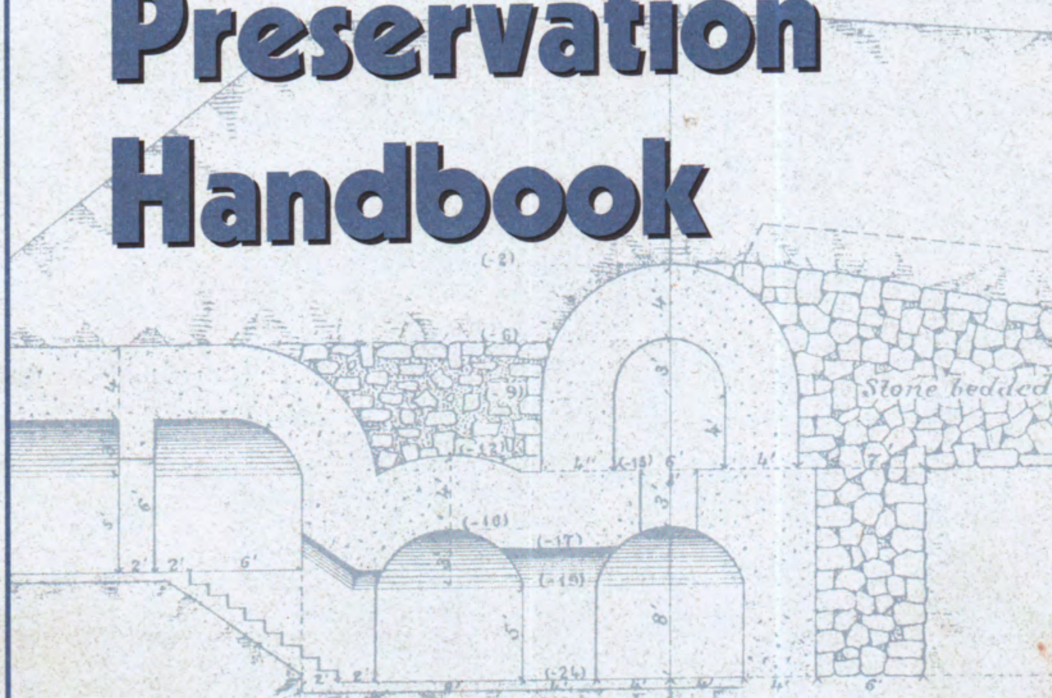
Historic Fortification Preservation Handbook



Prepared by

Pacific Northwest Preservation Partnership

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National Park Service
University of Oregon
Washington State Parks and Recreation Commission

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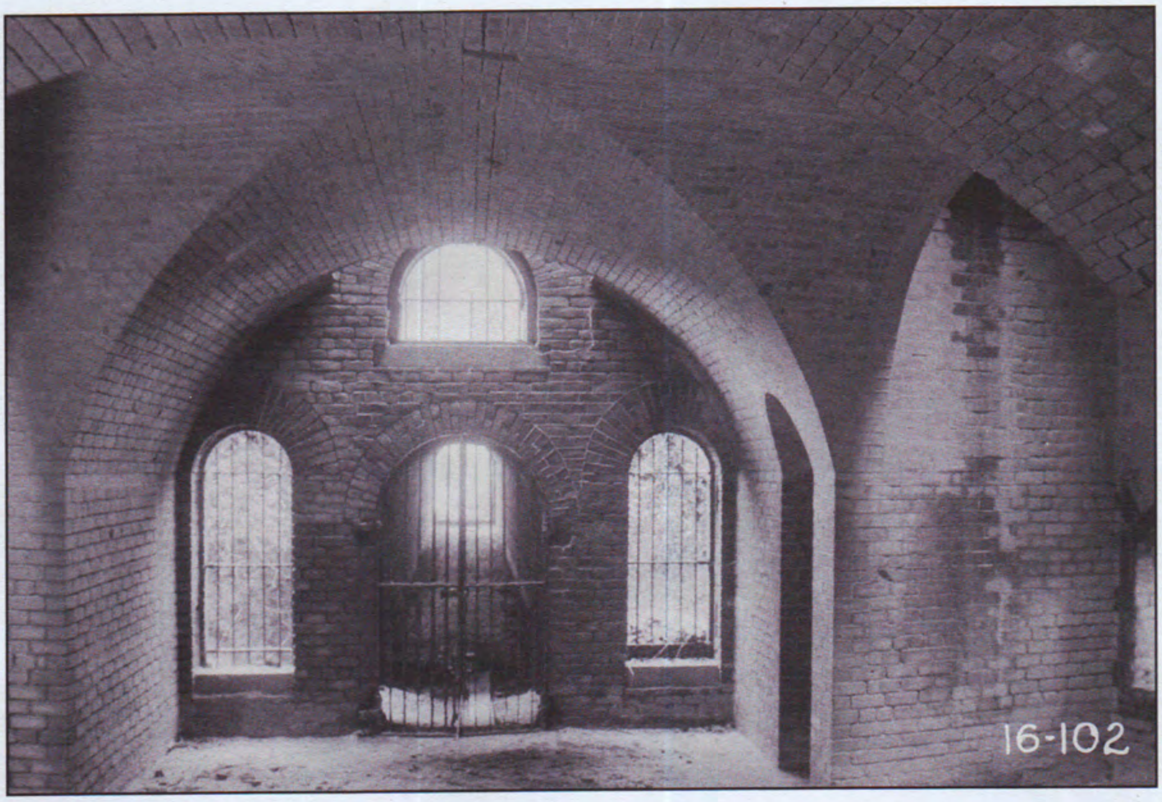
Facing Page:
Photo: Bastion interior at Fort Gaines, Alabama. Source: Library of Congress, Historic American Buildings Survey. Photographer: W.N. Manning, 1934.



"But every manmade structure, no matter how mundane, has a little bit of cathedral in it, since man cannot help but transform himself as soon as he begins to design and construct."

– ***The Existential Pleasures of Engineering*****, by Samuel C. Florman**

Acknowledgments

Two people created the conditions that made the *Historic Fortification Preservation Handbook* possible. Larry Fairleigh, Assistant Director for Resources Development, Washington State Parks and Recreation Commission, was an early and enthusiastic supporter, and assigned people and money to the job. Hank Florence, Historical Architect in the Columbia Cascades Support Office of the National Park Service, helped secure a Challenge Cost Share Grant, and provided continuing advice and helpful contacts.

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With any product whose origin lies in many sources, doubtless there are errors here, despite our best efforts to do away with them. As for those bad dates, questionable interpretations, odd allusions, and things that are just plain wrong, the responsibility is mine.

