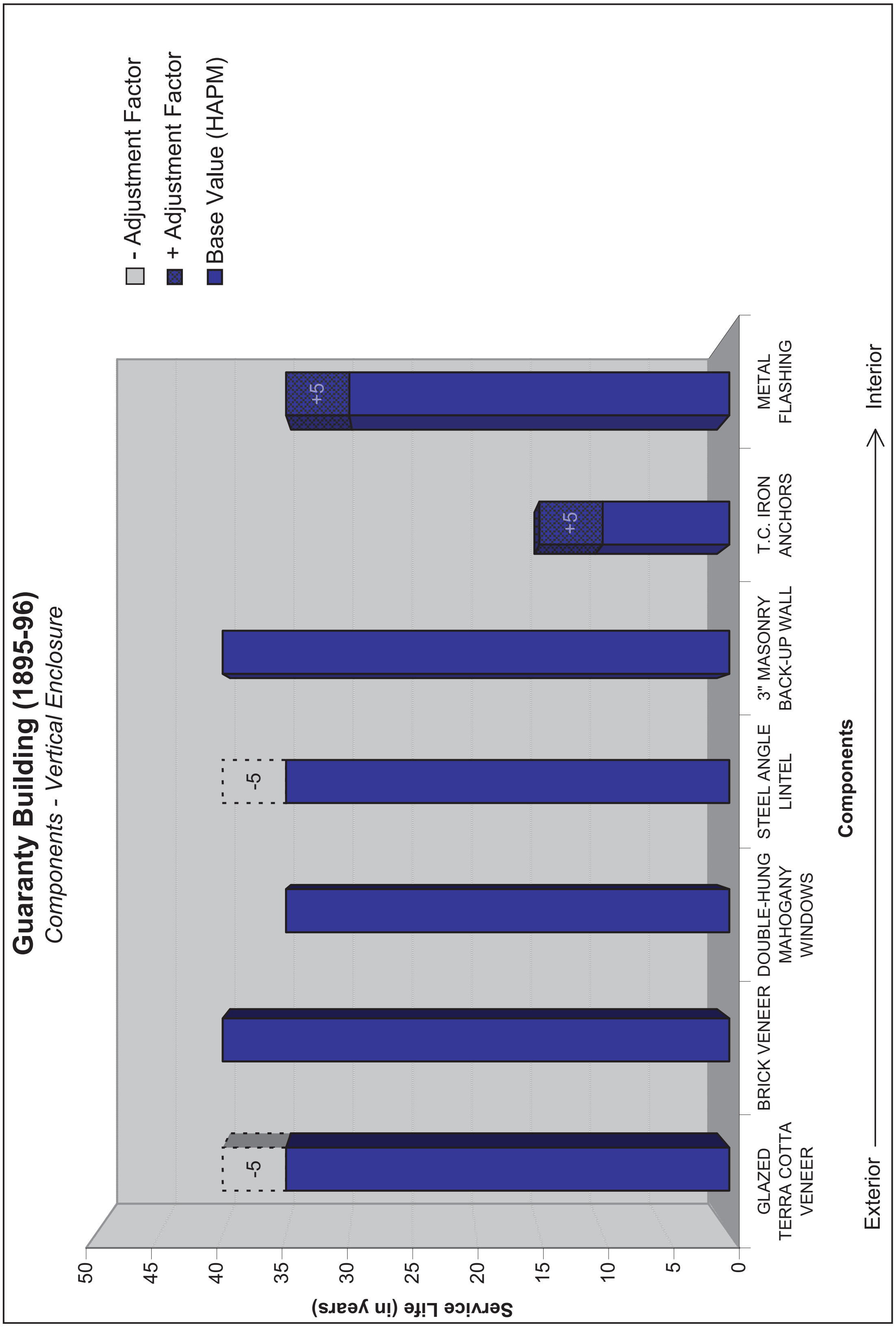
Drawing 7.1 - Plan section and portion of exterior envelope section, Citicorp Center (1974-77), Hugh Stubbins and Emery Roth & Sons, architects. Source: Citicorp Center file, David Guise Collection, Architectural Archives of the University of Pennsylvania, Philadelphia, Pennsylvania.



