Offprint from

Preservation Education & Research

Volume 7 | 2014

THE NATIONAL COUNCIL FOR PRESERVATION EDUCATION

1980

PER is published annually as a single volume. Copyright © 2014 *Preservation Education & Research.* All rights reserved. Articles, essays, reports and reviews appearing in this journal may not be reproduced, in whole or in part, except for classroom and noncommercial use, including illustrations, in any form (beyond copying permitted by sections 107 and 108 of the U.S. Copyright Law), without written permission.

ISSN 1946-5904

Front cover photograph credit: Wiss, Janney, Elstner Associates, Inc.; back cover credits, top to bottom: Library of Congress, Natalia Sanchez Hernandez; Wiss, Janney, Elstner Associates, Inc.

PRESERVATION EDUCATION & RESEARCH

EDITORS

Jeremy C. Wells, *Roger Williams University*
(jwells@rwu.edu)

Rebecca J. Sheppard, *University of Delaware*
(rjshep@udel.edu)

BOOK REVIEW EDITOR

Gregory Donofrio, University of Minnesota
(donofrio@umn.edu)

ADVISORY EDITORIAL BOARD

Steven Hoffman, *Southeast Missouri State University*

Carter L. Hudgins, *Clemson University/College of Charleston*

Paul Hardin Kapp, *University of Illinois at Urbana-Champaign*

Ted J. Ligibel, *Eastern Michigan University*

Vincent L. Michael, *Global Heritage Fund*

Andréa Livi Smith, *University of Mary Washington*

Michael A. Tomlan, *Cornell University*

Robert Young, *University of Utah*

NATIONAL COUNCIL FOR PRESERVATION EDUCATION EXECUTIVE COMMITTEE

Lauren Weiss Bricker, Chair,
California State Polytechnic University, Pomona

Trudi Sandmeier, Vice Chair and Memberships,
University of Southern California

Andréa Livi Smith, Vice Chair and Web Site Editor,
University of Mary Washington

Steven Hoffman, Secretary,
Southeast Missouri State University

Robert Young, Treasurer, *University of Utah*

Cari Goetcheus, Internships, *University of Georgia*

Michael Tomlan, Special Projects, *Cornell University*

Paul Hardin Kapp, Chair Emeritus,
University of Illinois at Urbana-Champaign

Preservation Education & Research (PER) disseminates international peer-reviewed scholarship relevant to historic environment education from fields such as historic preservation, heritage conservation, heritage studies, building and landscape conservation, urban conservation, and cultural patrimony. The National Council for Preservation Education (NCPE) launched PER in 2007 as part of its mission to exchange and disseminate information and ideas concerning historic environment education, current developments and innovations in conservation, and the improvement of historic environment education programs and endeavors in the United States and abroad.

Editorial correspondence, including manuscripts for submission, should be emailed to Jeremy Wells at jwells@rwu.edu and Rebecca Sheppard at rjshep@udel.edu. Electronic submissions are encouraged, but physical materials can be mailed to Jeremy Wells, SAAHP, Roger Williams University, One Old Ferry Road, Bristol, RI 02809, USA. Articles should be in the range of 4,500 to 6,000 words and not be under consideration for publication or previously published elsewhere. Refer to the back of this volume for manuscript guidelines.

Books for review, and book reviews, should be sent to Gregory Donofrio, School of Architecture, University of Minnesota, 145 Rapson Hall, 89 Church Street S.E., Minneapolis, MN 55455, USA. E-mail donofrio@umn.edu.

Subscriptions are US$60.00 per year. Payments can be made online at the NCPE Store (http://www.ncpe.us/storemembership) or send a check with name and mailing address to PER, c/o NCPE, Box 291, Ithaca, NY 14851, USA.

THE PRINCIPLES OF FUTURE-PROOFING: A BROADER UNDERSTANDING OF RESILIENCY IN THE HISTORIC BUILT ENVIRONMENT

BRIAN D. RICH

ABSTRACT—The principles of future-proofing are derived through a literature review of the use of the terms "future-proofing" and "resiliency" in the architecture, engineering, and construction (AEC) industry and other industries such as electronics and environmental design. The principles are focused on application to the preservation of historic buildings and are demonstrated through a case study of the 1980-2000 walrus head and tusk repairs at the Arctic Building in Seattle, Washington. The principles assist in consideration of the best practices for the treatment of an historic building by establishing a baseline series of criteria by which to evaluate interventions in historic buildings.

As architects and preservationists, we always strive to make the best designs within the constraints of our projects and our understanding of building technology. Sometimes the results are spectacular successes; at other times the results are less successful. The myriad decisions that contribute to the design and construction process inevitably impact the long-term success of a project. Future-proofing, the process of anticipating the future and developing methods of minimizing the effects of shocks and stresses due to future events, can help guide the rehabilitation process to optimum results. This essay brings together the many ideas of resiliency, future-proofing, historic preservation, and heritage conservation into a coherent set of principles and reveals patterns in a variety of lines of thinking that may remain hidden due to the variety of their sources.

This essay explores the concepts of future-proofing and resiliency present in the architecture, engineering, and construction (AEC) industry and other industries both within the United States and around the globe. Many of the concepts of future-proofing are also present in historic preservation and heritage conservation theory and practice, though not in a cohesive form. Through an analysis of the concepts of future-proofing and resilience, a set of principles is developed to guide the process of rehabilitation of historic buildings. Consideration of interventions in historic buildings in light of these principles may inform the rehabilitation process and prevent flawed rehabilitation efforts.

A case study of the interventions completed in the late twentieth century on the Arctic Building in Seattle, Washington, demonstrates two interventions to rehabilitate deteriorating terra cotta walrus head ornamentation. The first repair, while undoubtedly designed and executed to the best of the architects' and contractors' knowledge and ability, caused further damage. The second future-proof rehabilitation effort successfully remedied the problems of the original design as well as the first rehabilitation efforts.

How can these two interventions inform the rehabilitation process? How can we make more reliably successful designs and reduce the possibility of flaws that cause deterioration of either new, or, more important, historic building fabric? These questions are discussed and answered through analysis of the rehabilitations at the Arctic Building. Study of the 1982 rehabilitation of the walrus tusks at the Arctic Building demonstrates one manner in which rehabilitation efforts did not anticipate future stresses. Study of the 1996 rehabilitation of the walrus heads and tusks illustrates how the concepts of future-proofing may support the rehabilitation process.

THE CONCEPTS OF FUTURE-PROOFING AND RESILIENCE

Due to the complexity of buildings and the design and construction process, it is difficult, if not impossible, to know that our solutions will always be successful. The concepts of future-proofing and resiliency, two closely related subjects, provide guidance to the rehabilitation process. These concepts inform our ideas of how to achieve enduring and sustainable built environments. Whereas future-proofing is a concept found largely outside the United States, "resiliency" is a term increasingly used within the United States, though both are found in a variety of industries. There are also several related concepts already contained within architectural historic preservation and heritage conservation theory and practice.

The Concept of Future-Proofing

The concept of future-proofing is the process of anticipating the future and developing methods of minimizing the negative effects while taking advantage of the positive effects of shocks and stresses due to future events. While the connotations of the term "future-proofing" may be considered negative if the future is thought of in a negative light, similar to bullets and bullet-proofing, future-proofing can also be taken in a positive light. Buildings may also be able to take advantage of the changing attributes of a continually evolving environment, such as the restoration of blighted neighborhoods. If the term "future-proofing" is unpalatable to preservationists, one could also argue for a wider definition of "resiliency" since they both promote very similar concepts.

Future-proofing is a concept that is found in multiple different industries, though use of the term was uncommon in the architecture, engineering, and construction (AEC) industry until the past fifteen to twenty years. Future-proofing is a concept that has been developed largely outside the United States and outside the AEC industry. The industries where future-proofing is used include electronics, data storage, utilities systems, industrial design, environmental and ecological design, and energy conservation. Within the AEC industry, the term "future-proofing" is found most often in the sustainable design field. The concepts of future-proofing are more widespread in the AEC industry, but have not been brought together as a coherent approach to projects.

In the electronics industry, future-proofing references data and image storage and computer electronics. In future-proof electrical systems, buildings should have "flexible distribution systems to allow communication technologies to expand," says Raul Barreneche (1995, 123). Thomas and other designers at Bell Laboratories, Lucent Technologies Australia, focus heavily on the ability of a system to be reused and to be flexible in order to continue competing in the marketplace (Thomas et al. 2003, 150).

In one region of New Zealand, Hawke's Bay, a 2012 study by the consulting firm Page Bloomer Associates specifically sought to understand the existing and potential water demand in the region as well as how this potential demand might evolve with climate change and more intense land use. This information was used to develop demand estimates that would inform the improvements to the regional water system. Future-proofing thus includes forward planning for future development and increased demands on resources (Bloomer and Page 2012, i-vi).

In industrial design, future-proofing strives to encourage people to acquire fewer products by creating objects that hold more value for the purchaser (Kerr 2011, 7). Kerr goes on to state that future-proof products should have a degree of atemporality. As a product wears and ages, its overall desirability is maintained (Blanco-Lion, Pelsmakers, and Taylor 2011). Ideally, desirability exemplifies a positive change; the product can fit into society's paradigm of "progress" while simultaneously changing that paradigm (Kerr 2011, 9).

In the realm of sustainable and environmental issues, future-proof is used to describe the ability of a design to resist the impact of potential climate change due to global warming, based on research by faculty at University of Bristol and the University of Moratuwa in Sri Lanka. Two characteristics describe this impact. First, dependency on fossil fuels will be more or less completely eliminated and replaced by renewable energy sources. Second, society, infrastructure, and the economy will be well adapted to the residual impacts of climate change (Godfrey, Agarwal, and Dias 2010, 180). In the design of high-performance dwellings, "buildings of the future should be sustainable, low-energy and able to accommodate social, technological, economic and regulatory changes, thus maximizing life cycle value." Georgiadou, Hacking, and Guthrie (2013, 9) believe that the goal is to reduce the likelihood of a prematurely obsolete building design.