David M. Hansen
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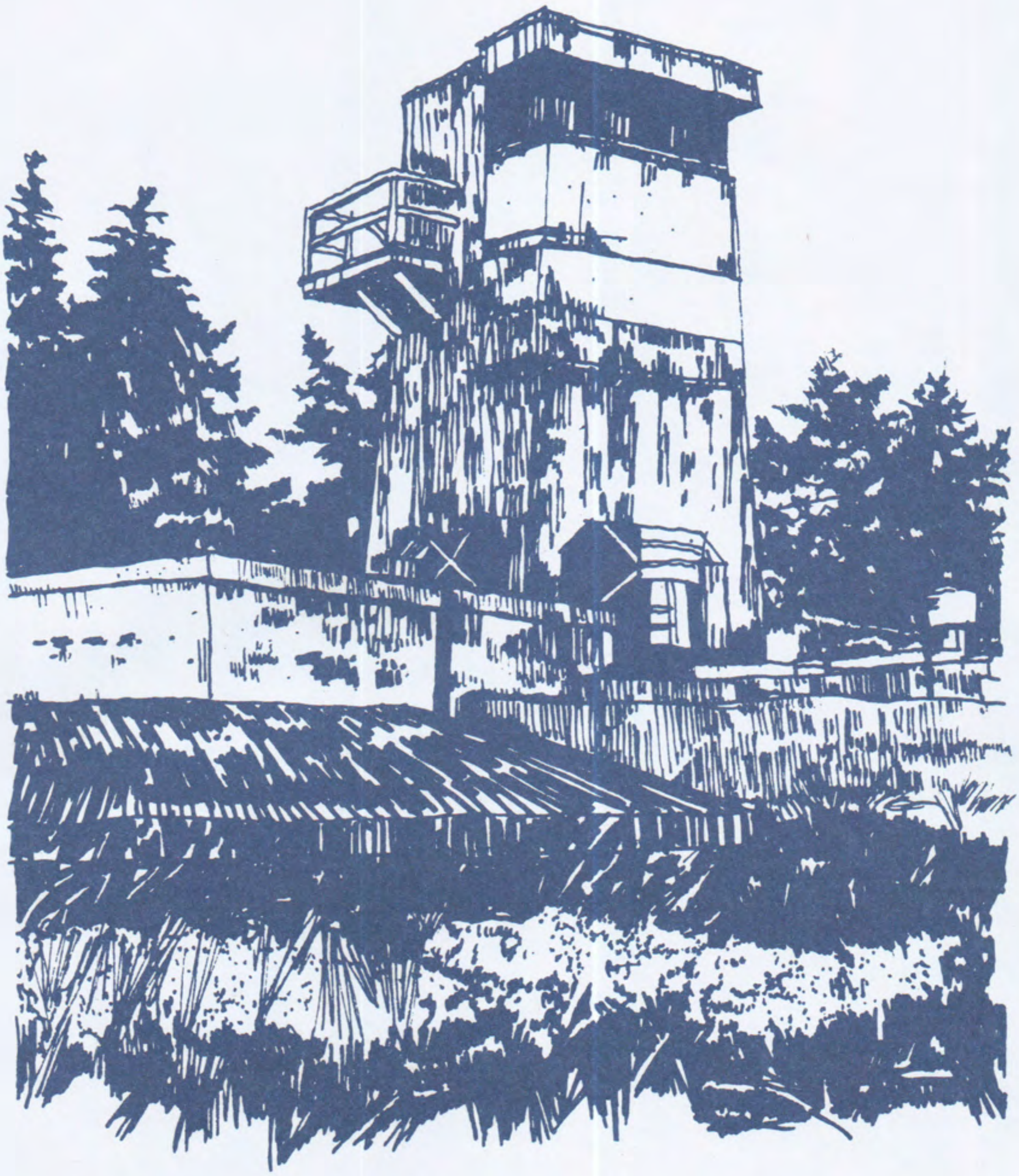
Part One: Introduction



A World-Wide Resource

Whether composed of earth, stone, brick, or concrete, fortifications built to protect a nation or a people from assault appear on every temperate continent. Interest in them is equally widespread, and growing as a result of heritage tourism and an expansion of appreciation for the recent past. The World Heritage List, for example, maintained by the International Council on Monuments and Sites includes a great variety of fortifications. Some of them are familiar, such as the Great Wall in China, or Hadrian's Wall in England. Others are less so since World Heritage properties extend the lineage of fortifications back to the Iron Age as well as forward into the modern era (the late 19th and early 20th century defenses of Amsterdam, and the 17th to 20th century military engineering at St. George in Bermuda).[1]

Globally, fortifications are part of our tradition of design and building.

National programs of designation also include fortifications in their listings, and perhaps because of such recognition, there are frequent indications that people want to do something with them. Recent examples include the International Conference on the Preservation and Use of Historic Citadels (Berlin), the International Roundtable of Mayors of Fortress Cities (Suwon, Korea), Defense of Britain Project Seminars (York, England), the opening of the Museum of Coastal Defense (Hong Kong, with the occasion marked by the issuance of a celebratory postage stamp), colloquia on military engineers in France and Poland, not to mention the activities of enthusiast organizations whose members often form the core of local preservation and interpretation efforts.[2] Interest in the preservation of fortifications in the United States is thus but one expression of an awakening recognition globally that these structures are part of our tradition of design and building. It is happening none too soon. Lack of maintenance and repair can do what attacking armies and navies could not, and in some regions, the assaults of the climate steadily undermine the work of the best builders.

More than anything else, our willingness to see fortifications as worthy of preservation (to the extent that we are able to have that vision) is based on a growing embrace of the recent past as having cultural merit. As is explained in Part Two, the inclusion of fortifications is not always accepted. That is true perhaps in part because the most numerous examples of fortifications in the United States are the coastal works of the late 19th century through World War II. They are the mute evidence of a time of global conflict, an age of extremes that has been characterized as the as the most terrible in western history. Many of the coastal defenses of the United States that constitute the subject of this publication are part of that age, although they are disassociated from the battles that reduced many of their counterparts in other countries to unrecognizable rubble at a cost of thousands of lives. They do, however, help us understand our place in the century just past, and in that respect they can play a valuable part in education. No law requires their preservation. Our own sense of history, and our own under-

[1] *ICOMOS News* 10 (December 2000): 31.

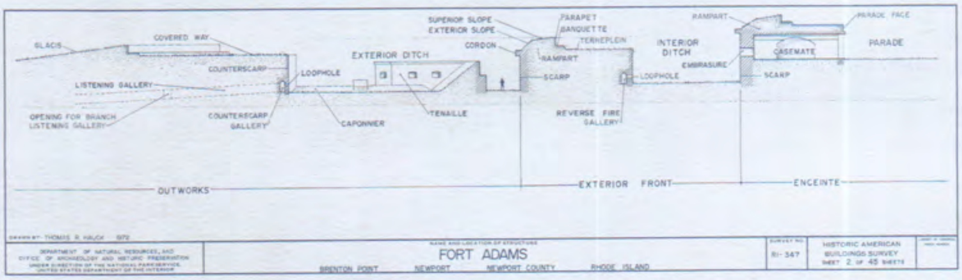
[2] *Casemate* (Fortress Study Group Newsletter) 61 (May 2001): 2; *ICOMOS News* 10 (July 2000) calendar; *Casemate* 60 (January 2001): 4; *Casemate* 59 (September 2000): 13.

standing that the social value of these relics will increase with time, should motivate us toward their care.[3]

The Fundamental Principles—Identify, Evaluate, Protect, and Document

Fortifications are specialized structures, but the basic practices of historic preservation still apply. Their owners need to be able to identify where and what the fortifications are, evaluate their significance, repair deteriorated features and thereby protect what is important, and document the actions that have been taken.