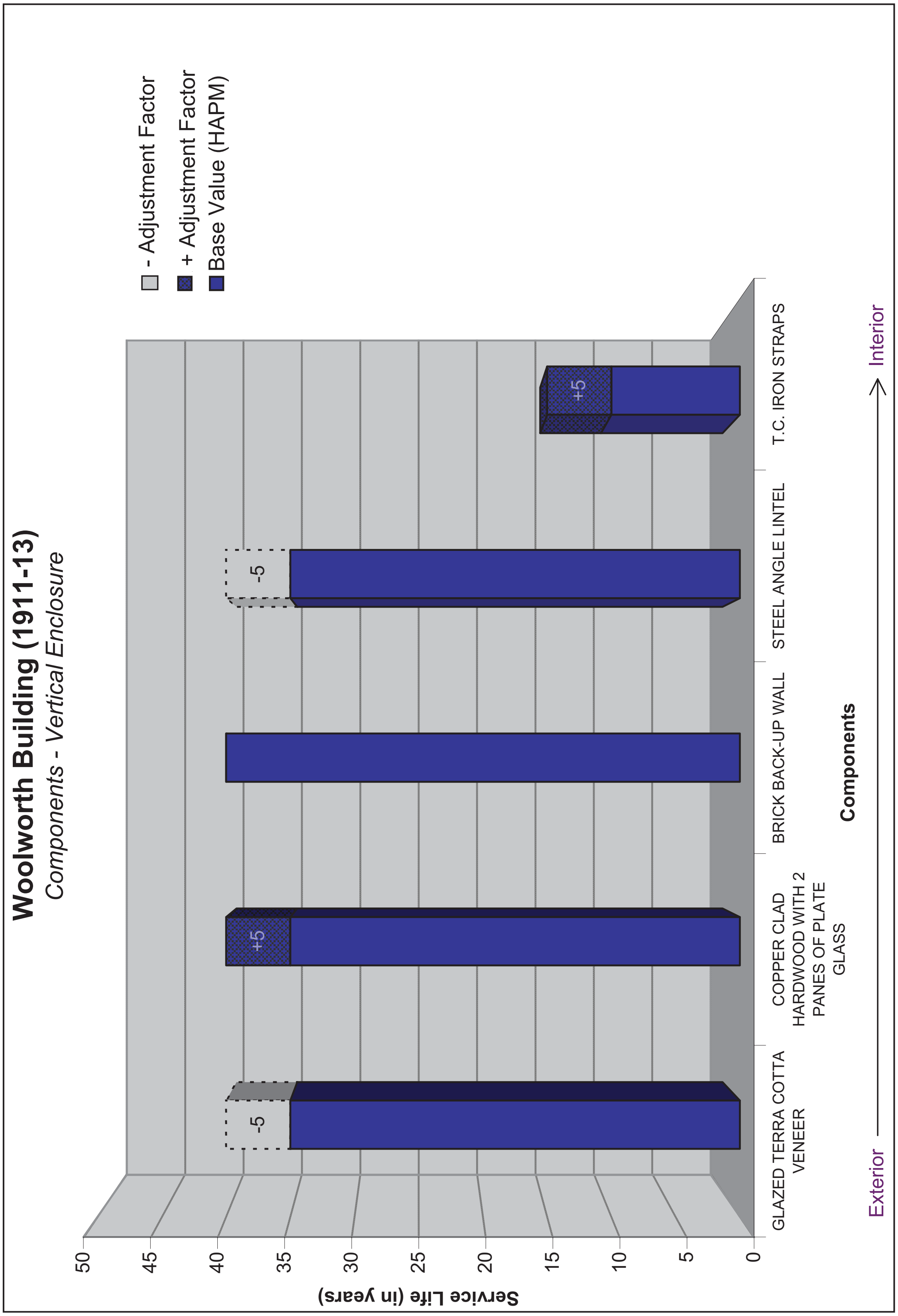
Drawing 7.2 - Exterior envelope section, AT&T Building (1978-84), Philip Johnson, architect. Source: AT&T Building file, David Guise Collection, Architectural Archives of the University of Pennsylvania, Philadelphia, Pennsylvania.



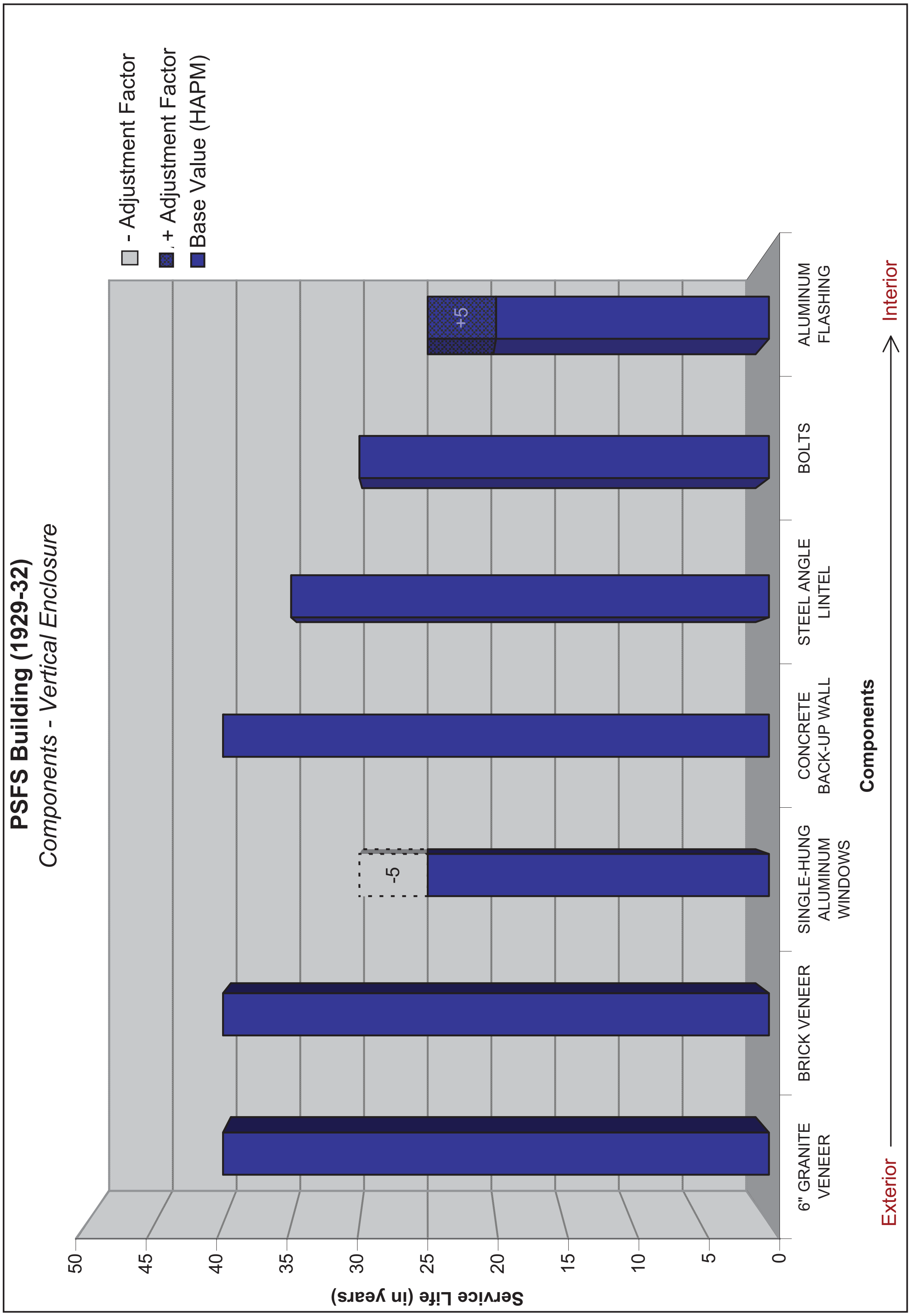
Drawing 8.1 - Exterior envelope section, New York Times Tower (2005-07), Renzo Piano and FxFowle Architects, architects. Source: FxFowle Architects.