The concept of future-proofing also comes up in some literature with specific regards to sustainable preservation strategies. Initial studies on climate change and historic structures were carried out by English Heritage in 2004, and scientific research such as *Engineering Historic Futures* and the European Union's *Noah's Ark Project* have been completed (Cassar 2009). Cassar, for example, suggests interest in sustainable rating systems if durability is incorporated as a metric for evaluating buildings. Cassar also argues that historic buildings must fully engage in the process of "adaptation to climate change," lest they become redundant and succumb to "environmental obsolescence" (Cassar 2009, 7). Cassar also recommends a "'long life, loose fit' strategy to managing historic buildings" (Cassar 2009, 8), meaning that sustainable design protocols must be able to be adapted to the particular circumstances of each building rather than applied to the entire built environment with broad brush strokes. Most important, Cassar highlights one of the underlying values of future-proofing— the "historic built environment is a finite and non-renewable resource"—and concludes that "heritage must adapt to changes, physical and intellectual, within its environment" (Cassar 2009, 10). Because embodied energy comprises a significant percentage of energy consumed over a building's service life, the preservation and adaptation of buildings plays a "central role in conserving the past and the future" (Holland 2012, 5).

The hygrothermal performance of the original building materials at the Hudson Bay Department Store in Victoria, British Columbia, was carefully analyzed to ensure that improvements would not reduce the "building's time-proven durability" (Dam 2011, 47). In reference to the Marquette Railroad Depot in Bay City, Michigan, Tyler and Dilcher note that "the use of durable, long-lasting materials was cost effective 100 years ago, and restoring those materials today extends their service into the next century" (Tyler and Dilcher 2010, 24). All of these articles on sustainable preservation strategies discuss various concepts of future-proofing, including durability, doing no harm, extension of service life, adaptability, and avoiding obsolescence.

As mentioned above, a future-proof building is also one that does not become obsolete. Reed and Warren-Myers state that in the valuation of real estate, there are three traditional forms of obsolescence: physical, functional, and aesthetic. Physical obsolescence occurs when the physical material of the property deteriorates and needs to be replaced. Functional obsolescence occurs when the property is no longer capable of serving the intended use or function. Aesthetic obsolescence occurs when fashions change or when something is no longer in style. A potential fourth form, sustainable obsolescence, occurs when a property no longer meets one or more sustainable design goals (Reed and Warren-Myers 2012, 1). Obsolescence is an important characteristic of future-proofing a property because it emphasizes the need for the property to continue to be viable.

In Australia, research commissioned by Health Infrastructure New South Wales explored "practical, cost-effective, design-related strategies for 'future-proofing' the buildings of a major Australian health department" (Carthey et al. 2011, 89). This study, conducted by several faculty and staff at the University of New South Wales, concluded that a focus on a whole lifecycle approach to the design and operation of health facilities would have clear benefits (Carthey et al. 2011, 106). By designing flexible and adaptable structures, one may defer the obsolescence and consequent need for demolition and replacement of many health facilities, thereby reducing overall demand for building materials and energy (Carthey et al. 2011, 106).

In 1997, the MAFF laboratories at York, England, were described by Lawson as "future-proof" by being flexible enough to adapt to developing rather than static scientific research (Lawson 1997). In 2012, a New Zealand–based organization promoting future-proofing outlined eight principles of future-proof buildings: smart energy use, increased health and safety, increased lifecycle duration, increased quality of materials and installation, increased security, increased sound control for noise pollution, adaptable spatial design, and reduced carbon footprint (CMS 2012).

Future-proofing, as evidenced in the above industries, offers several concepts that may guide enduring interventions in our built environment as well. These concepts include obsolescence, durability, adaptability, sustainability, local materials and labor, atemporality, forward planning, and re-use. In the AEC industry and many other industries in the United States, the closely related concept of resilience has gained a significant following and offers several key concepts as well, as we will see in the discussion that follows.

The Concept of Resilience

"Resilience" is a current buzzword used to describe architecture and environments that can withstand external shocks to a system. While commonly used in the popular media, the term "resilient" has also received significant attention in recent scholarly articles. Not only has the term become common in reference to the built environment, but it is also widely used in reference to computing and networking systems, environmental and biological studies, and individual people.

As Jill Fehrenbacher notes, "In November 2012, 'Resilient Design' was a trending search term in Google, moving from near obscurity in the months before the devastating super storm to a popular catchphrase post-Sandy" (Fehrenbacher 2014). The Resilient Design Institute (2013) offers a succinct summary of the principles of resilient design. Intended to be broadly interpreted and applied, they are not specifically focused on the built environment. They do, however, offer some vital clues about resilience that can be applied to the built environment.

- Resilience transcends scales.
- Resilient systems provide for basic human needs.
- Diverse and redundant systems are inherently more resilient.
- Simple, passive, and flexible systems are more resilient.
- Durability strengthens resilience.
- Locally available, renewable, or reclaimed resources are more resilient.
- Resilience anticipates interruptions and a dynamic future.
- Find and promote resilience in nature.
- Social equity and community contribute to resilience.
- Resilience is not absolute.

Very few scholarly articles specifically discuss "resilient architecture," though resiliency is a common topic of discussion in many areas of our lives today. Many of the articles that do discuss "resilient architecture" focus on networks and technology systems. For example, Shi and Khan use resiliency to describe shared-memory multicores for computing and communication networks (Shi and Khan 2013). Another article discusses resiliency in off-shore wind farm communication networks, suggesting that a resilient communication network "can be achieved through a combination of redundancy and Quality of Service" (Gajrani, Gopal Sharma, and Bhargava 2013, 023139-1).

According to Applegath et al. (2010), the principles of a resilient built environment include:

- local materials, parts, and labor
- low energy input
- high capacity for future flexibility and adaptability of use
- high durability and redundancy of building systems
- environmentally responsive design
- sensitivity and responsiveness to changes in constituent parts and environment
- high level of diversity in component systems and features

One approach to resilient cities is an integrated multidisciplinary combination of mitigation and adaptation to raise the level of resilience of the city. In the context of urban environments, resilience is less dependent on an exact understanding of the future than on tolerance of uncertainty and broad programs to absorb the stresses that the urban environment might face. The scale of the context is important: events are viewed as regional stresses rather than local. The intent for a resilient urban environment is to keep many options open, emphasize diversity in the environment, and perform long-range planning that accounts for external systemic shocks (Thornbush, Golubchikov, and Bouzarovski 2013). Options and diversity are strategies similar to ecological resilience, discussed below. This approach again points out the importance of flexibility, adaptability, and diversity to future-proofing urban environments.

Personal resiliency is a common theme in the discussion of recovery from the Boston Marathon bombing (Time 2014) and other natural disasters such as Hurricane Sandy (Bernstein 2012). Important in these stories of personal resilience is the ability of people to persevere in spite of severe physical and mental injuries, "shattered bones, severe burns, and shrapnel wounds" (Sanchez 2014). Resilience in the workforce in China is the subject of another paper. Increasing performance pressure is requiring employees to be more resilient. The paper notes that there is an "increasing overlap between the key attributes in resilience and soft skills. This overlap of resilience and soft skills is identified in 9 dimensions: vision, determination, interaction, relationships, problem-solving, organization, self-confidence, flexibility & adaptability, and pro-activeness" (Wang, Cooke, and Huang 2014, 135).

In its common usage, "resilience" describes the ability to recoil or spring back into shape after bending, stretching, or being compressed. In ecology, the term "resilience" describes the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state (Applegath et al. 2010). Resilience in the natural environment is a subject of current research as humans take more interest in the impacts human activity has on our planet. In an article about the development of urban social-ecological systems, Schewenius, McPherson, and Elmqvist argue that "urban futures that are more resilient and sustainable require an integrated social-ecological system approach to urban policymaking, planning, management, and governance" (2014, 434).

Biological resilience is commonly discussed in research focused on the ability of a living organism to resist and even thrive despite changes to its natural environment. In biological studies off the coast of Italy, oceanic sediment bacteria are described by Kerfahi et al. as resilient in the face of rising levels of carbon monoxide in the ocean waters. Here, resilient is taken to mean that the bacteria are resistant to the corrosive waters (Kerfahi et al. 2014). In an environmental study by Hoggart, "coastal habitats surveyed are relatively resilient to flooding due to their species rich nature and their ability to adapt to flooding. However, specific groups of plants such as grasses are more affected by flooding and less able to recover" (Hoggart et al. 2014, 170). This suggests that adaptability and the ability to recover from flooding are important attributes of resilience.

Through this sampling of recent articles on resilient design and resiliency in computer networks, personal resiliency, and resiliency in urban, ecological, and biological systems, it is clear that the term has been widely used. From these articles, it is also clear that there are several characteristics of resiliency that are similar to the concepts of future-proofing. These characteristics include redundancy, diversity, flexibility, durability, adaptability, and local resources such as materials and labor, to anticipate systematic shocks in a changing future.

Resilience and Climate Change in Heritage Resources

Resiliency and future-proofing are also at the core of the discussion of the impacts of climate change on cultural heritage. The Getty Conservation Institute (GCI), the Association for Preservation Technology (APT), the National Trust for Historic Preservation, UNESCO, and English Heritage all have focused on this issue in recent years. The Spring 2011 issue of *Conservation Perspectives*, the GCI newsletter, is dedicated to the intersection of the impacts of climate change and our heritage. In this edition of the newsletter, Cassar states that climate change "poses significant challenges for cultural heritage" (Cassar 2011, 11). Much of what Cassar discusses in her article describes the need to understand the impacts of climate change on our heritage and developing policies to address these impacts. The policies Cassar promotes deal with how to respond to climate change in a way that will help our heritage endure. The concepts of future-proofing are an essential component in responding to climate change by providing the framework for implementing the policy Cassar promotes developing. In the same issue of *Conservation Perspectives*, Jean Caroon states in an interview that "there's no way to make a building that doesn't have an environmental impact," but that "you can lessen the environmental impact by taking existing objects and extending their service life" (Caroon 2011, 19). Decreasing environmental impacts and extension of service life are two very important concepts in future-proofing. This edition of *Conservation Perspectives* concludes with a list of several other sources that discuss the impacts of climate change on cultural heritage and the need to respond to these impacts.