Many fortifications built prior to 1890 are conspicuous, and there is no doubt about where and what they are. Even a small fortification has distinctive features that we recognize as belonging to that particular class of building even if we might not have the vocabulary to describe them. Our ken extends to the rambling profiles of very large structures like Fort Adams, Rhode Island, and its impressive display of military architecture, skilled construction, and national investment.



This sectional elevation through the land front of Fort Adams hints at the specialization of fortification design.

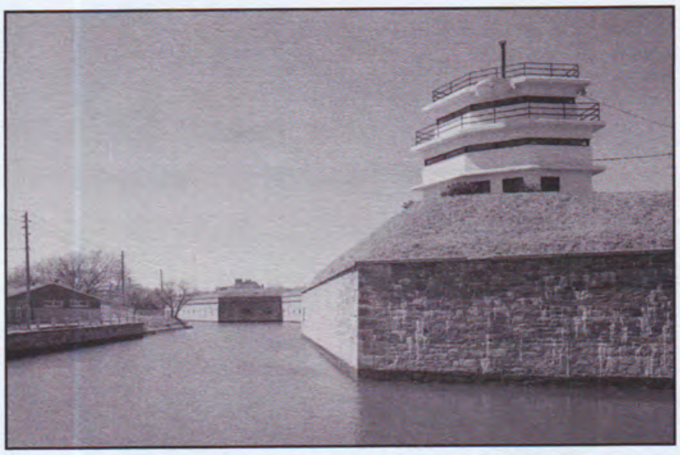
It is more difficult to identify fortifications built after 1890. They are neither compact nor are they conspicuous. For reason that are explained in Part Two, this most recent period produced structures that are scattered widely, and related components of such fortifications might be separated by miles of land and water. In some instances, the structures may not be readily identifiable as belonging to a system of defense. The complexity is compounded by changes in land ownership. What was once a large military reservation may now be a group of smaller parcels owned privately or in a mix of public and private ownership, and used for purposes that range from residential to educational.

Under these circumstances, the tendency is to equate significance with size, public ownership, and listing in the National Register of Historic Places. While this is not necessarily an empty conclusion, it does force military architecture into a format that is a better fit for more conventional types of historic property. Fortifications typically are large, especially the masonry structures of the Second and Third Systems. The eye also tends to fasten on concrete gun and mortar batteries. They are the most impressive defensive structures of the late 19th and 20th centuries, and because they housed the cannon that were the keystones of any protected harbor, they too have acquired the mantle of importance. However,

[3] John Schofield, "Conserving Recent Military Remains: Choices and Challenges for the 21st Century," in *Managing Historic Sites and Buildings*, Gill Chitty and David Baker, eds. (New York and London: Routledge, 1999), 174-175.

often overlooked are the many small auxiliary structures that made for the complete functioning of the defense. They are important pieces that complete the full picture of significance.

Because the transition from military to civilian use was made often without regard to any historic values that the fortifications may have had at the time the property transfers took place, important fortifications are today held by private owners and public agencies alike. While few masonry fortifications are in private hands, relatively more examples of the era of concrete fortifications are held privately. The results have been mixed. There are instances where private ownership has ensured a degree of integrity that would have been difficult to sustain under the management of a public parks agency or historical organization. There are also examples where the interests of the private landowner did not include the historic values of former fortifications. Similarly, public ownership has not always meant that the cultural resources were well cared for or that the challenge of understanding and interpreting them was well met. A basic requirement for any owner, public or private, is to gain a sense of the historic importance of the holdings because the quality of significance cannot be determined by current ownership. It is false to assume that the most important fortifications are always contained in national, state, or local parks, or that such fortifications receive appropriate care.



Fort Monroe, Virginia, is a National Historic Landmark. Its span of construction extends from the early 18th century through World War II. Shown here is the 1943 harbor entrance control station, rising above the original walls. The control station is the only architecturally designed fortification structure built in the United States during the 20th century.

The National Register of Historic Places, the nation's list of properties that are worthy of preservation, contains many examples of fortifications, and National Register listing is the mark of validity for thousands of buildings, structures, objects, sites, and districts. The National Register criteria are broad and flexible, as they must be to be able to recognize the full extent of the national patrimony. The disadvantage is that they are ill-suited to help the stewards of historic fortifications know much about the significance of the properties in their care. The language of many Register nominations tends to emphasize the broad patterns of national defense over an examination of what the particular fortification might represent in the evolution of military architecture. In some cases, fortifications have been excluded from the designation process in favor of listing the associated garrison buildings, probably because the conventional building forms of barracks, stables, and warehouses were more easily comprehensible. National Register listing alone does not tell us enough about the origin and evolution of a wide variety of fortification types.

We need to know what is important because we have to make choices. Federal defense dollars no longer support fortifications, and have not done so for over half a century. The funds that are available, whether from public appropriation or private donation, can only meet a fraction of the need for preservation. We must be able to commit to actions that are based on significance, and in the case of the fortifications that are in public ownership and interpreted as historic properties, that are best able to transmit that quality to a wide range of visitors. If we do not have the financial or human assets to care for everything, how do we choose what we will care for? How do we make that choice and still honor our responsibility to be the competent caretakers of all our historic resources?

The successful preservation of historic fortifications depends on the willingness of owners and managers to learn about the complexities of the resources and construction materials.

Once we understand what is important, it will be an easier job to apply the well-understood protective treatments of preservation, rehabilitation, restoration, or reconstruction, and to get on with business at hand. But it is not a straightforward task. Although built of familiar materials, fortifications employ those materials in untypical ways, and the conventions developed through work with more common building types are not always of much help when we try to apply the practices of historic preservation to these singular structures. Wall dimensions can sometimes exceed 20 feet in thickness, and we have no way of knowing what is happening in the interior of that mass that itself might be composed of different materials assembled in ways that are not certain. Some fortifications are so large and dense that they establish their own interior micro-climate, a feature that experience with other building types can do little to resolve. Not knowing exactly what to do can become a justification to do nothing. The absence of any treatment at all is also a choice, and it is the most common one made by the managers of fortifications. It is the choice that has brought fortifications to their curious place as among the most notable and least maintained historic properties in the nation.

Of the four choices, preservation, with its emphasis on stabilization and limited repair, is our most likely selection. Rehabilitation is possible, although reuse is a distant hope for most fortifications. We can also consider restoration, but the cost implicit in the treatment demands that we have no doubt that the significance will warrant the expense. Reconstruction is the least likely for reasons of high cost and also of limited advocacy: it is difficult to support reconstruction if extant and genuine resources will go untended as a result.