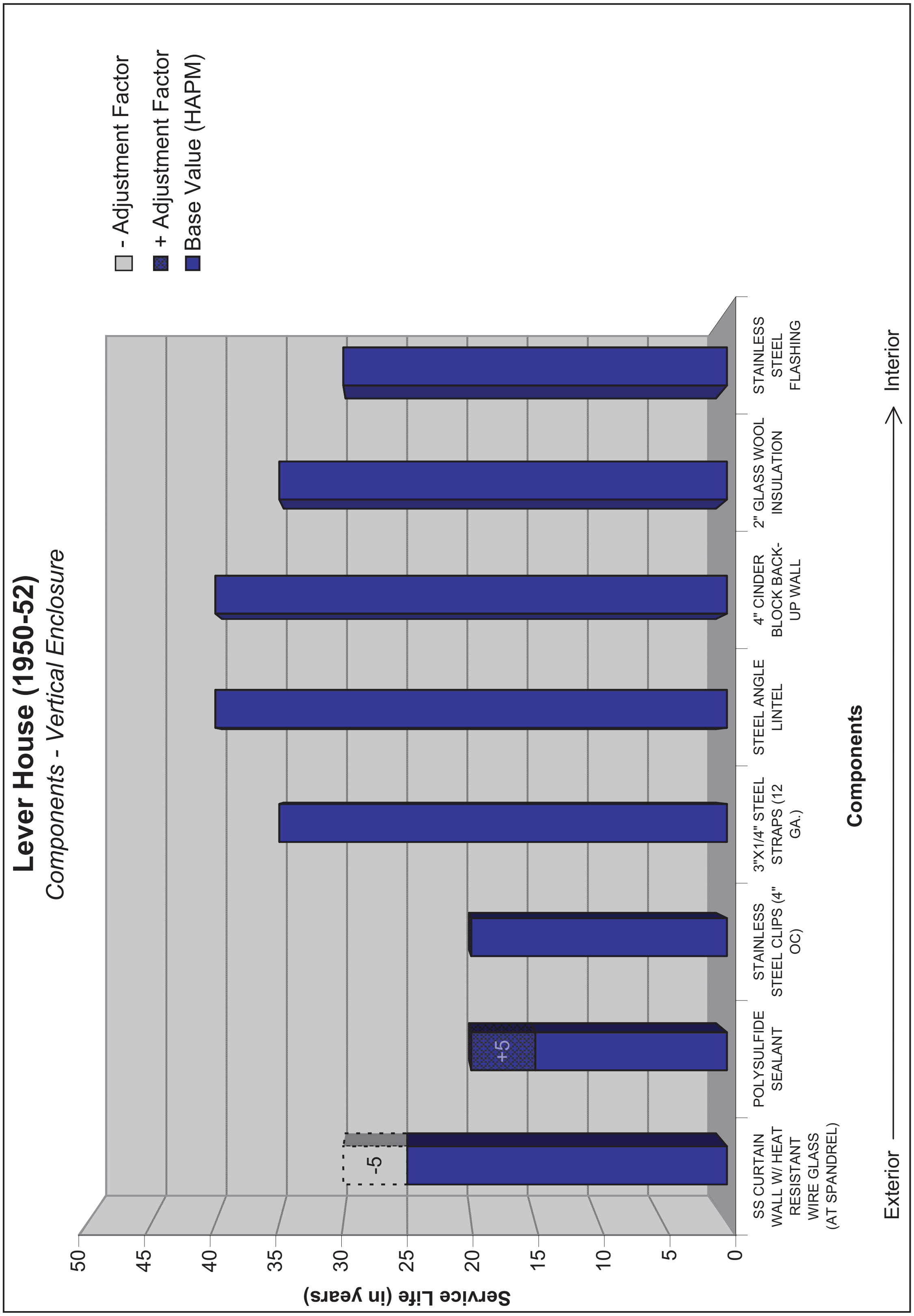
Graph 4.1 - Service Life Analysis - Guaranty Building.