One of these other sources, APT, has dedicated a symposium to the subject. In 2004, the APT formed a Technical Committee on Sustainable Preservation and a subcommittee on climate change. The following year, the Halifax Symposium was held at the 2005 APT Annual Conference. At this symposium, several concepts were found in common between sustainability and the mission of APT. The principal concepts, summarized by Lesak (2005), include:

- understanding the importance of stewardship and planning for the future
- building to last, including material selection and treatment, craft, and traditional building techniques

- durability and service life of materials and assemblies and their implications for lifecycle assessment
- understanding extending buildings' service lives and systems renewal

The concepts also included a system of evaluation of existing buildings that included "creating sustainable building stock…by assessing material value and energy value" (Lesak 2005, 4). The last level of evaluation included a "product rating system to establish, test, and/or confirm effectiveness, durability, life cycle impacts, [and] renewability" of building materials and products (Lesak 2005, 4). One of the latest developments at APT is a planned special issue of the APT bulletin that focuses on climate change and preservation technology (Rankin 2014). From these statements, several concepts of future-proofing are highlighted, including forward planning, durability, extension of service life, including building systems, and lifecycle assessment.

UNESCO has published several documents that address climate change and heritage conservation, most notably World Heritage Report 22 titled *Climate Change and World Heritage* (UNESCO 2007). This report discusses predicting and managing the impacts of climate change and offers strategies for implementing responses. Much of Report 22 discusses developing a better understanding of the impacts of climate change through modeling, monitoring, and research and appropriate dissemination of the information (UNESCO 2007). However, the report also discusses the need for "adaptive design" in several places as well as identification and promotion of "synergies between adaptation and mitigation" (UNESCO 2007, 41). The report also recommends "increasing resilience of a site by reducing non-climactic sources of stress" and "adapting to the adverse consequences" of climate change (UNESCO 2007, 11). These statements in Report 22 demonstrate the characteristics of adaptation and increased fortification of heritage sites, both of which are important concepts in future-proofing and resiliency.

English Heritage's Conservation Bulletin dedicated its Spring 2008 issue to climate change as well, titling it "Adapting to a Changing Climate." In this issue, Cassar identifies several key research outputs that are necessary to address climate change that are similar to the approach to resilient cities discussed above. These include "adaptations to climate change" and "damage mitigation strategies for materials and assemblies" (Cassar 2008, 11). These outputs reflect the need for heritage to be reinforced and made more durable to resist the future impacts of climate change. These research outputs, thus, reflect the goals of future-proofing and resilience.

Clearly, resilience and climate change have been at the center of discussions on cultural heritage both within the United States and internationally. These discussions often focus on key aspects of future-proofing and resilience, including adaptation to climate change, extension of service life, and mitigation of the effects of climate change.

ATTRIBUTES OF FUTURE-PROOFING IN HISTORIC PRESERVATION AND HERITAGE CONSERVATION

There are many attributes of future-proofing that are inherent in aspects of historic preservation and heritage conservation theory and philosophy. Here, cultural heritage, while including the built environment referred to by the term "historic preservation," is also understood to include a broader realm of artifacts and intangible characteristics of a society, including artwork, sculptures, dance, clothing, and other expressions of our unique identities. In the context of historic buildings, the writings of Georg Morsch, James Marston Fitch, and Bernard Feilden are examples of how the concepts of future-proofing are embedded in preservation theory. The writings of Cesare Brandi, Paul Philippot, and Ernst Van de Wetering also address aspects of future-proofing and resilience in cultural heritage, advocating careful consideration of our heritage that is the goal of future-proofing. Each of these more nuanced approaches to conservation demonstrates some of the characteristics of future-proofing, but these characteristics have not been brought together as a single system of principles until now.

Georg Morsch's concept of conservation, outlined in 1980, includes two major goals: "first, that historical evidence and vestiges must be decipherable; and, second, that evidence and vestiges must be decipherable by a broad public which requests flexible approaches on certain conservation concepts" (Burman 1997, 278). This concept of interventions in historic buildings points out the need for flexibility while retaining a clear understanding of the historic fabric of the building.

James Marston Fitch argues that obsolescence of buildings is often determined on the basis of "superficial examination and inadequate data" (Fitch 1990, 63). Fitch goes on to suggest that there are important new techniques available that make the rehabilitation of historic buildings much more feasible, alluding to extending the service life, fortifying, and increasing the durability and redundancy of historic buildings. Modern preservation technologies make it possible to "reclaim even seriously damaged building fabrics and extend their effective life for decades into the future" (Fitch 1990, 105). Fitch also argues that "interventions for adaptive use will ordinarily be more conservative externally than internally," allowing for flexibility and adaptability to accommodate the new uses within the building (Fitch 1990, 169). Last, Fitch argues that the "reworking of extant structures to adapt them to new uses is as old as civilization itself" and has significant lifecycle benefits as the "characteristic mode of energy conservation" (Fitch 1990, 165).

Bernard Feilden calls conservation "primarily a process that leads to the prolongation of the life of cultural property for its utilization now and in the future" (Feilden 2003, x). Feilden advocates evaluation of all practical alternatives in a rehabilitation "to find the 'least bad' solution" (Feilden 2003, xi). Despite the awkward phrasing, the intent is derived from the Hippocratic approach of "do no harm," which he obliquely references and which is the basis of the future-proof concept of preventing decay. Feilden also advocates rehabilitation by keeping buildings "in use—a practice which may involve what the French call *'mise en valeur,'* or modernization with or without adaptive alteration" (Feilden 2003, 10), another goal of future-proofing.

The concept of different approaches to conservation and rehabilitation is captured in the variety of heritage conservation policy documents used across the globe. From the four different Standards developed by the National Park Service in the United States to the multitude of documents available to members of the World Heritage Convention, general and specialized guidelines are available. Flexibility and adaptability of treatment and use, maintaining authenticity, differentiation of additions, and implied support for the extension of the service life of historic buildings are all characteristics of these documents. In the words of Burman, we should "treat a historic monument in such a way that it could serve as an example for other cases, not as a straightjacket" (Burman 1997, 286).

The goal of heritage conservation is to preserve for all eternity the objects thought of as the world's patrimony (Appelbaum 2007). In this process, there are a myriad of different possibilities for the goals of the conservation treatment as well as the actual treatment methods and materials. Just as architectural historic preservation theory has evolved, so has conservation theory. Today, many of the key attributes of heritage conservation are similar to the concepts of future-proofing and resiliency.

By the middle of the twentieth century, the understanding of restoration evolved to include the functional restoration of a work of art and architecture as well as painting and sculpture. Cesare Brandi writes about art and architecture as equally valid works of art. However, the functional properties are still held secondary to the "primary or fundamental aspect that respects a work of art as a work of art" (Brandi 1996a, 230). In contrast to Viollet Le Duc's definition of restoration, Brandi holds that "restoration is the methodological moment in which the work of art is appreciated in its material form and in its historic and aesthetic duality, with a view to transmitting it to the future" (Brandi 1996a, 231). Brandi suggests that for buildings, the exterior appearance is primary, but that, in line with modern preservation requirements and designation of significant features, interior walls and structures may be altered to improve the building. This is important to the understanding of future-proofing and resiliency because it allows for flexibility and adaptability as well as the extension of service life, reduction of obsolescence, fortification, and increased durability and redundancy.

Brandi goes on to say that while "patina documents the passage through time of the work of art and thus needs to be preserved," the patina should be an "imperceptible muting" of the original materials and must be brought into equilibrium with the original materials (Brandi 1996b, 378). Brandi's intent is that the patina should not overwhelm and disguise the original, nor should patina be completely removed, but rather a balance must be sought between the two. This approach promotes the understanding not only of the original material but also the aging and interventions that it has been subjected to over its history.

For Philippot, it is the authentic relationship between the past and the present that must be integrated "into the actualization of the work produced by the intervention" (Philippot 1996c, 225). This is also very similar to the concept of promoting understanding of the historic structure both before and after rehabilitation. Most important here is recognition and respect for the *Gesamkunstwerk*, or "unity resulting from the cooperation and collaboration of the various arts and crafts" that made the historic building (Philippot 1996a, 271). A natural consequence of this approach then becomes evident when considering lacunae, or missing pieces, and new interventions. These interventions should be made in such a way as to “reestablish continuity … while being easily identified on closer inspection” (Philippot 1996b, 359). This again underscores the importance of understanding the evolution of an historic structure.

Conservation theory has evolved to understand that “each treatment, or even non-treatment, nevertheless involves an interpretation of the object” (Van de Wetering 1996, 193). “Restoration has a certain autonomy independent, to some extent, from the artist’s intentions” (Van de Wetering 1996, 196). However, like Ruskin’s philosophy, Van de Wetering also holds that there is a “growing awareness that we will never understand the artist’s intentions to their full extent and that consequently our interpretations … never entirely cover the truth” (Van de Wetering 1996, 196). The restoration approach will thus vary; depending on the subject of the rehabilitation, different approaches may be appropriate. One approach, that of the collector, “prefers no restoration over authentic appearance,” or, alternatively, one recognizes that “interventions are often inevitable” and are the “concrete manifestation of an interpretation” of the historic object (Van de Wetering 1996, 197). Like Brandi and Philippot, Van de Wetering argues for the ability to understand the original aged object as well as its history, and, further, that this be conveyed to future observers.