Documenting what has been done is a frequent weak point in many preservation efforts, and here again, fortifications pose special needs. Because only limited repair has been carried out on fortifications as a class of properties, it is important to track and to understand what is happening to those repairs themselves. Often years must pass before we will know if a repair has solved the problem for which it was designed. If the repair is sound after one, five, or ten years, we should be able to use the technique with increasing confidence at other locations and under similar circumstances; if it has failed, we need to be able to understand why before we can move to more effective methods. Good documentation—records that are concise, clear, and locatable—will help increase our knowledge of what works and what does not.

How to Use This Handbook

The *Historic Fortification Preservation Handbook* addresses the fundamentals. In the pages that follow, we lay out background and approaches to identification, evaluation, protection, repair (which includes aspects of preservation, rehabilitation, and restoration), and documentation. Examples and case studies provide details as well as encouragement.

Good documentation—records that are concise, clear, and locatable—will help increase our knowledge of what works and what does not.

Part Two of the *Handbook* contains two related but independent sections. The first section of Part Two describes the origin of fortifications in the United States, and identifies the transition between the designs for masonry fortifications and the designs for structures of concrete. The second section moves from historical exposition to a direct application of that knowledge in a way that recognizes both the significance and the condition of character-defining features.

The *Handbook* includes several different methods of inventorying character-defining features. The simplest is a field survey form that can be used with little more equipment than a clipboard and pencil. The most complex is a method developed by the National Park Service for the Andrew Johnson Homestead, but adapted to record features and conditions at Fort Pickens, Florida. It is well-suited for property owners whose field assessments are linked to the preparation of budgets and project planning. The forms vary in their sophistication but they accomplish the same end: they identify features and conditions as an initial step in the appropriate treatment of fortifications.

The survey documents prepare the way for an analysis of problems and treatments, the subject of Part Three. Part Three discusses the common conditions that are found in historic fortifications, from wet interiors to the accumulation of graffiti, and the methods available to treat them. The content is based on the practical experience of those who care for fortifications as well as accepted practices in addressing the conservation of concrete, masonry, wood, and metals as culled from preservation and materials literature.

Part Four discusses management, with the assumption that most of the historic fortifications being actively managed are in public ownership. It presents considerations of interpretation and visitor safety, and options for care based on those and other aspects.

Any of the four parts may be read independently of the others, and as a result, those with a particular interest should be able to reach what they need quickly. The *Handbook* may also be read from front to back, since the text builds as it moves forward.

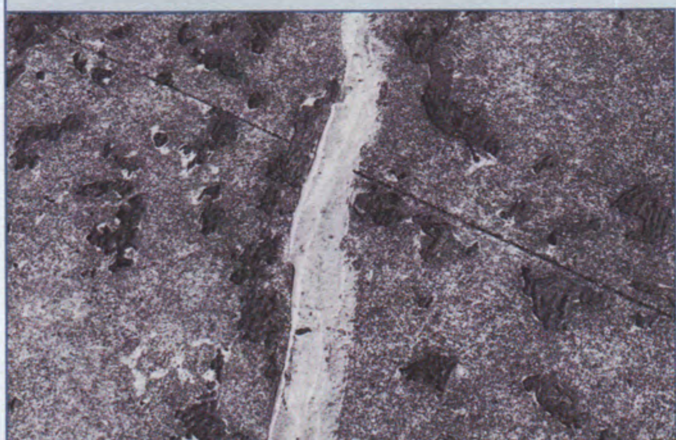
Preservation Treatments as Applied to Fortifications

There are three ways to protect any extant historic building or structure: preservation, rehabilitation, or restoration. In certain cases, the form and detail of a missing historic feature may be represented through reconstruction. These treatments apply equally to fortifications, and as with other types of buildings and structures, the boundaries of the definitions are often not distinct.

Washington State Parks ranger Evan Roberts applies a corrosion inhibitor to help preserve metal work on an disassembled ammunition hoist at Fort Columbia State Park.

Preservation. Preservation means taking steps to correct problems that could lead to greater difficulties later on if left untreated now. Painting iron and steel doors, keeping drains free-flowing, clearing vegetation, and diverting water away from interiors are maintenance actions that the military themselves undertook when fortifications were in active service, and they are just as important now. Preservation can also mean limited repair, such as replacing sections of railing or correcting spalled concrete or masonry surfaces.

Rehabilitation. Rehabilitation anticipates that the degree of deterioration is sufficiently advanced so that more repair and replacement of materials will be required than in a preservation treatment. Extensively damaged or missing features will have to be replaced using original materials or appropriate modern substitutes. Rehabilitation can also include the concept of reuse, usually with the idea that a new use will help the fortification sustain itself through income generated when the completed rehabilitation is put into service. It is a goal infrequently reached because fortifications are too specialized to be easily adaptable to other functions. In 1970, the Washington State Arts Commission proposed the reuse of a fortification as a performance stage, with the high ground to the rear of the structure forming a natural amphitheater. It was an ingenious idea, but probably doomed from the start by both the impacts to the historic resource and the limitations inherent in the space. Fortifications in some locations have been incorporated

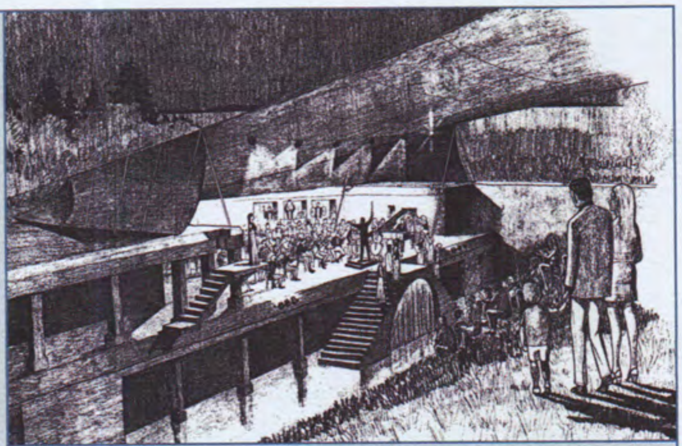


Preservation measures must be appropriate. This waterproofing mastic applied over a crack in a large concrete fortification is not only unsightly and not respectful of the original workmanship, its lack of chemical or physical compatibility with the concrete guarantees ineffectiveness.

into gardens, but a more successful rehabilitation that involved aspects of reconstruction is the subject of the accompanying case study.

Restoration. Restoration is a treatment that returns a fortification or one of its components to its appearance at an earlier time. The reasons are almost always associated with the desire to interpret an aspect of history that cannot be successfully understood without recapturing the past in three dimensions. A good restoration emerges from a foundation of research and careful craftsmanship, nurtured by an adequate budget.

Reconstruction. Reconstruction is rebuilding a resource that no longer exists. As with restoration, the reasons for reconstruction are always linked to interpretation and the need to convey an essential aspect of a fortification to the public. Reconstruction is difficult because its success depends upon the amount of information available to authentically recreate what is missing; what is not known has to be invented. Cost also is a limiting factor, and reconstruction is usually the most expensive of the preservation treatments. It is most often reserved for our most important resources. For example, the 1976 reconstruction of the Spanish water battery at Fort Barrancas, Florida, returned to public view the central portion of the late 18th century fort that had collapsed. The project recovered an important architectural element without which the fort could not be adequately interpreted, and also helped preserve fragments of the original brick masonry. Similarly ambitious is the plan of Oregon State Parks to reconstruct the original Fort Stevens, a pentagonal earthwork built during the Civil War. The work has begun and is partially complete at the time of this writing, with the goal of presenting the expansion of the military post from the 1860s through World War II.