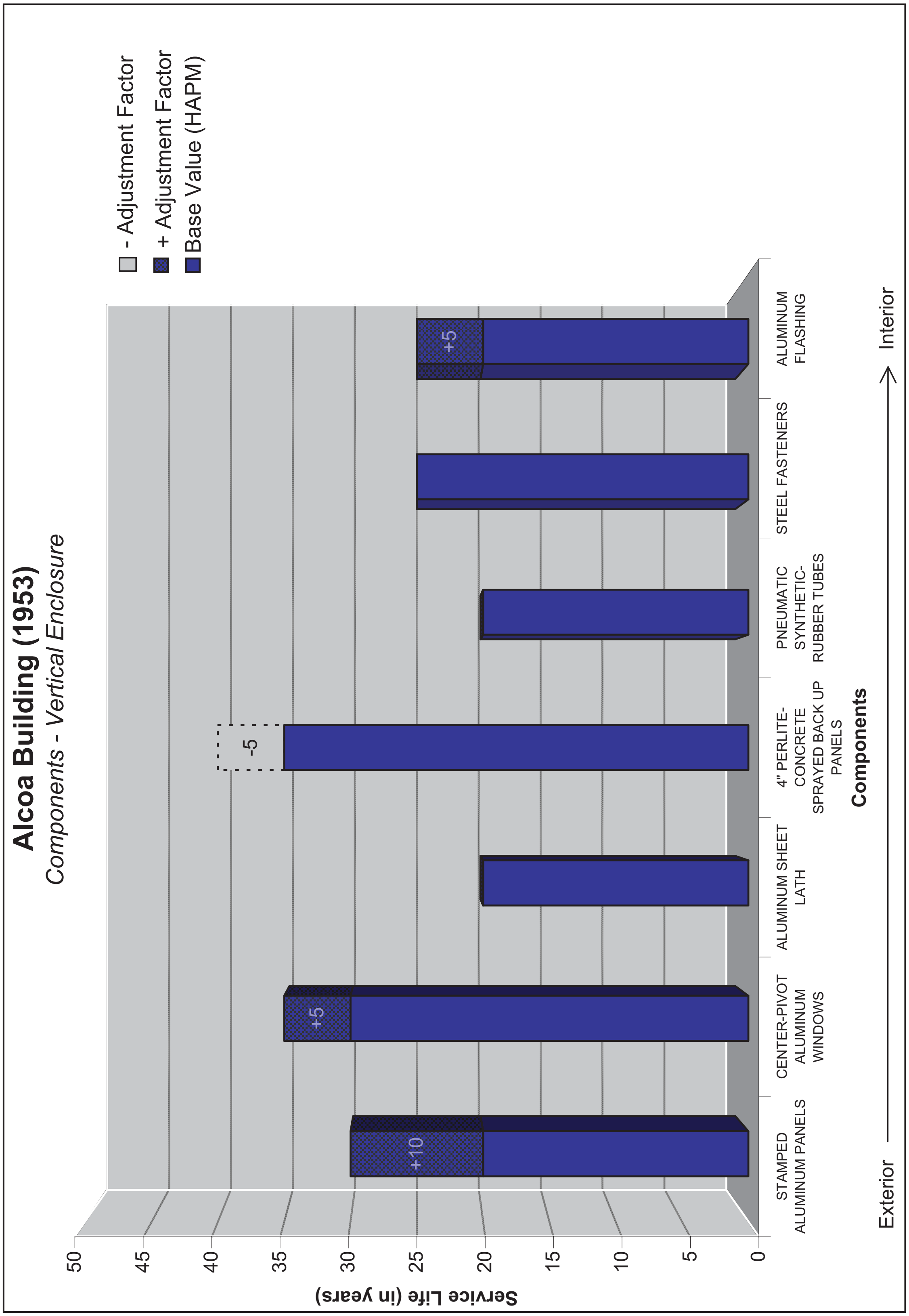
Graph 4.2 - Service Life Analysis - Woolworth Building.



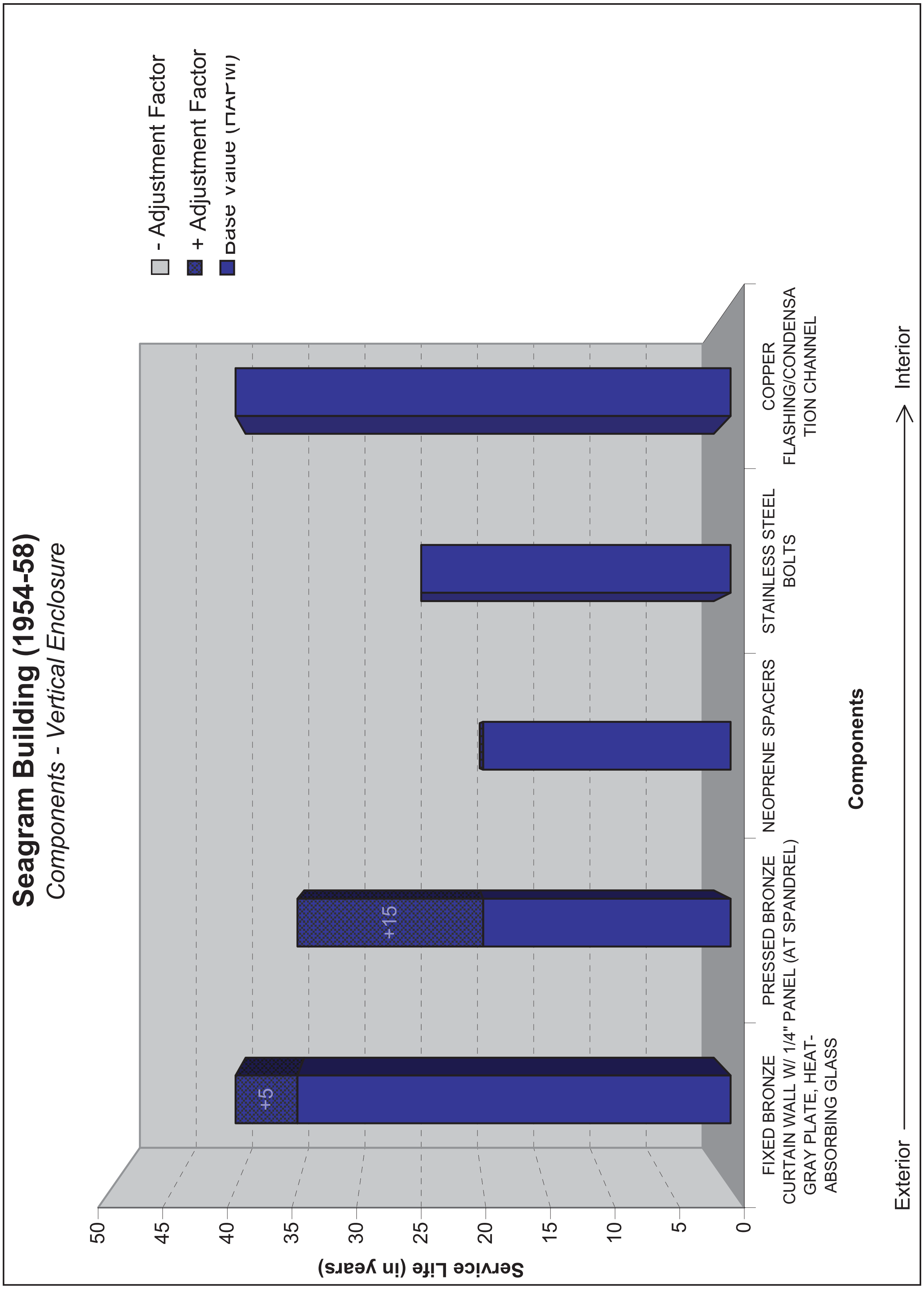
Graph 5.1 - Service Life Analysis - PSFS Building.