Appelbaum suggests that there are potential differences between the “ideal state for the object” and the “realistic goal of the treatment” (2007, xx) The goal of conservation is to protect the object, extend its service life, and reduce its obsolescence by making the object desirable to keep (Appelbaum 2007, xxvii). As noted by Van de Wetering, a treatment involves an interpretation. A treatment, then, is “an interpretation chosen to enhance the meanings for which the object is valued and to accommodate its intended future” (Appelbaum 2007, xxi). “Treatments that improve aesthetics, usability, or lifespan of an object all increase its utility” (Appelbaum 2007, xxvi). Appelbaum goes on to say that “slowing an object’s deterioration also increases utility,” “an object that cannot be used … provides no benefit,” and “treatment is supposed to provide the physical strength to make those improvements last” (Appelbaum 2007, xxvii). Appelbaum’s statements contain many references to future-proof concepts, including preventing deterioration and decay, reduced obsolescence, and extension of service life, among others.

Implicit in the dozens of cultural heritage policy documents that address both heritage conservation and historic preservation are the doctrines of minimal intervention, reversibility, and differentiation. The concepts of reversibility are embedded in the Secretary’s Standards, the Venice Charter, and multiple other documents. Yet, as Muñoz Viñas points out, true reversibility is not possible and the concept is thus evolving to that of “removability” or “retreatability” (Muñoz Viñas 2005). Indeed, the phrasing of Rehabilitation Standard 10 already softens the relentless intent of reversibility by allowing for the “essential form and integrity” of an historic property to be returned (Weeks 2000). Minimal interventions are typically recommended to prevent loss of original historic fabric. Article 13 of the Venice Charter requires that additions do not “detract” from the historic building or its context (ICOMOS 1964). Similarly, the Secretary’s Rehabilitation Standard 7 requires that treatments use the “gentlest means possible” (Weeks 2000). Differentiation is explicitly included in the Secretary’s Rehabilitation Standard 9: “the new work shall be differentiated from the old” (Weeks 2000). Articles 9 and 12 of the Venice Charter speak to differentiation as well, requiring that “work which is indispensable must be distinct” and “distinguishable” from the original historic fabric (ICOMOS 1964). In the discussion of the concepts of future-proofing and resilience, the doctrines of minimal intervention, reversibility, and differentiation may be incorporated through inclusion of cultural heritage policy documents.

The fields of historic preservation and heritage conservation have evolved since the nineteenth century to offer many of the same concepts as future-proofing and resilience. However, historic preservation and heritage conservation have not developed a coherent theory or set of principles around these concepts. Future-proofing and resilience have developed clearer definitions in different industries, as discussed above, and these may be analyzed to determine common characteristics. This analysis of the concepts of future-proofing and resiliency and their applications in a multitude of industries, including historic preservation and heritage conservation, may be brought together to develop a rubric or tool to support the rehabilitation process and avoid unsuccessful designs. To do this, one may develop a single set of principles that can guide the rehabilitation process.

THE PROPOSED PRINCIPLES OF FUTURE-PROOFING HISTORIC BUILDINGS

The concepts of future-proofing and resiliency both offer significant and compelling ideas that can be beneficial to the development of design solutions in the built environment and, more specifically, historic buildings. I propose that, when the concepts of future-proofing and resiliency are brought together, the following set of guiding principles may be developed.

1. **Prevent decay.**
   Promote building materials, methods, maintenance, and inspections that prevent premature deterioration of our built environment. It is natural for all building materials to deteriorate. Maintenance and interventions in historic structures should mitigate the deterioration of the existing building fabric rather than accelerate deterioration. I propose the following oath, with acknowledgment of the Hippocratic Oath and Cervat Erder's proposal (Erder 1977):

   > *The procedures and materials selected will be for the benefit and respect of our cultural heritage. We will give no harmful treatment, nor counsel such, nor aid in the deterioration or demolition of any monument. As stewards of our heritage and for the benefit of society, we will spurn harmful practices and document all steps taken.*

2. **Promote understanding.**
   Allow for understanding of the built environment and its place in our built heritage. Minimal interventions in existing structures allow future students of history to understand and appreciate the original historic building and *Gesamkunstwerk*, or unity of craft, as well as the patina. Interventions that have kept it viable should remain distinguishable from the original structure.
3. **Stimulate flexibility and adaptability through diversity.**
   Flexibility and adaptability of our built environment and our attitudes toward it are essential to retention of our built environment in a disposable society. The interventions in an existing structure should not just allow flexibility and adaptability, but also stimulate it while minimally impacting the historic building fabric. Adaptability to the environment, uses, occupant needs, and future technologies by keeping a diverse array of options open is critical to the long service life of a historic building..
4. **Extend service life.**
   Extend the service life of our built environment so it may continue to contribute to our economy, culture, and sustainable society. Regular maintenance and appropriate interventions in existing buildings help to make the buildings useable for the long-term future rather than shorten their service life.
5. **Fortify!**
   Fortify our built environment against climate change, extreme weather, and shortages of materials and energy. Interventions should prepare buildings for the impacts of climate change by reducing energy consumption; reducing consumption of materials; and helping them to withstand extreme natural events, such as hurricanes, floods, and tornadoes.
6. **Increase durability and redundancy.**
   Interventions in existing buildings should use equally durable building materials. Don't mix short-term materials with long-term materials. Materials that deteriorate more quickly than the original building fabric require further interventions and decrease the service life of a building. Building designs should either include components with similarly long service lives or be designed for disassembly for replacement of the shorter life components. Redundant systems provide backup in the event that a primary system fails and allow a building to continue to function.
7. **Reduce obsolescence.**
   Don't accept planned obsolescence. The built environment should be able to continue to be used for centuries into the future. Take an active approach to preventing physical, functional, aesthetic, and sustainable obsolescence. Regularly evaluate and review current status in terms of future service capacity. Find the most appropriate uses for the building, even if that means it has to be unused for a short period of time.
8. **Consider lifecycle benefits.**
   Consider the long-term lifecycle benefits of interventions in our built environment. The embodied energy and material resources in existing structures should be incorporated in environmental, economic, social, and cultural costs for any project.
9. **Be local and healthy.**
   Incorporate non-toxic, renewable, local materials, parts, and labor into our built environment. The parts and materials used in designing and implementing building interventions should be available locally and installed by local labor. This

means that the materials and manufacturing capabilities will be readily available in the future for efficient repairs.

10. **Take advantage of cultural heritage policy documents.** Cultural heritage policy documents provide excellent guidance for the long-term retention of an historic building. From the Secretary's Standards to the World Heritage Convention's charters, documents, and declarations, these documents offer invaluable guidance, including the concepts of minimal intervention, reversibility, and differentiation, when working with historic buildings as well as other existing buildings. Above all, in striving to meet the above principles, respect the historic building as a work of art, including its past interventions.

Having analyzed the characteristics of future-proofing and resilience and developed a set of principles to guide the design of interventions, it is instructive to see how the principles of future-proofing may be applied in a case study. The case study that follows describes two rehabilitation efforts involving the walrus heads on the Arctic Building in Seattle, Washington. These rehabilitations are an example of an initial non-future-proof rehabilitation in the 1980s and a subsequent future-proof rehabilitation in the late 1990s. The author was not involved in these two rehabilitation projects.

THE ARCTIC BUILDING: A CASE STUDY

The 1980s rehabilitation of the walrus heads demonstrates the potential for well-intentioned rehabilitations and repairs of problems in historic buildings to create further problems and cause further damage to the building. The contribution of the successful 1990s rehabilitation of the walrus heads to preservation and future-proofing of the Arctic Building led to the successful conversion to a boutique hotel. While this particular case study addresses decorative terra cotta elements, the consequences and the application of the principles of future-proofing are relevant in all types of interventions in historic buildings wherever a cultural heritage policy document such as the Secretary of the Interior's Standards (Weeks 2000) is applied, as will be discussed later.

Background—History of the Arctic Club Building

Fig. 1. The double walrus heads at the southwest corner of the Arctic Building in Seattle, Washington. Note the highly decorative terra cotta, bright colorful palette, and the tusks that hang from the walrus heads. (Credit: Brian Rich, 2013.)

After the Alaska Club merged with the Arctic Club in 1908, the Arctic Club launched efforts to "construct a Class A fireproof building especially designed for the club" (Davis 1981, 10 2003). In 1917, A. Warren Gould, architect for the owner, pioneered the use of lightweight glazed molded terra cotta over a reinforced concrete frame to create the ornament on the exterior of the building and to resist fires like the Seattle fire of 1889. The Arctic Building was recognized as one of the finest examples of multicolored matte-glazed terra cotta in the Northwest (Figures 1, 2, and 3). It had "been well received by the public, and [had] won much commendation, which after all is the true measure of success," according to Gould in a *Pacific Builder and Engineer* article of February 23, 1917 (Davis 1981, 13; DeCoster 2010).

The Arctic Club Building remained the home of the club until 1971. From 1971 until 1988, the privately man-

Fig. 2. Aerial photo of the Arctic Building from the southwest. (Credit: City of Seattle Archives, SPU Fleets and Facilities Department. Imagebank Collection. Item No: 120399.)

Fig. 3. View of the exterior of the Arctic Building from the intersection of Third Avenue and Cherry Street. The walrus heads adorn the third floor. (Credit: Brian Rich, 2013.)

aged building was leased to the city of Seattle. In 1988, it was sold to the city of Seattle and used for city offices and public events (DeCoster 2010). Throughout this period of time, there were several interventions in the building as it was transformed fully to city office use. In 2005, a new private owner rehabilitated the building, converting it into a boutique hotel. The Arctic Club Building was listed on the Washington and National Registers of Historic Places in November 1978. The building was also designated a City of Seattle Landmark on April 4, 1985.