Some idea of the challenges that fortifications pose for rehabilitation are hinted at in this 1970 sketch depicting a gun battery converted to a performance stage.

This searchlight shelter at Fort Rodd Hill National Historic Site near Victoria, British Columbia, has been restored to its World War II guise as a beach shanty, complete with false roof and row boat.

Most reconstruction subjects have been earthworks, as depicted in this 1950s photograph of Fort Raleigh, North Carolina. It is also a good example of the precise geometry that is characteristic of permanent fortification.

Case Study: Rehabilitation

Submarine Mining Complex, Fort McKinley
Portland, Maine
— Joel Eastman

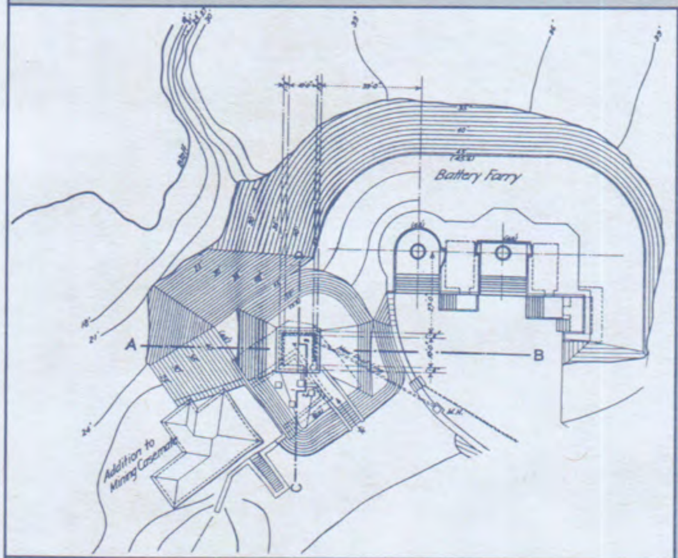


Figure 1. The layout of the 1902 mining casemate and gun battery and the 1909 addition to the mining casemate, with the 1920 range finder station for the battery located on top of the mining casemate. U.S. Army Corps of Engineers, February 17, 1919, U.S. National Archives, College Park, Maryland.

This case study describes the approach used to rehabilitate a submarine mining complex at a former coast artillery post that is now privately owned.

Fort McKinley on Great Diamond Island was one of five turn-of-the-century coastal fortifications built to defend the harbor of Portland, Maine, by use of gun batteries of various sizes and controlled submarine mines to be planted in wartime. All the forts were declared surplus after World War II and sold, two to state and municipal agencies and three others to private parties. Fort McKinley was purchased by a developer who placed the fort on the National Register of Historic Places and created a condominium project. The barracks, officers quarters, and other permanent buildings were rehabilitated and turned into housing, while the rest of the property was subdivided. Many of the lots along the shoreline included gun batteries, observation stations, and submarine mine facilities, all of which were protected by the fort's listing on the National Register and a memorandum of agreement with state regulatory agencies.

Figure 2. A portion of the 1902 brick mining casemate as it appeared in 1996, with one of the steel window shutters askew. The walls and ceiling of the concrete shell are visible, as is the air space that surrounds the brick walls.

Site Development

The submarine mining complex on the north fork of the island is unique in that includes four generations of mine buildings and a three-inch mine field defense gun battery. All of these structures are within a large ocean-front lot that includes two building sites. The property was competitively priced because of the mine structures and gun battery, which the developer believed would be viewed as obstacles by potential purchasers (Fig. 1).

The first mining casemate was built about 1891. It was a small concrete vault buried in a hillside next to the shore, accessed by a tunnel, with electrical wiring running through a cable gallery to the mine field. This cramped, poorly ventilated structure, which housed an electrical control panel and storage batteries for power, proved inadequate, and a new mining casemate was constructed on top of it in 1902, utilizing the cable gallery of the original building.

Figure 3. The 1909 wood frame addition to the mining casemate as it appeared in 1996, with the wing on the right collapsed. The earth cover of the 1902 mine casemate is visible above the addition with the 1920 range finder station on top.

This second structure was built of brick within a heavily reinforced concrete shell covered with sand and sod to protect it from naval gunfire. The brick casemate had several large windows on the rear for light, and featured an air space between it and the walls of the concrete shell (Fig. 2). When this casemate also proved too small during operation, a wood framed, cement plaster addition with a low-pitched roof was put up in 1909 to house storage batteries, a gasoline-powered generator, and a dormitory and latrine (Fig. 3). The experience of the Great War demonstrated the need to provide overhead protection for tactical structures, and as a result, in 1920 a new concrete building, similar to the mine casemate, was constructed for the generator and storage batteries; the wood-frame building was retained as a dormitory. A new range finder station was also added in 1920 (Fig. 4).

New Uses

By the time the mining complex lot was sold by the developer in 1996, the 1909 wood-frame addition had deteriorated beyond repair. The owner, Ed Drinan, hired an architect with historic preservation experience to design a residence that would be as similar as practicable to the original building. The plan was endorsed enthusiastically by the Maine Historic Preservation Commission, which oversees National Register activities in the state. The new structure used the foundation of the original building, and utilities entered the site via the original concrete conduits (Fig. 5). The windows and doors duplicated those in the original structure in size, style, and location. The building was sided with wood shingles over plywood and the trim painted to match the original army olive drab (Fig. 6). The inte-

Figure 4. The 1920 range finder station built on top of the 1902 mining casemate. A coincidence range finder mounted in the station was to provide range data to the minefield defense battery located to the right.

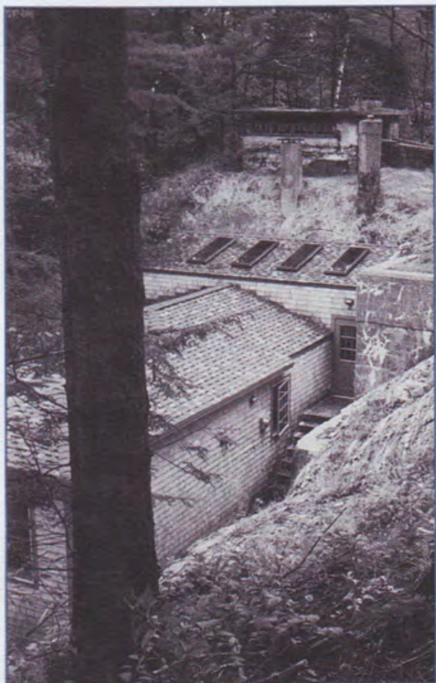


Figure 5. A view of the new residence built on the foot print of the 1909 addition. The connection to the earth-covered 1902 mining casemate is visible, as is the range finder station.

rior walls and ceilings of the residence were plastered like the 1909 structure. The end of the building facing the mine casemate was also plastered and painted by a local artist to resemble the appearance of the original exterior walls. Drinan duplicated the connection between the addition and the mine casemate with modern roofing and skylights.