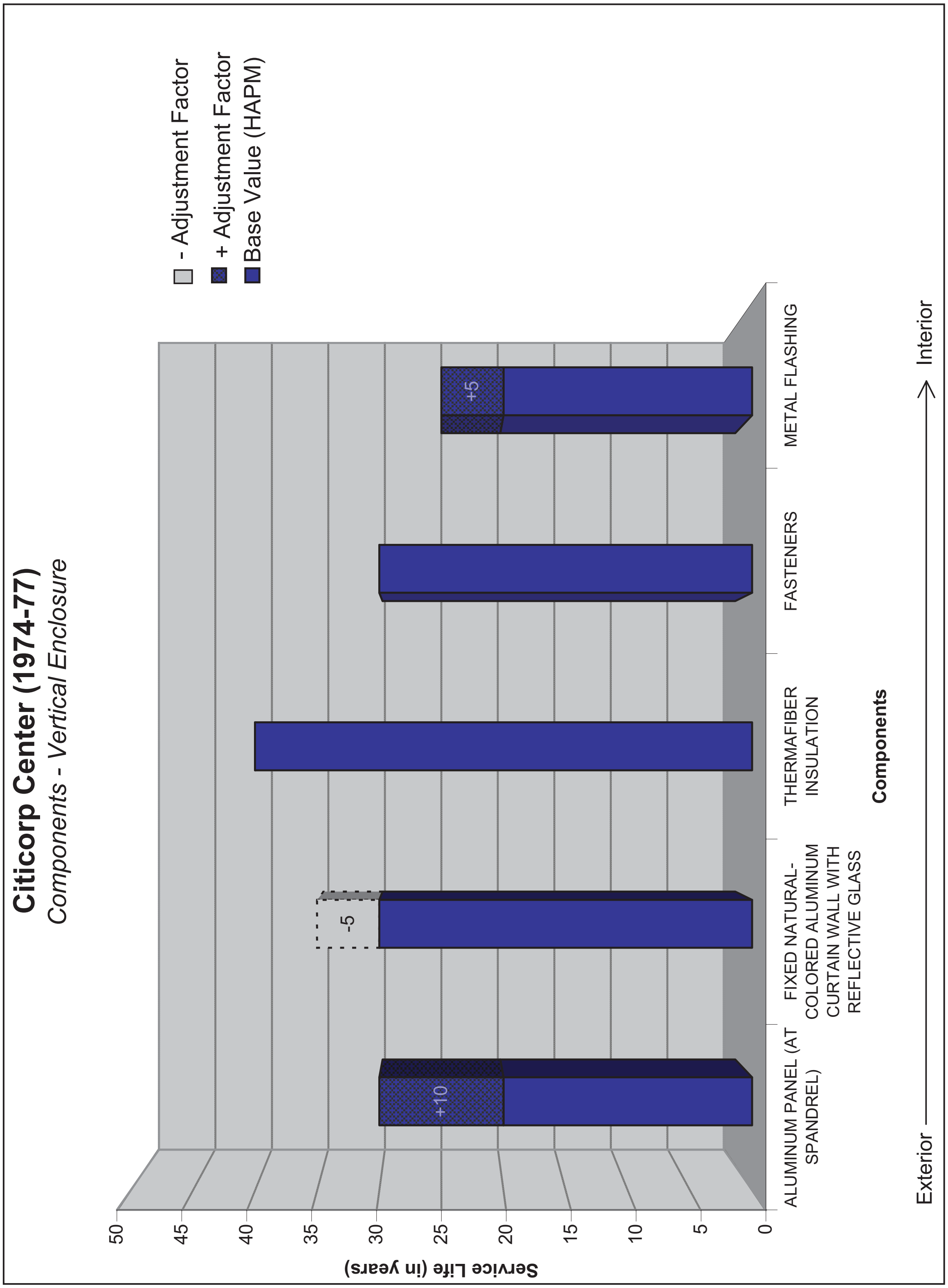
Graph 6.1 - Service Life Analysis - Lever House.



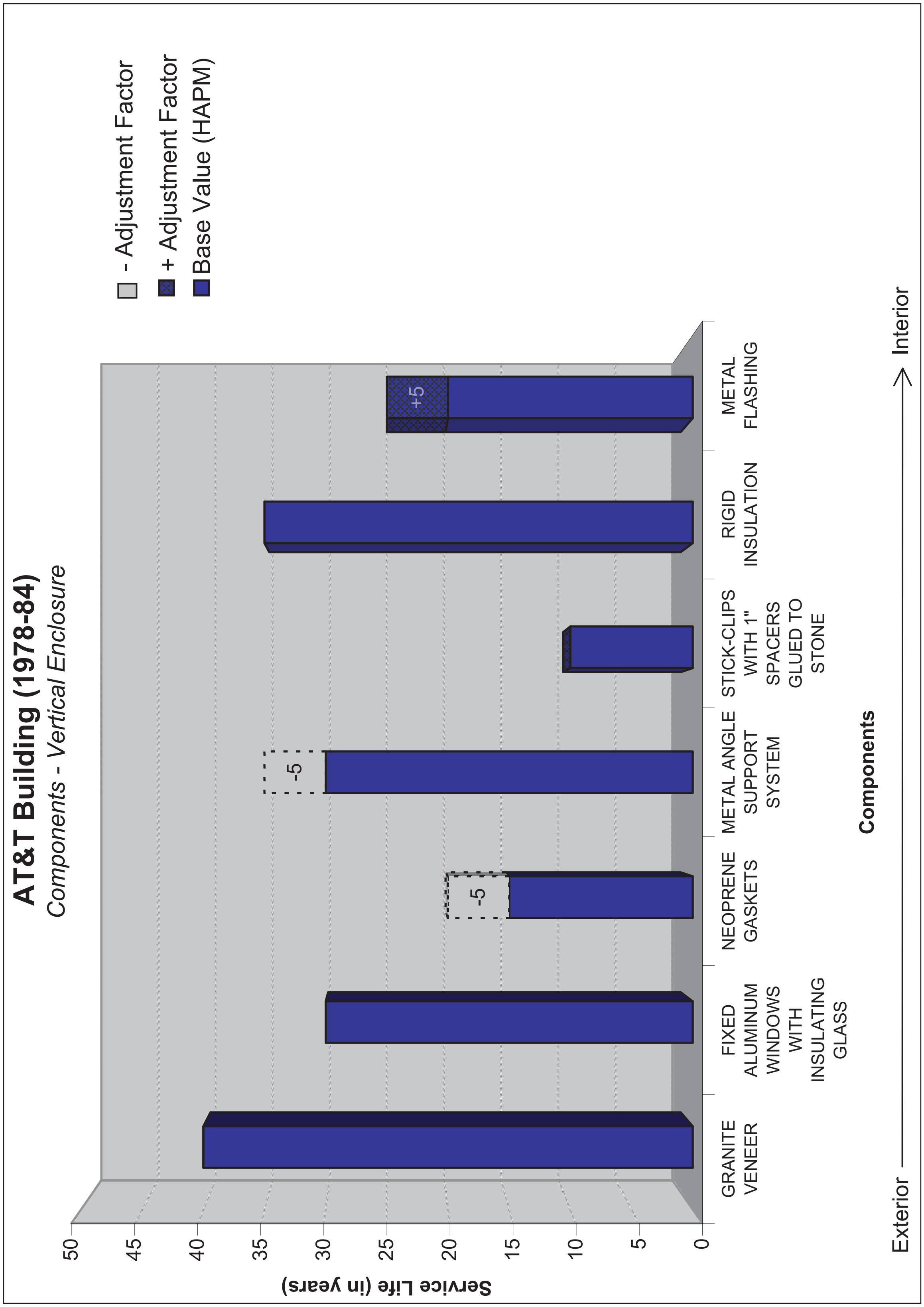
Graph 6.2 - Service Life Analysis - Alcoa Building.