Intervention and Deterioration: The 1982 Walrus Tusk Intervention

Several exterior interventions were made to the Arctic Building during the 1980s and 1990s, though this case study focuses on the twenty-seven walrus heads. Though the walrus tusks are said to have been removed after the 1949 earthquake, some tusks must have remained in place until 1982 (Woodbridge, Montgomery, and

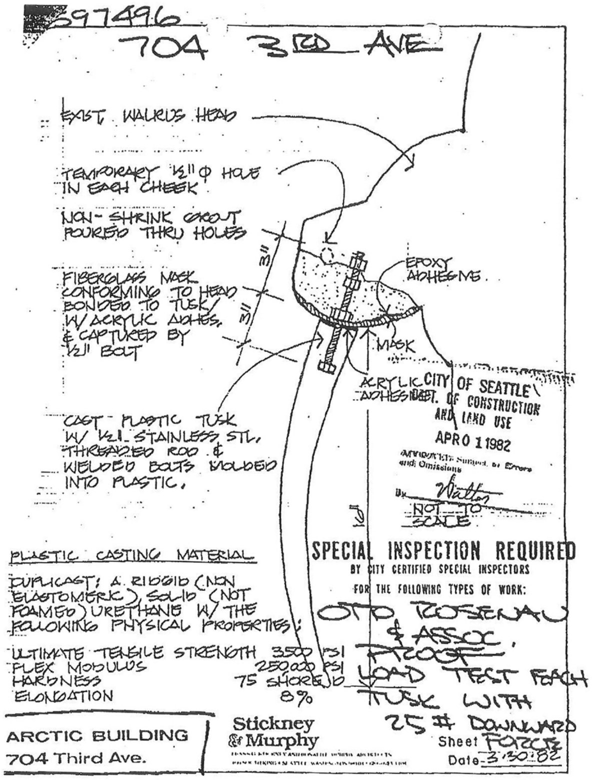

Fig. 4. Section detail of 1982 walrus tusk replacement detail by Stickney Murphy Architects. (Credit: Image courtesy of the Seattle Landmarks Preservation Board. Original detail by Stickney & Murphy Architects, 3/30/1982.)

Streatfield 1980, 123). In 1982, all of the walrus tusks were replaced by cast urethane plastic replicas. It was reported in 1996 that the original tusk failure had occurred due to "corrosion of the mild steel used to anchor the tusks into the terra cotta heads," but there are no records to corroborate this information (Morden and Slaton 1996, 2).

Details developed for the 1982 tusk restoration called for four major items to be installed (Figure 4). These items included new cast urethane plastic tusks, stainless steel threaded rods, a fiberglass mask to reconstruct the walrus face, and non-shrink grout. To anchor the new tusks, the cavities of the terra cotta walrus heads were filled with a combination of gypsum and Portland cement grout. The details called for holes on the front of the walrus snout to inject the grout. According to the 1982 design detail, the grout not only anchored the tusk, but held a fiberglass mask in place as well. The original mild steel rods supporting the

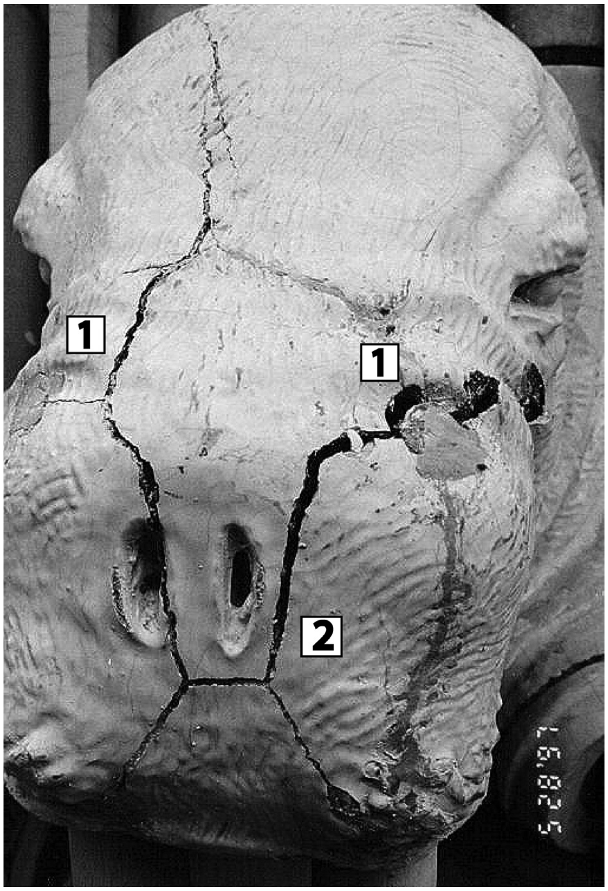

Fig. 5. Existing conditions in late 1995. Note the dark spots above the nostrils to the right and left (1). These are the holes grout was filled through. Note that they are on top of the walrus head. Also note the cracking of the snout (2). (Credit: Wiss, Janney, Elstner Associates, Inc.)

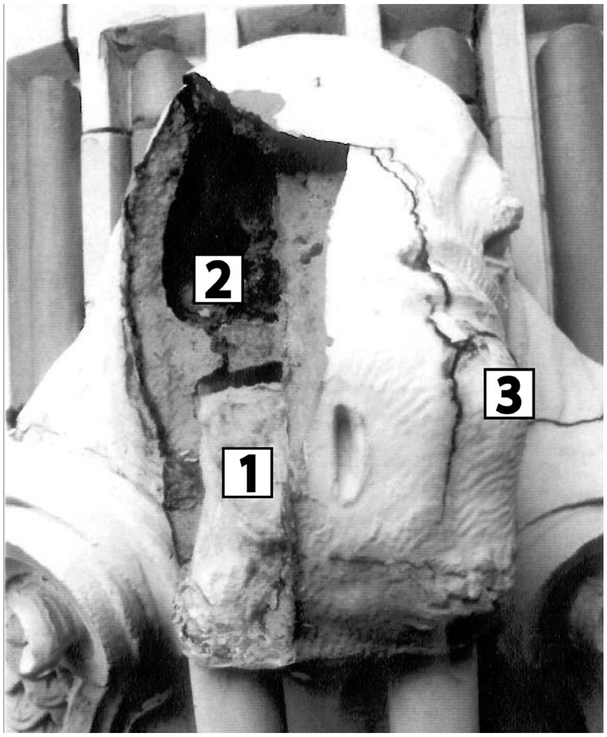

Fig. 6. 1996 inspection photo of walrus head S-1. Note the white grout sections filling the sinus cavity area of the walrus head (1). This meant there was no space left for the grout to expand into when the gypsum got wet. Note also the crack in the internal webbing (2). The damage to the internal structure of the head was so severe that this head had to be replaced. Note the cracks radiating from the dot on the top right of the walrus snout (3). This dot is the injection point for the 1982 grout installation and created a weak point in the terra cotta. (Credit: Morden & Slaton, WJE.)

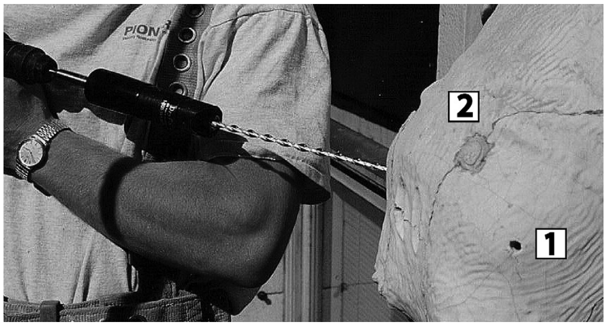

Fig. 7. 1996 walrus head rehabilitation. Note the drilled hole (1) for insertion of a helical anchor to pin sections of the walrus snout that had fractured due to expansive grout in the cavities of the terra cotta unit. The white dot (2) on top of the nostril is where the expansive grout was injected in the 1982 repair. (Credit: Wiss, Janney, Elstner Associates, Inc.)

original terra cotta tusks were removed in the 1982 restoration (Morden and Slaton 1996, 6). Within one to two years after the 1982 tusk replacement, minor repairs of new cracks observed in the walrus heads were performed.

Investigation: The 1995 Condition Survey

In late 1995, a condition survey and investigation of the walrus heads was performed by Wiss Janney Elstner (Morden and Slaton 1996). Overall, the building was determined to be in "good condition," but the walrus heads were a different story. The degradation of the walrus heads had progressed to the point where the ornamental terra cotta units were wrapped with chicken wire and duct tape to hold the pieces together until repairs could be made (Morden and Slaton 1996, 1). A field survey of the walrus heads found many modes of deterioration present. Fractures, spalling, cracks, crazing, and rust jacking (expansive corrosion of ferrous metals) were observed. The investigation discovered that the holes for the 1982 grout injection were located at the top surfaces of the walrus heads rather than on the vertical surfaces as detailed in the repair plan (Figures 5, 6, and 7). The 1995 investigations also discovered that the fiberglass masks had not been installed (Morden 2013).

On-site observations of the locations of the cracks in the walrus heads provided important clues about the deterioration. The cracks were located around the grout injection holes and the voids in the terra cotta where the grout had been injected (Morden 2013; Morden and Slaton 1996, 6).

Analysis—Causes of Deterioration

There are several potential deterioration mechanisms in glazed terra cotta cladding systems. These include crazing of the glazed face of the terra cotta; spalling; deterioration of the anchors or mortar; and unrelieved stresses due to settlement, movement, or rust jacking (Tiller 2004, 67-69). Many of these were observed in the 1996 investigation and repaired in the subsequent rehabilitation work. Although several of these factors contributed to the deterioration of the walrus heads and tusks, the key causes of the deterioration were (1) the original mild steel anchor rods for the tusks, (2) the grout injection hole location for the 1982 rehabilitation, and (3) the gypsum-Portland cement grout that was used in the 1982 tusk replacement.

In the 1982 tusk replacement, stainless steel anchors were used for the new tusk anchors to avoid rust jacking. The force of rust jacking can split stone and other masonry materials over time (Tiller 2004, 68). Because stainless steel anchors were used, rust jacking was precluded as the cause of the cracking of the walrus heads.