The owner was unsure about what use could be made of the casemate itself, but once the new residence was completed, he discovered that it would make an excellent living room and bedroom. The mass of concrete and brick made it cool in the summer and easy to heat in the winter. The casemate was in such good condition that Drinan merely cleaned the painted brick walls and installed new electrical wiring.

The 1920 concrete engine room and storage battery room also required little work. Windows and doors were repaired, and new wiring installed to make it an excellent dry storage area and workshop. The range finder station only required the repair of windows and a door. Because of its view of the water and western orientation, Drinan decided to use the station as a seasonal sitting room or bedroom.

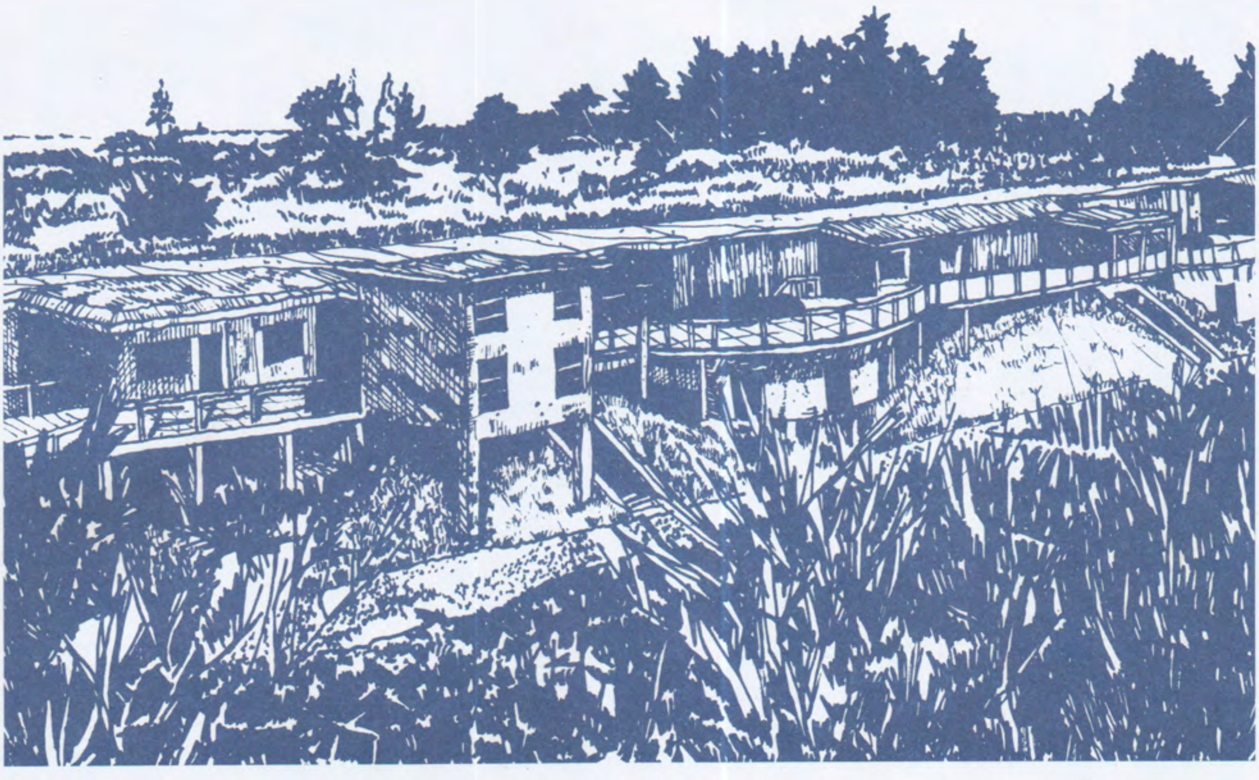
Enhancements

The gun battery was in excellent condition, and the owner envisioned the large open area behind it as a Japanese garden and a site for entertaining friends and family. Drinan was forced to sell the property in 1998, but the new owners, Peter and Pam Macomber, share the same vision, have used the property in the same manner as Drinan, and are continuing the rehabilitation process. The new owners have covered the brick walls of the 1902 casemate with mat polyurethane to encase the original paint, added additional electrical wiring, and installed a gas heater. They have also rewired the range finder station and are using it for a summer bedroom. The next project will be the rehabilitation of the gun battery. In addition to rewiring and reinstalling the steel doors on the magazines, the Macombers hope to purchase a pair of three-inch guns to remount in the battery to complete this imaginative rehabilitation of a unique former military complex.

Figure 6. A portion of the new residence that shows the results of the effort to make the structure mimic the original building. The windows and doors are the same sizes and placed in the same locations. The shingled side walls pick up the color of the cement plaster, and the trim is painted in Army olive drab.

Photo credit: Figures 2–6, Ed Drinan.

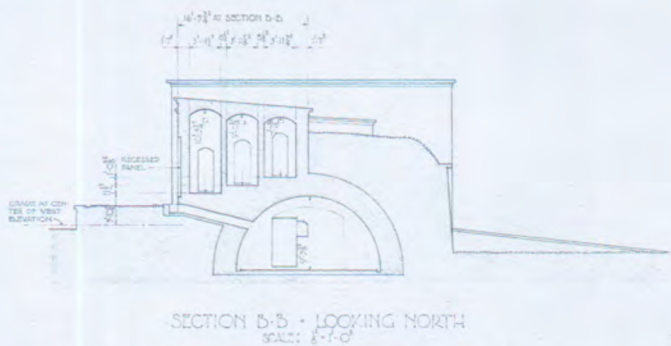
Part Two: Fortifications as Historic Properties



Architectural Overview and Assessment

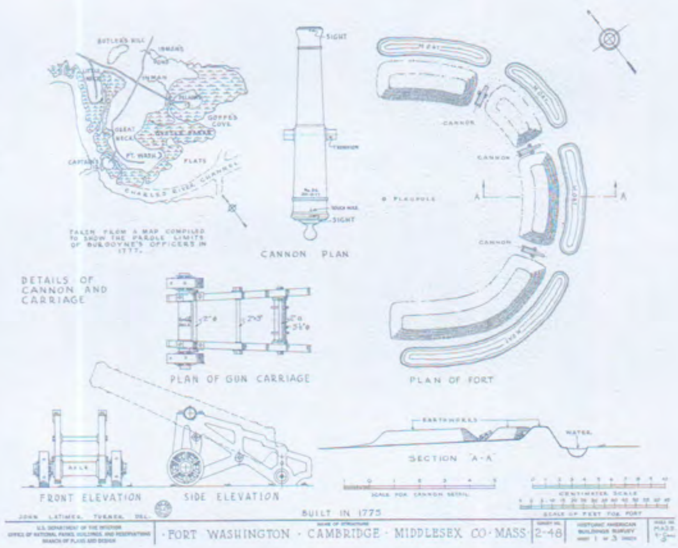
Fortifications are perplexing, especially in the United States. As examples of architecture, they do not fit into conventional schemes of style, even with the ever-widening array of what we consider valuable and significant. The generosity that architectural historians direct toward vernacular buildings does not reach fortifications. Similarly, the backward glance at our own recent past has elevated commercial designs–gas stations, diners, motels–to new levels of appreciation, yet there is no similar interest in the equally rich design history of fortifications. It is the blind spot of our patrimony.