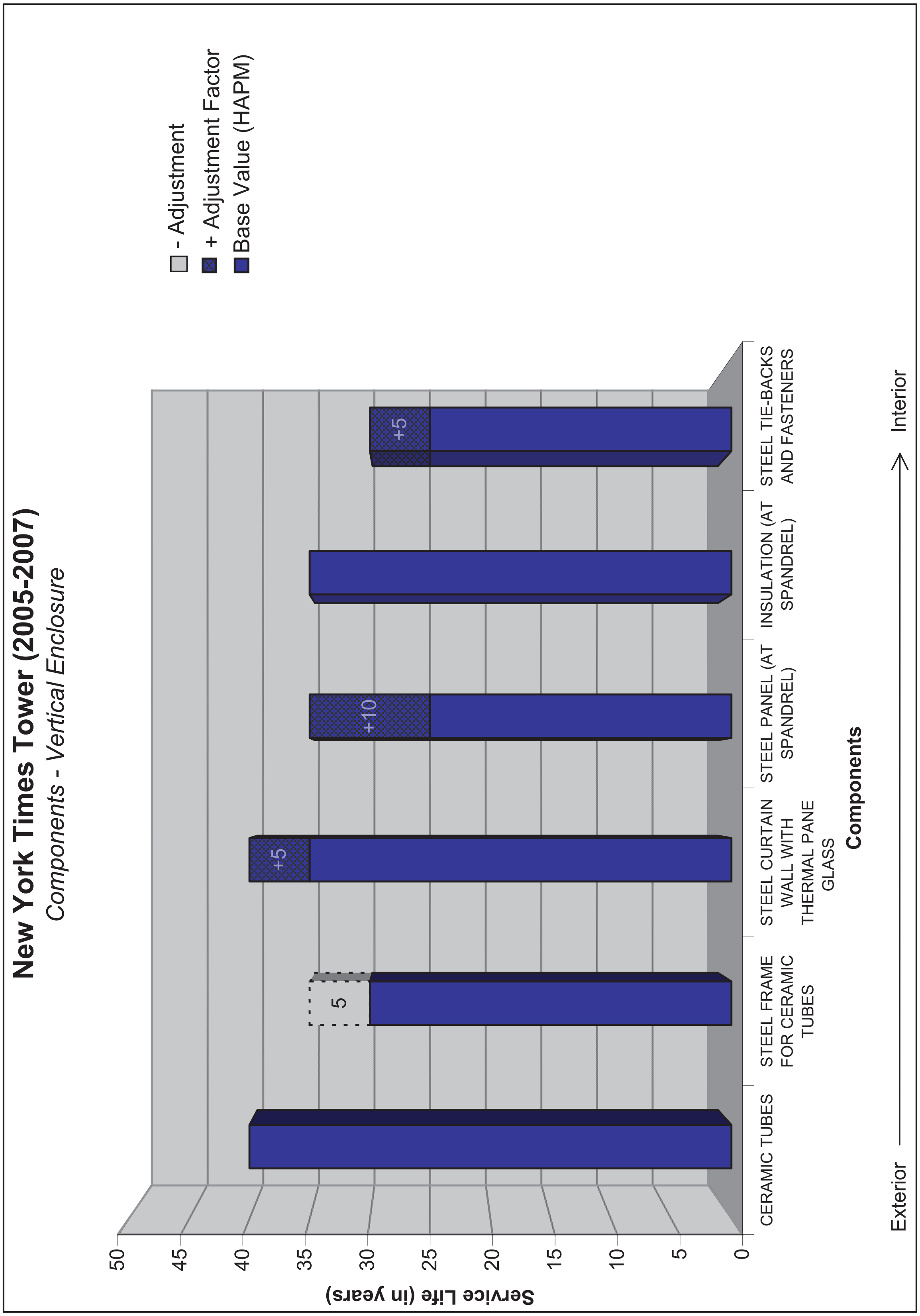
Graph 6.3 - Service Life Analysis - Seagram Building.