The location of the grout injection holes is a likely contributor to the deterioration of the walrus heads. Water likely penetrated the terra cotta units and the grout infill within the walrus heads through the grout injection holes in addition to existing mortar joints, cracks, and spalls in the glazing (Morden and Slaton 1996, 6). The location of the grout injection holes may have made this water infiltration worse because they were located on top of the walrus heads. In addition, however, the hole location also allowed the grout to fill the entire terra cotta cavity, leaving the grout no place to expand.

Gypsum and Portland cement are usually used together to combine the benefits of the rapid hardening of gypsum with the long-term strength and durability of Portland cement. Typically, gypsum quantities in such grout mixes are strictly limited by ASTM C150 to balance gypsum expansion and shrinkage of the grout during curing (Hime 1993). Conditions where there is excessive gypsum can lead to sulfate attack. Sulfate attack is the chemical reaction of gypsum to water, resulting in ettringite. Delayed ettringite formation (months or years after initial curing) causes heterogenous expansion (equal in all directions) and pressure on the surrounding terra cotta, resulting in cracking or spalling of the terra cotta (Collepardi 2001, 1-2). Eventually the chemical reaction between the gypsum and water would convert all of the gypsum to sulfate compounds and stop, but it is impossible to tell when that process would be complete (Morden 2013; Morden and Slaton 1996, 6).

Material samples of the grout that held the walrus tusks were taken and confirmed a high percentage of gypsum in the grout. A material analysis found that the grout consisted of 32 percent deleterious sulfate compounds. These compounds were in the form of gypsum (calcium sulfate hydrate) and ettringite (calcium sulfoaluminate hydrate) (Backus 1996). In this instance, because of the full cavities, there was no place to relieve the pressure from the ettringite formation.

Repair and Restoration: The 1996 Walrus Head and Tusk Intervention

The initial 1996 restoration plans included replicating ten walrus heads in terra cotta to match the originals where structural integrity was completely compromised

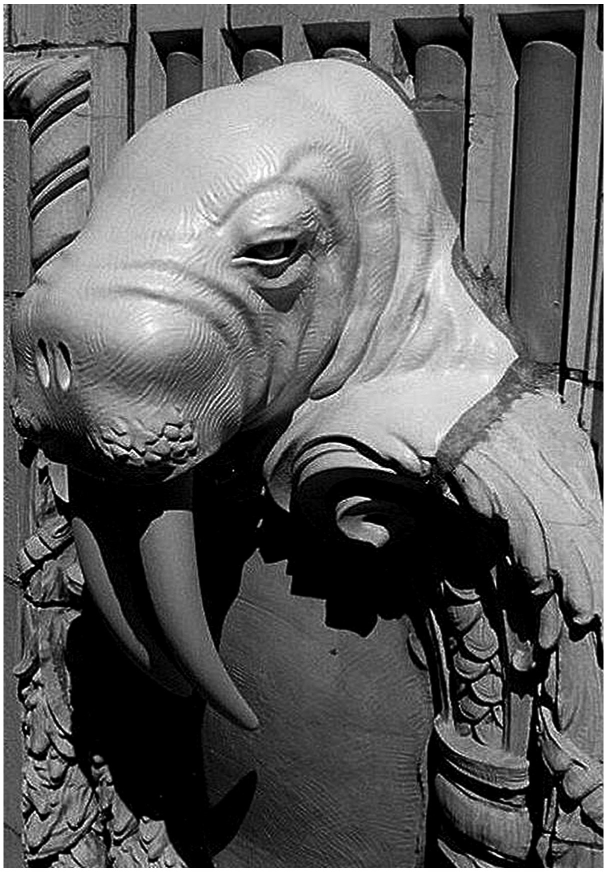

Fig. 8. 1996 replica walrus head. The joints between terra cotta pieces are filled with mortar after the epoxy sets around the threaded rod anchors. (Credit: Wiss, Janney, Elstner Associates, Inc.)

and replacement pieces were recommended. A total of twelve walrus heads were replaced after two were later found to be too severely damaged to be repaired. Alternative materials for replication were considered, but since the cost was approximately the same, terra cotta was preferred in accordance with the Secretary of the Interior's Standards for Rehabilitation (Morden 2013). All of the urethane tusks had been salvaged and were reinstalled in the new heads by bolting them through the new terra cotta. No grout was used to install the tusks (Morden 2013).

A variety of repairs were planned for the remaining fifteen of the twenty-seven walrus heads. Where structural integrity was believed to be acceptable, the walrus heads were repaired. Additional helical anchors were provided for seven walrus heads where sections of terra cotta were beginning to delaminate. Where possible, cracks were cut out to a width and depth suitable for grout infill (Figure 8). The 1982 gypsum-Portland cement grout was removed to the extent possible (Morden 2013). Repairs of the other modes of deterioration were also performed.

Current Condition of the Walrus Heads

The condition of the walrus heads has been monitored in multiple ways since the 1996 rehabilitation in order to ascertain whether there has been any further deterioration of the remaining walrus heads. Follow-up review of the walrus heads has been performed by Wiss, Janney, Elstner as well as by the building maintenance personnel through the late 1990s and no additional issues were observed (Morden 2013).

The 2005 Certificate of Approval application for rehabilitation of the Arctic Building as a boutique hotel does not note that any work on the terra cotta facade would be required other than cleaning (Day 2005). The terra cotta facade elements are noted as being "intact and in fair to good condition" (Day 2005). However, it is reported that minor repairs have been undertaken to the terra cotta focusing primarily on stabilization of the parapets. No further rehabilitation of the walrus heads was required at the time of the rehabilitation according to the architects (Weaver 2013). Photos of the current conditions taken in November 2013 by me were reviewed and discussed with Mark Morden during a 2013 interview regarding the project due to concerns about further deterioration. Based on the limited information in the photographs, Morden concluded that there had been no further deterioration (Morden 2013).

Case Study Conclusions

The case study of the interventions on the walrus heads at the Arctic Building is an example of two repairs, one of which in 1982 caused further damage to the historic building, and a second one in 1996 that resolved all of the issues in the original walrus head design as well as the 1982 restoration.

It is difficult if not impossible to be certain that any design, original or an intervention in an existing building, will be a long-term solution. The two rehabilitations of the walrus heads, while chronologically close to each other and addressing the same portion of the Arctic Building, raise questions about how we can know that our designs are going to endure. What can we learn from these two interventions? How can we improve our rehabilitation process and prevent ourselves from unwittingly incorporating flaws in our designs? How can we make our designs more reliably successful?

These interventions serve as an example of how the concepts of future-proofing and resiliency could have supported the rehabilitation process. Consideration of the concepts of future-proofing and resiliency in both the AEC and other industries led to the development of a set of principles of future-proofing that may be used as a tool or rubric in support of the rehabilitation process when working with historic buildings. In the instance of the walrus head rehabilitations, we can retrospectively apply the principles of future-proofing to demonstrate how they would have affected the 1982 rehabilitation and how the 1996 rehabilitation is future-proof.

SUPPORTING THE REHABILITATION PROCESS—THE PRINCIPLES IN ACTION

How do the principles of future-proofing help to solve the problem of the interventions in the Arctic Building? Was the Arctic Building a future-proof building even before the interventions? Consideration of the principles of future-proofing help to prevent the problems of the Arctic Building by preventing the inclusion of flaws in the design in the first place. This may be demonstrated through the application of the principles to each of the designs.

There is an argument to be made that the Arctic Building, as a whole, is a future-proof building. The existing glazed terra cotta shell of the building can last for centuries if it is well maintained. Terra cotta is a durable material that endures the moderate Pacific Northwest weather well. The flaws in early twentieth-century terra cotta building systems are well known today and can be overcome with thoughtful consideration (principle 1). The building is also easily understood as an historic building in its exterior appearance and significant interior spaces that have been renovated and converted to new uses over time. These uses included the original Arctic Club headquarters, with leasable spaces for their tenants, adaptive reuse as offices and public event spaces for the city of Seattle, and adaptive reuse as a boutique hotel. Attitudes toward this building have been clearly flexible in finding ways to accommodate different uses and tenants (principles 2 and 3).

The Arctic Building continues to demonstrate its future-proof nature through adaptation to the new uses without losing its historic character, even including additional floors being added to the building (principle 3). With careful rehabilitations, the building's service life has been extended into the foreseeable future (principle 4). The building has been fortified against the most significant danger in Seattle, earthquakes, through a complete seismic retrofit. The most recent rehabilitation takes advantage of sustainable features such as the high level of daylight exposure of the rooms and the operable windows. This will support the building through environmental changes (principles 5 and 6).

With the complete rehabilitation in 2005, all of the building systems have a reduced potential for physical, functional, and aesthetic obsolescence. The exterior shell of the building has been rehabilitated, including the walrus heads, and the interior has also been rehabilitated for ongoing use, preventing physical obsolescence. The multiple uses of the building over its history demonstrate that the building is unlikely to be functionally obsolete. While aesthetics are in the eye of the beholder, it is clear that the Arctic Building holds broad appeal since that is one of the bases of its designation as a landmark (principle 7).

The lifecycle benefits of retaining a masonry and steel structure are clear. Significant resources were used to create the building. The Arctic Building's rehabilitation has contributed to the local economy through jobs completing the rehabilitation and by revitalizing a portion of downtown Seattle and bringing more jobs and more tourism to the area (principle 8). While the Arctic Building's materials are most likely not locally manufactured, and the building may not be considered future-proof in this way, many rehabilitation materials are local and certainly the labor to perform the rehabilitations was local (principle 9). Last, it is clear that the cultural heritage policy documents relevant to this building have been followed as a consequence of its designation as a landmark and the stewardship of its owners and architects (principle 10).