Fortifications are also largely missing from the national pattern of preservation and reuse, and here for reasons that are easier to understand. The success of the historic preservation movement has been based on the ability of historic buildings to be adapted to new uses. Under that approach, factories have become apartment blocks, warehouses have become offices, and homes have been fitted with modern electrical and mechanical systems so that they meet contemporary standards of habitability. It has worked because the materials and methods of construction of most building types are flexible; approached with ingenuity, they are ready to take on a new purpose. Fortifications stand well apart from that tradition. Defensive structures come from a wholly different legacy of building, even though they might be composed of the same brick, stone, and concrete as the cities they were intended to protect. They are also highly specialized structures, their unique qualities expressed through peculiar floors plans and great density of materials. Dark, damp, huge, and complex, fortifications defy reuse.



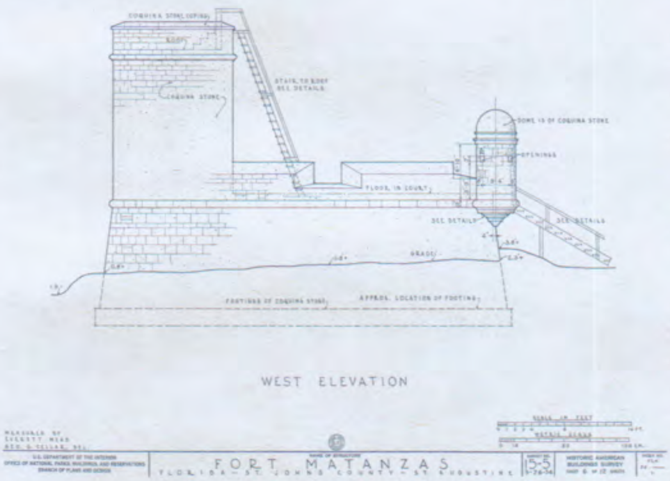
Fortifications often contain interiors that are difficult to adapt. Fort McHenry, Baltimore, Maryland.

It is not that fortifications have no place in our past. Some have figured prominently in the formation of the nation and are among our oldest structures (Castillo de San Marcos, begun in 1672) as well as most famous (Fort McHenry, begun in 1798, and whose bombardment inspired the national anthem). Yet there are hundreds more surviving today, evidence of four centuries of continuous fortification construction on the North American continent. It is evidence as well of a much older tradition, coming to the New World from inspirations conceived in the Renaissance that were themselves sophisticated extensions of building forms as ancient as the walls of Jericho.



During the Revolutionary War, some fortifications were hastily built of earth. Fort Washington, Cambridge, Massachusetts.

Fortifications in the United States share another feature in common with fortifications elsewhere: in aggregate, the majority of them were never the sites of battle. Their significance differs from those that were actively used, and it is the association with design and construction as expressions of national defense policies that lends to them their importance. That means that for many fortifications, the architectural component of their significance is equal to, if not greater than, their historical component.



Local construction materials, such as the coquina stone used in this 1740 tower, could be very durable. Fort Matanzas, St. Augustine, Florida.

Most histories of fortification in the United States focus on chronicle and technology. Many authors have contributed to fixing the construction sequence of works large and small, and have made careful notations of how and when they were armed and served. While the creation of such a record is necessary to establish in time any historic resource, these facts alone contribute little to our understanding of the form of the fortifications themselves. The stewards of these resources today should plan to care for them in a way that supports their significance, and that will require a deeper perception of what they are as structures and how they developed.

The Origin of Fortification Forms

Fortification construction in the United States began in 1794 with the creation of what has become known as the First System, and concluded in World War II.[1] The design and building of the earliest works depended upon Europeans, not Americans, schooled in the engineering institutions of France because there was no source of similarly skilled individuals in North America. Those designers were deeply influenced by Sebastien le Prestre de Vauban, whose complex and deep polygonal traces characterized 17th century fortification in his native France. Vauban's goal under Louis XIV was a system to reinforce the nation's eastern border, and his designs created strongholds behind which the country would remain intact despite the most intense assault. But his highly developed land-based forms (one observer has called them an articulated ditch about 100 meters wide) had only limited applicability on the other side of the Atlantic.[2]

Land vs Coast Defense. Here there was no need to defend a land frontier because it did not exist, at least in the European sense. Westward from the

[1] Some students of fortification extend the period into the 1950s with the construction of facilities for Nike missile systems. While any program of defense is an expression of national policies, it is overly generous to suggest that there is any architectural continuity between fortifications and the missile complexes of the Cold War.

[2] Horst de la Croix, *Military Considerations in City Planning: Fortifications* (New York: G. Braziller, 1972), 53.

Atlantic shore, settlement was sparse and scattered, and although fortifications would be a feature of westward movement, there would be no true national boundary to defend other than the coastline. As a result, what Vauban had designed to hold out against large field armies became in the United States much more simple structures intended primarily to mount cannon that could be used to defeat the vessels of an invader. Coastal fortifications would become the most well-developed expression of fortification in the United States, and would acquire an increasingly native character.

The profile of the works of the First and Second systems was low, continuing a trend that had begun with the introduction of cannon in the 15th century. Since iron cannon balls could defeat the high walls of fortifications built before the middle 1400s, the designs of defenses after that time called for walls of much less height but much greater depth. The stout proportions of the new parapets were greatly resistant to cannon, but they were not always the best form for coast defense. Since cannon could be mounted only on top of a parapet wall that was already low, there was not enough room to install all of the guns that might be necessary to defend a waterway. The solution to that dilemma came from another French designer.

The distinctive vertical walls and rounded forms inspired by Montalembert's design. Castle Clinton, New York, New York.