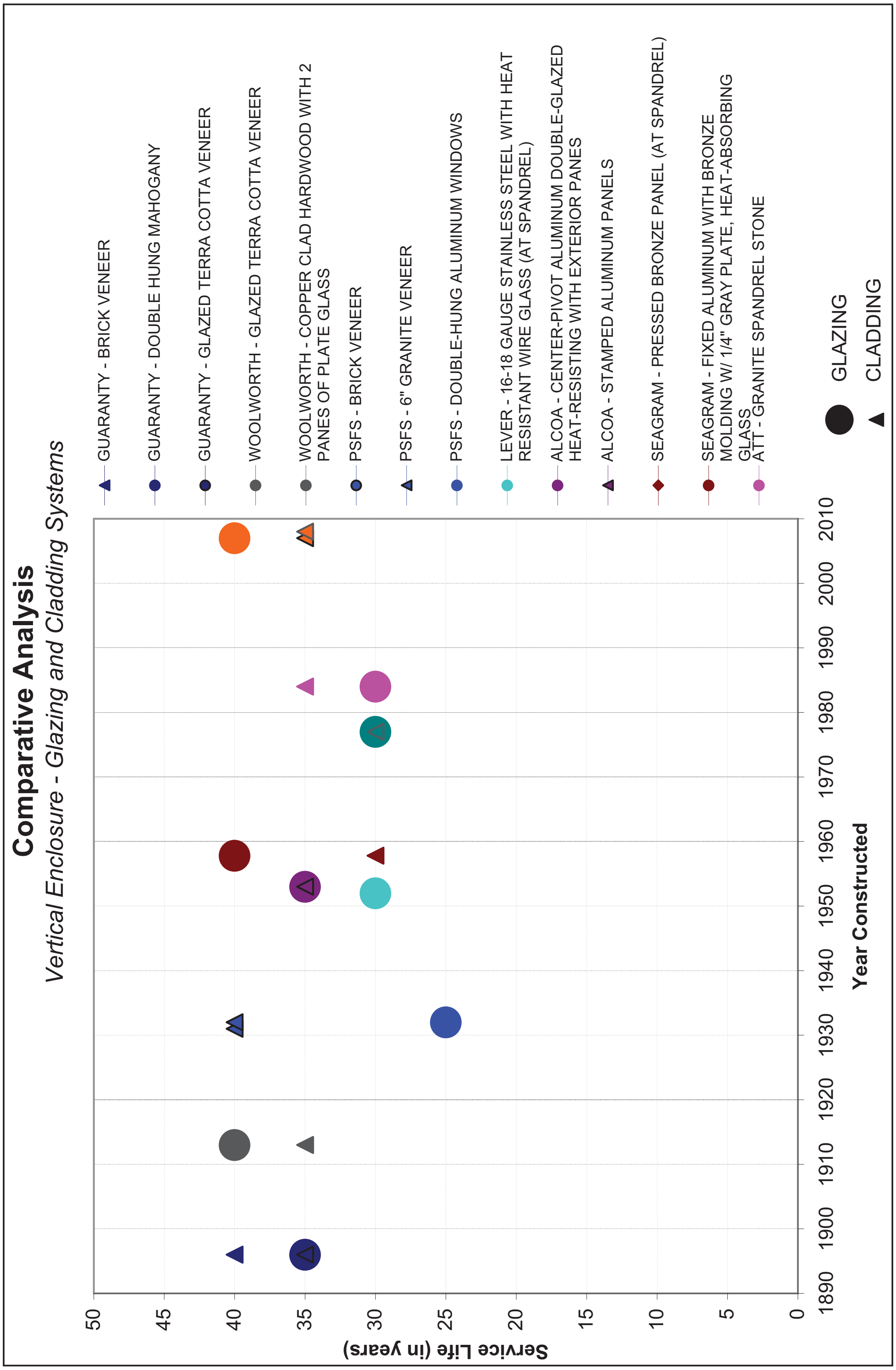
Graph 7.1 - Service Life Analysis - Citicorp Center.



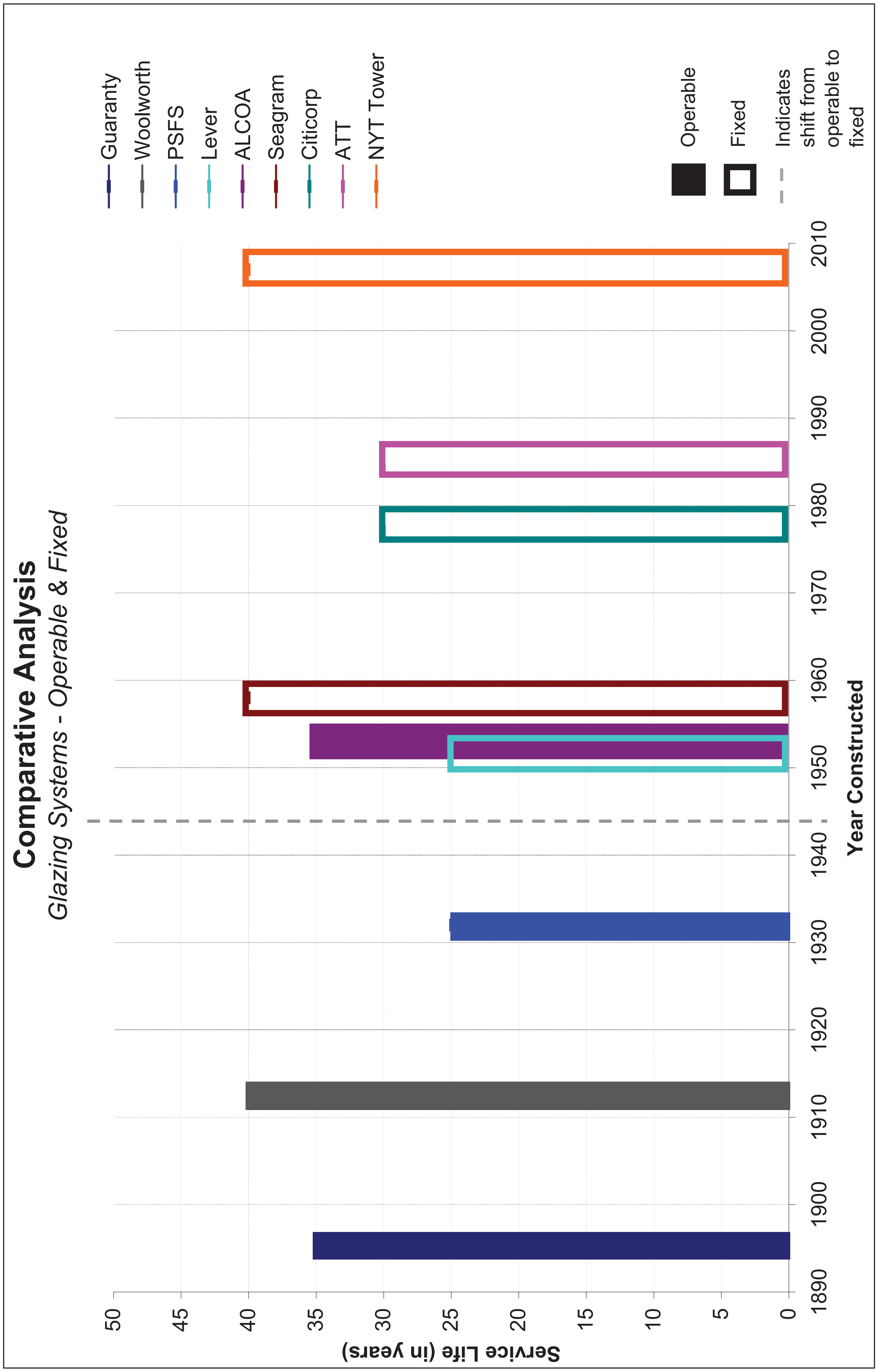
Graph 7.2 - Service Life Analysis - AT&T Building.