Another valid question is whether the rehabilitation of the walrus heads was future-proof. Arguably, the 1982 rehabilitation was not, but the 1996 rehabilitation is future-proof. At the time of the design of the Arctic Building, it would have been well known through observation that ferrous metals expand as they corrode. How then would the application of the principles of future-proofing have prevented this problem? Starting with principle 1, if one is aware that ferrous metals deteriorate in an expansive manner and that terra cotta is brittle, one might not believe it appropriate to combine the two materials. Designers combining steel and terra cotta likely would have considered their designs to meet principle 5 as well, believing that the terra cotta cladding protected the ferrous metals from corrosion, especially where glazed terra cotta is used. This exposes one of the challenges of future-proofing and design in general: that we design to the best of our ability. It also underscores the importance of flexibility and adaptability, durability and redundancy. The simultaneous consideration of principles 1 and 8 may arrive at the conclusion that ferrous metals and terra cotta should not be combined. By considering both the concepts of preventing deterioration and long-term lifecycles for buildings at the same time, one may choose to take a different design path.

Similar principle-based considerations may be made for the use of the gypsum grout in the 1982 repairs, though the time scale is much smaller since the properties of gypsum were being published in the late 1970s and the repairs were completed in the early 1980s. Certainly a better understanding of the chemical reaction of gypsum and water and the use of lower quantities of gypsum in the grout mixture would have made the 1982 rehabilitation more future-proof. If one were to bear in mind the principles of preventing deterioration, extending the service life, and increasing durability, the problem of the expansive nature of the ettringite formation could have been avoided.

Closely related to the grout mixture is the amount of grout injected into the walrus heads. Thoughtful consideration of the same principles would have led a contractor to understand that completely filling the terra cotta cavities and giving the gypsum-Portland cement grout no place to expand into was not advisable. Similarly, an understanding of the nature of ettringite formation by the contractor would have led the contractor to place the holes in a less exposed location. The holes may have also been filled with a different material to prevent water infiltration.

Regardless of the nature of the 1982 rehabilitation of the walrus heads, what is clear is that the future-proof rehabilitation in 1996 led to preservation of the Arctic Building and its continued viability. In 2005, a new owner rehabilitated the building, converting it into a boutique hotel, giving it a new lease on life and an ongoing role in the heart of Seattle.

CONCLUSION

One may take issue with the term “future-proofing” when it is applied to the historic preservation field. However, the concepts of future-proofing and resiliency as embodied in other industries are applicable to the AEC industry as well. Whether conceived as future-proofing or as a wider understanding of resiliency, the concepts advocated here are focused on the long-term endurance of our built environment and reducing material consumption in a resource-limited world.

At the time of the 1982 interventions in the Arctic Building walrus tusks, it may not have been possible to consider the design through the lens of the principles of future-proofing. The 1982 rehabilitation serves as an example of a non-future-proof intervention in an historic building. There are three major points to examine in the consideration of the future-proof nature of the repairs to the walrus heads, including the original design of the terra cotta tusks, the gypsum grout used in the 1982 repairs, and the location of the grout injection holes.

Ideally, future-proof designs incorporate all of the principles discussed above. Realistically, however, future-proof designs may never accommodate all of the proposed principles. Rather, they may be very strong in some principles and less so in others. The nature of a design, the circumstances of its creation, and the preferences of the designer will likely determine the ways in which a project is future-proof.

The potential for future deterioration raises a question not addressed here about long service life for buildings. What exactly is meant by a building’s long service life? Is it one hundred years? Two hundred? Four hundred? More? For many, twenty to thirty years seems quite reasonable. Regardless of the threshold, buildings will deteriorate over time. Perhaps an appropriate perspective is that we should not cause the premature deterioration of our built environment through insensitive interventions in existing structures.

Architects and preservationists generally understand and accept that no project is going to be perfect. Our designs are limited by the knowledge we possess and consider at the time of design. One does not have the ability or time to understand in minute detail all the aspects of a building material that is proposed in our designs. Perhaps by keeping the principles of future-proofing and resiliency in mind, we can do better.

BRIAN RICH, AIA, LEED BD+C, CCCA, PMP, is principal of Richaven, PLLC, a full-service architectural consulting firm specializing in historic preservation projects, with an applied focus on the latest technical and sustainable strategies to projects of all types. Rich serves as president of the board of trustees for the Northwest Chapter of Association for Preservation Technology International and on the Washington State Heritage Barn Advisory Committee. In the past Rich has served as chair of the King County Landmarks Commission and as chair of the King County Landmarks Commission’s Design Review Committee as well as 4 Culture’s Historic Preservation Advisory Committee and American Institute of Architects, Seattle Chapter Historic Resources Committee.

REFERENCES

Appelbaum, Barbara. 2007. *Conservation Treatment Methodology*. Amsterdam: Elsevier Ltd.

Applegath, Craig, et al. 2010. *Resilient Design Principles and Building Design Principles.* Retrieved March 10, 2014, from www.ResilientCity.org.

Backus, Lisa A. 1996. *Grout Studies for Martin Smith, Inc.*, January 31. Wiss, Janney, Elstner, Inc.

Barreneche, Raul A. 1995. "Wiring Buildings for the Future." *Architecture*, 84 (4): 123-29.

Bernstein, Fred A. 2012. "It Happened Here: Hurricane Sandy's Impact." *Architectural Record*, 200 (12): 19.

Blanco-Lion, Cristina, Sofie Pelsmakers, and Melissa Taylor. 2011. "Sustainable Solution for the Reconstruction of Low Income Housing in Post-Disaster Zones." Paper presented at the 27th International Conference on Passive and Low Energy Architecture: Architecture and Sustainable Development, PLEA 2011, July 13-15, Louvain-la-Neuve, Belgium.

Bloomer, Dan, and Phillipa Page. 2012. *Hawke's Bay Water Demand 2050: A Report for Hawke's Bay Regional Council.* Page Bloomer Associates Ltd.

Board, Landmarks Preservation. 1987. *Rules and Regulations, Code of Ethics, and Procedures.* Vol. Seattle Municipal Code Section 25.12.

Brandi, Cesare. 1996a. "Theory of Restoration I." In *Historical and Philosophical Issues in the Conservation of Cultural Heritage,* edited by Nicholas Stanley-Price, Mansfield Kirby Talley, and Alessandra Melucco Vaccaro. Los Angeles: Getty Conservation Institute.

Brandi, Cesare. 1996b. "Theory of Restoration II." In *Historical and Philosophical Issues in the Conservation of Cultural Heritage,* edited by Nicholas Stanley-Price, Mansfield Kirby Talley, and Alessandra Melucco Vaccaro. Los Angeles: Getty Conservation Institute.

Burman, P. 1997. "Ethical Considerations in Selection of Conservation Treatments." In *Saving Our Architectural Heritage: The Conservation of Historic Stone Structures: Report of the Dahlem Workshop on Saving Our Architectural Heritage—the Conservation of Stone Structures, Berlin, March 3-8, 1996,* edited by Norbert S. Baer and Rolf Snethlage. New York: John Wiley & Sons.

Carthey, J., et al. 2011. "Flexibility: Beyond the Buzzword—Practical Findings from a Systematic Literature Review." *Health Environments Research and Design Journal*, 4 (4): 89-108.

Caroon, Jean. 2011. "Conservation Writ Large: A Discussion about Sustainability and Heritage." *Conservation Perspectives*, 26 (1): 18-23.

Cassar, May. 2008. "Adapting to a Changing Climate: Threats and Opportunities: The Historic Environment and Climate Change." *Conservation Bulletin, A Bulletin of the Historic Environment*, 57: 7-11.

Cassar, May. 2009. "Sustainable Heritage: Challenges and Strategies for the Twenty-First Century." *APT Bulletin*, 40 (1): 3-11.

Cassar, May. 2011. "Impact of Climate Change on Cultural Heritage: From International Policy to Action. Conservation Perspectives." *The GCI Newsletter*, 26 (1): 10-11.

CMS. 2012. *What is Future-Proof Building?* Construction Marketing Services Limited. Retrieved November 18, 2013, from http://www.fpb.co.nz/what-is-future-proof-building/.

Collepardi, M. 2001. "Ettringite Formation and Sulfate Attack on Concrete." In *Fifth CANMET/ACI International Symposium on Recent Advances in Concrete Technology*, 21-38.

Dam, John. 2011. "Improving Hygrothermal Performance of a Historic Building in British Columbia." *APT Bulletin*, 42 (4): 47-52.

Davis, Deb. 1981. *The Alaska & Arctic Buildings.* Ed. Cherry Street Properties, Ltd. and Foster & Marshall Realty Inc. Seattle: Frank Potter & Associates.

Day, Stephen J. 2005. *Certificate of Approval Application: Rehabilitation Plans for the Arctic Club Building*. Seattle, WA: Arctic Club Hotel LLC.

DeCoster, Dotty. 2010. *Arctic Building (Seattle). Historylink.Org Essay 9462*, October 21. Retrieved November 10, 2013, from http://www.historylink.org/index.cfm?DisplayPage=output.cfm&file_id=9462.

Erder, Cevat. 1977. *The Venice Charter Under Review.* Last modified November 10, 2011. Retrieved March 11, 2014, from http://www.international.icomos.org/venicecharter2004/erder.pdf.

Fehrenbacher, Jill. 2014. *Resilient Design: Is Resilience the New Sustainability?* May 11. http://inhabitat.com/resilient-design-is-resilience-the-new-sustainability/.

Feilden, B. 2003. *Conservation of Historic Buildings*. 3rd ed. Oxford: Architectural Press.

Fitch, James Marston. 1990. *Historic Preservation: Curatorial Management of the Built World*. Charlottesville: University Press of Virginia.

Gajrani, Kiran, Krishan Gopal Sharma, and Annapurna Bhargava. 2013. "Resiliency in Offshore Wind Farm Communication Networks." *Journal of Renewable & Sustainable Energy*, 5.

Gamache, Shawna. 2008. "Arctic Club Hotel: A Remodel Rich with Northwest History." *Seattle Daily Journal of Commerce*, June 20 .

Georgiadou, M. C., T. Hacking, and P. Guthrie. 2013. "Future-Proofed Energy Design for Dwellings: Case Studies from England and Application to the Code for Sustainable Homes." *Building Services Engineering Research and Technology*, 34 (1): 9-22.

Godfrey, Patrick, Jitendra Agarwal, and Priyan Dias. 2010. *Systems 2030 —Emergent Themes, Civil Engineering and Environmental System*, 27 (3): 177-187.

Hime, William G. 1993. "Gypsum: Not for Moist Environments." *The Construction Specifier.* July. Opinion Section. 46 (7): 41-42.

Hoggart, S. P. G., M. E. Hanley, D. J. Parker, D. J. Simmonds, D. T. Bilton, M. Filipova-Marinova, E. L. Franklin, I. Kotsev, E. C. Penning-Rowsell, S. D. Rundle, E. Trifonova, S. Vergiev, A. C. White, and R. C. Thompson. 2014. "The Consequences of Doing Nothing: The Effects of Seawater Flooding on Coastal Zones." *Coastal Engineering*, 87: 169-82.

Holland, Mark. 2012. “Conserving the Future: The Need for Sustainability in City Planning and Preservation.” *APT Bulletin*, 43 (1): 3-6.
ICOMOS, International Council on Monuments and Sites. 1964. *The International Charter for the Conservation and Restoration of Monuments and Sites (The Venice Charter 1964)*, United Nations World Heritage Convention, http://www.international.icomos.org/charters/venice_e.pdf.

Kerfahi, Dorsaf, Jason Hall-Spencer, Binu Tripathi, Marco Milazzo, Junghoon Lee, and Jonathan Adams. 2014. “Shallow Water Marine Sediment Bacterial Community Shifts Along a Natural CO Gradient in the Mediterranean Sea Off Vulcano, Italy.” *Microbial Ecology*, 67 (4): 819-28.

Kerr, Joseph Robert. 2011. “Future-Proof Design: Must All Good Things Come to an End?” Master’s thesis, University of Calgary.

Kreisman, Lawrence. 1999. *Made to Last: Historic Preservation in Seattle and King County.* Seattle: Historic Seattle Preservation Foundation in association with the University of Washington Press.

Lawson, Bryan. 1997. “Future Proof: The MAFF Laboratories at York.” *Architecture Today*, 82: 26-32.

Lesak, John D. 2005. “APT and Sustainability: The Halifax Symposium.” *APT Bulletin*, 36 (4): 3-4.

Mitchell, Bob, Pioneer Masonry Restoration Company, Inc. 2013. *Discussion of the Arctic Building Walrus Head and Tusk Repairs*, November 21. Ed. Brian Rich..

Morden, Mark, Wiss, Janney, Elstner Associates, Inc. 2013. *Discussions on the Arctic Building Walrus Head and Tusk Repairs*, November 25. Ed. Brian Rich.

Morden, Mark, and Deborah Slaton. 1996. *Terra Cotta Condition Survey & Investigation of the Walrus Heads, Arctic Building, Seattle, Washington*. Seattle, WA: Wiss, Janney, Elstner Associates, Inc.

Morris, William. 1996. “Manifesto of the Society for the Protection of Ancient Buildings.” In *Historical and Philosophical Issues in the Conservation of Cultural Heritage*, edited by Nicholas Stanley-Price, Mansfield Kirby Talley, and Alessandra Melucco Vaccaro. Los Angeles: Getty Conservation Institute.

Muñoz Viñas, Salvador. 2005. *Contemporary Theory of Conservation*. Burlington, MA: Elsevier Butterworth-Heinemann.

Ochsner, Jeffrey K. 1994. *Shaping Seattle Architecture: A Historical Guide to the Architects.* Seattle: University of Washington Press in association with the American Institute of Architects Seattle Chapter and the Seattle Architectural Foundation.

Philippot, Paul. 1996a. “Historic Preservation: Philosophy, Criteria, Guidelines I.” In *Historical and Philosophical Issues in the Conservation of Cultural Heritage*, edited by Nicholas Stanley-Price, Mansfield Kirby Talley, and Alessandra Melucco Vaccaro. Los Angeles: Getty Conservation Institute.

Philippot, Paul. 1996b. “Historic Preservation: Philosophy, Criteria, Guidelines II.” In *Historical and Philosophical Issues in the Conservation of Cultural Heritage*, edited by Nicholas Stanley-Price, Mansfield Kirby Talley, and Alessandra Melucco Vaccaro. Los Angeles: Getty Conservation Institute.

Philippot, Paul. 1996c. “Restoration from the Perspective of the Humanities.” In *Historical and Philosophical Issues in the Conservation of Cultural Heritage*, edited by Nicholas Stanley-Price, Mansfield Kirby Talley, and Alessandra Melucco Vaccaro. Los Angeles: Getty Conservation Institute.

Rankin, Nancy. 2014. *Forthcoming APT Bulletin Special Issue.* Ed. Brian Rich.

Reed, Richard, and Georgia Warren-Myers. 2012. “Is Sustainability the 4th Form of Obsolescence?” Paper presented at PRRES 2010: Proceedings of the Pacific Rim Real Estate Society 16th Annual Conference.

Reigl, Alois. 1996. “The Modern Cult of Monuments: Its Essence and Its Development.” In *Historical and Philosophical Issues in the Conservation of Cultural Heritage*, edited by Nicholas Stanley-Price, Mansfield Kirby Talley, and Alessandra Melucco Vaccaro. Los Angeles: Getty Conservation Institute.

Resilient Design Institute. 2013. The Resilient Design Principles. Retrieved May 20, 2014, from http://www.resilientdesign.org/the-resilient-design-principles/.

Ruskin, John. 1996. “The Lamp of Memory II.” In *Historical and Philosophical Issues in the Conservation of Cultural Heritage*, edited by Nicholas Stanley-Price, Mansfield Kirby Talley, and Alessandra Melucco Vaccaro. Los Angeles: Getty Conservation Institute.

Sanchez, Ray. 2014. “A Year after Boston Marathon Attacks, Survivors are Defiant and Resilient.” April 21 *CNN News*. http://www.cnn.com/interactive/2014/04/us/boston-marathon-victims/.

Schewenius, Maria, Timon McPhearson, and Thomas Elmqvist. 2014. “Opportunities for Increasing Resilience and Sustainability of Urban Social-Ecological Systems: Insights from the URBES and the Cities and Biodiversity Outlook Projects.” *AMBIO—A Journal of the Human Environment,* 43 (4): 434-44.

Shi, Qingchuan, and Omer Khan. 2013. “Toward Holistic Soft-Error-Resilient Shared-Memory Multicores.” *Computer*, 46 (10): 56-64.

Thomas, C., M. A. Bickerstaff, L. M. Davis, T. Prokop, B. Widdup, G. Y. Zhou, D. Garrett, and C. Nicol. 2003. “Integrated Circuits for Channel Coding in 3G Cellular Mobile Wireless Ssystems.” *IEEE Communications Magazine*, 41 (8): 150-59.

Thornbush, M., O. Golubchikov, and S. Bouzarovski. 2013. “Sustainable cities targeted by combined mitigation-adaptation efforts for future-proofing.” *Sustainable Cities and Society* 9:1-9.

Tiller, de Teel Patterson. 2004. *The Preservation of Historic Glazed Architectural Terra-Cotta. The Preservation of Historic Architecture: The U.S. Government’s Official Guidelines for Preserving Historic Homes.* Ed. U.S. Office of Archeology and Historic Preservation, Technical Preservation Services Division. Guilford, CT: Lyons Press.

Time. 2014. *Boston Is Ready to Run Again: Stories of Resilience One Year Later. Time Magazine*.

Tompkins, Larry, Pioneer Masonry Restoration Company, Inc. 2013. *Discussion of the Arctic Building Walrus Head and Tusk Repairs*, November 25. Ed. Brian Rich.

Tyler, Ilene, and Ann Dilcher. 2010. “Sustainable Heritage Conservation: Pere Marquette Railroad Depot in Michigan.” *APT Bulletin*, 41 (1): 21-26.

UNESCO. 2007. *Report #22: Climate Change and World Heritage: Report on predicting and managing the impacts of climate change on World Heritage and Strategy to assist States Parties to implement appropriate management responses*. Ed. UNESCO, *World Heritage Reports*. Paris: UNESCO World Heritage Centre.

Van de Wetering, Ernst. 1996. "The Autonomy of Restoration: Ethical Considerations in Relation to Artistic Concepts." In *Historical and Philosophical Issues in the Conservation of Cultural Heritage*, edited by Nicholas Stanley-Price, Mansfield Kirby Talley, and Alessandra Melucco Vaccaro,. Los Angeles: Getty Conservation Institute.

Viollet-le-Duc, Eugene-Emmanuel. 1996. "Restoration." In *Historical and Philosophical Issues in the Conservation of Cultural Heritage*, edited by Nicholas Stanley-Price, Mansfield Kirby Talley, and Alessandra Melucco Vaccaro. Los Angeles: Getty Conservation Institute.

Wang, Jue, Fang Lee Cooke, and Wenhui Huang. 2014. "How Resilient is the (Future) Workforce in China? A Study of the Banking Sector and Implications for Human Resource Development." *Asia Pacific Journal of Human Resources*, 52 (2): 132-54.

Weaver, Hank. 2013. *Discussion of the 2005 Rehabilitation of the Arctic Building*, November 5. Ed. Brian Rich.

Weeks, Kay. 2000. "The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines on Preserving, Rehabilitating, Restoring and Reconstructing Historic Buildings." National Park Service, U.S. Department of the Interior, Technical Preservation Services, last modified September 18, 2000. Retrieved March 12, 2014, from http://www.nps.gov/hps/tps/standguide/.

Woodbridge, Sally B., Roger Montgomery, and David C. Streatfield. 1980. *A Guide to Architecture in Washington State: An Environmental Perspective.* Seattle: University of Washington Press.