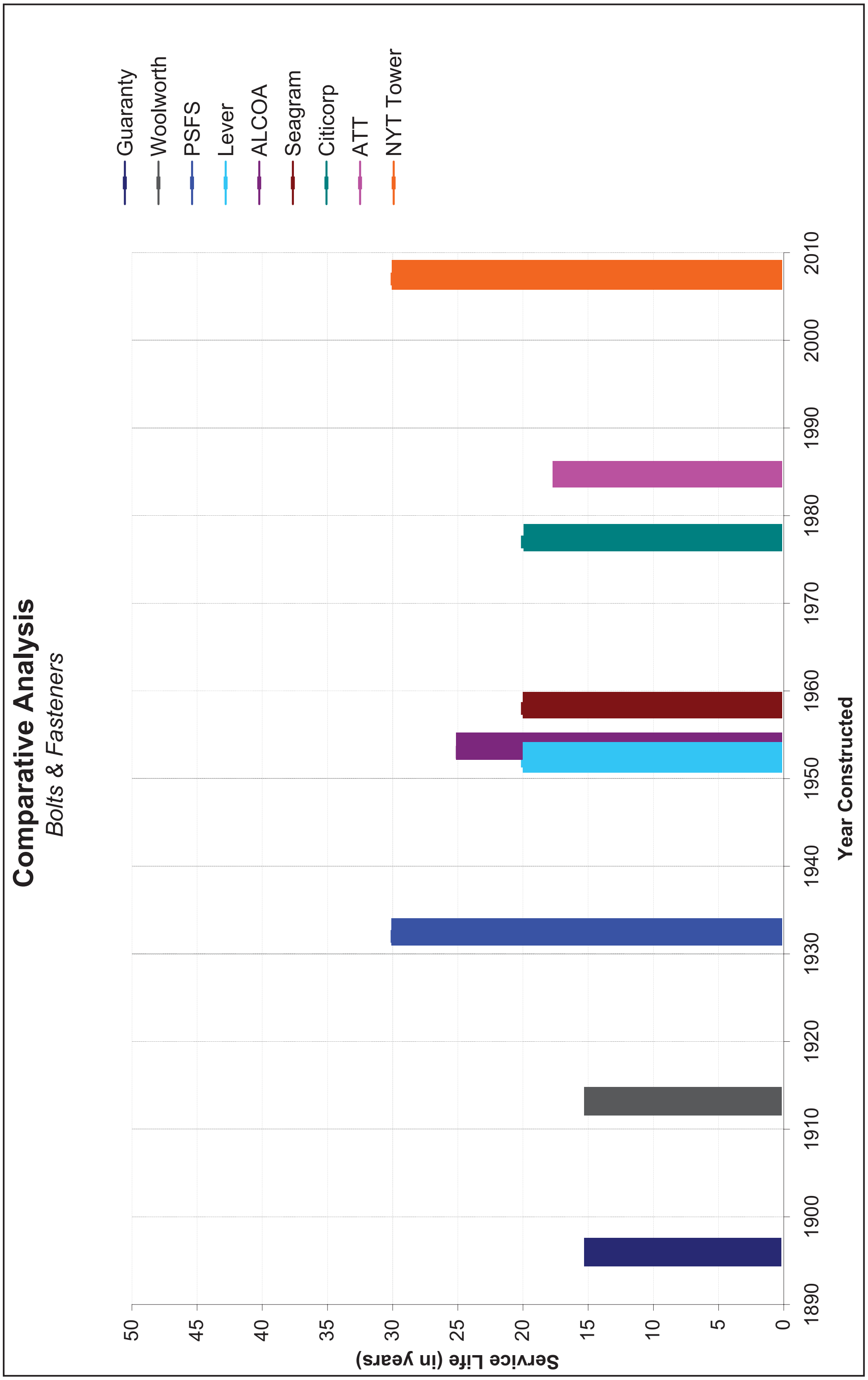
Graph 8.1 - Service Life Analysis - New York Times Tower.



Graph 9.1 - Comparative Analysis - Glazing and Cladding Systems.



Graph 9.2 - Comparative Analysis - Glazing Systems.



Graph 9.3 - Comparative Analysis - Bolts & Fasteners.

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