Like Vauban, Marc-René, the Marquis de Montalembert, immersed himself in the design of land fortresses, yet he had a great impact on American coastal fortifications. His contribution lay in the innovation of multi-story masonry towers mounting many guns placed behind a deeply serrated land front that in plan resembled an encircling row of giant saw teeth. There were other improvements–his insights into the design of fortifications were set out in 11 thick tomes published in 1776–but it was the towers that appealed most to engineers in the United States. They meant that more cannon could be placed in a single structure, and that the subsequent volume of gun fire could overwhelm any naval attack. Montalembert's round and upright fortifications gave a distinct appearance to such Second System works as Castle Clinton (New York, 1808) and Castle Pinckey (Charleston, 1809), and influenced the design of some of the largest works of the Third System of fortifications, built between 1817 and the onset of the Civil War. The Third System was also the most complete of the three, and reflected a desire for permanence and sophistication that was not always present in the building efforts that had preceded it.[3]

Civil to Military Engineering. The Third System marked another major shift. Until the early 19th century, the building of fortifications and the building of

[3] Quentin Hughes, *Military Architecture* (New York: St. Martin's Press, 1974) 138-40; Marguerita Z. Herman, *Ramparts: Fortifications from the Renaissance to West Point* (Garden City Park, New York: Avery Publishing Group, 1992), 72.

cities had been closely allied, and many of the great men of the Renaissance had either built or expounded on the building of fortifications. Leonardo da Vinci, Albrect Durer, Michelangelo, Brunelleschi, Bramante, and Cellini did not distinguish between the planning of fortifications and the planning of cities: it was all of a piece. They understood that military art could give rise to noble civil enhancements. Probably nowhere was the intimate connection between military skills and great beauty better expressed than at Vaux and the 17th century Italian villa gardens whose water features and precise landscapes were the products of lessons learned in the construction of fortifications. Some of that tradition also came to North America, although at a much more modest scale. Pierre-Charles L'Enfant, creator of the city plan for the national capitol (whose radial streets harked back to the lay-out of the fortified cities of France and Italy) was also a skilled builder of fortifications. Benjamin Latrobe, architect of the Capitol building, was also engineer to the First Regiment of the Virginia Militia, and as such set up a new trace for Fort Nelson in 1798. Less famous but still in the same mold was Joseph Francois Mangin, designer of the New York city hall and Fort Columbia, and Robert Mills, best known for the Washington Monument and who also contributed to the defenses of Charleston.[4]

As the range of cannon increased, fortifications moved farther away from the cities they were intended to protect, and as they did so, their designs became more specialized.

As the range of cannon increased, fortifications moved farther away from the cities they were intended to protect, and as they did so, their designs became more specialized. No longer could one person be expected to deploy equal skills in the conventions of planning a city or its individual buildings and the special-purpose structures needed to defend them. Military architecture, the design of fortifications, became the province of engineers alone. The division was given even greater emphasis by John Smeaton, the designer of the Eddystone Lighthouse, when he declared in 1750 that engineering itself had two specialties, one civil and the other military, recalling the early connection of engineers with warfare. Increasingly with the coming of the Third System and for the more than 100 years of fortification construction that followed, engineers (and despite Smeaton's insistence, military and civil alike) designed and directed the construction of America's greatest seacoast defenses.[5]

The adoption of Montalembert's methods, or more correctly his perpendicular arrangement of tiers of cannon, was one of the salient features of the Third System of fortifications, although variety was its greatest characteristic. It was distinguished from the First and Second Systems not only by the shape of the defenses themselves, but also by the decades-long construction period when there was no real threat of attack from the sea. As fortification builders everywhere have

[4] Simon Schama, *Landscape and Memory* (New York: Alfred A. Knopf, 1995), 338-9; National Archives and Records Administration, Record Group 77, Records of the Office of the Chief of Engineers, Fortification Files, Dr 60 Sht 2, Fort Nelson, July 1798; Willard B. Robinson, *American Forts: Architectural Form and Function* (Fort Worth, TX: Amon Carter Museum of Western Art, 1977), 70, fig. 26.

[5] Samuel C. Florman, *The Existential Pleasures of Engineering* (New York: St. Martin's Griffin, 1996) 121; Florman, *The Civilized Engineer* (New York: St. John's Griffin, 1987), 42.

known, fortifications erected during peace time tend to be better thought-out and better constructed than those put up in the haste of war or its imminent appearance.

Many of the new defenses followed the French style in that they featured the bastions introduced by Vauban and employed by his students in the United States and Europe long after his death. A very few of them, most significantly Fort Adams (Rhode Island, begun about 1824), featured well-developed land defense forms away from the seaward elevations of the main structure. Where sites could be found in shallow water or on islands where defense from land attack was not an important consideration, the massive brick and stone walls went upward, rising three, four, and sometimes five stories high on vaults which formed casemates or chambers for cannon. These immense masonry polygons are the best remembered products of the Third System, Fort Sumter and Fort Pulaski being the most familiar for the role they played in the Civil War. Others are remarkable for their sheer size. Fort Adams was designed to mount 468 guns in a one-mile perimeter; Fort Monroe (Virginia, begun about 1819) was larger still, but with fewer guns. The imposing Fort Jefferson (Florida, 1845), located in the remote Dry Tortugas, enclosed almost all of its 16-acre building site to accommodate 450 cannon. Manning requirements were equally large, with 2400 required at Adams and Monroe and 1500 at Jefferson.[6]

Vertical walls became taller and more massive in many works of the Third System. Fort Jefferson, Dry Tortugas, Florida.

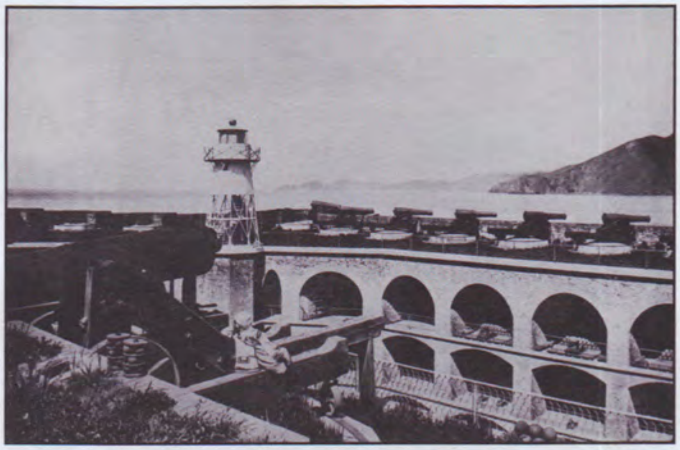
Of the largest, many were never completed, although they were under construction for years. Despite that, the great vertical structures of the Third System embody what most observers, from passers-by to serious scholars, would label a fort or a fortress. They alone in the United States could meet the test of Alberti in that a fortification "ought to look fierce, terrible, rugged, dangerous, and unconquerable." Perhaps for that reason, most historians and architectural historians who look at fortifications find their interest drawing to a close with the Civil War, which marked the end of the bastioned trace and multiple tiers of the Third System. Why the study should end there is not altogether clear, since a fortification system that was much more ambitious followed some 20 years later.[7]

A New Program. Some authors talk about a Golden Age of American fortification, and almost without exception, they mean the years of the Third System. One writer has called it the "last great period of innovative fortification . . . [producing] the most elaborate and, historically, most interesting forts of American history," and another author refers to it as a "stable refuge in a fast-changing world," suggesting further that it dominated the thinking of military engineers and left

[6] Robinson, 99, 115.

[7] As quoted in Hughes, 69.

them helpless in the face of an increasingly industrial age that required other forms for fixed defense. An architectural historian in an otherwise excellent treatment of masonry fortifications concludes his presentation by noting that after the Civil War "architecture for defense was simply unable to keep pace with weapon design," observing further that their "beauty of form result[ed] from clarity of purpose." Without exception, these conclusions are at the least not helpful and in some cases are simply wrong.[8]



The casemates of a Third System fortification. Fort Point, San Francisco, California.

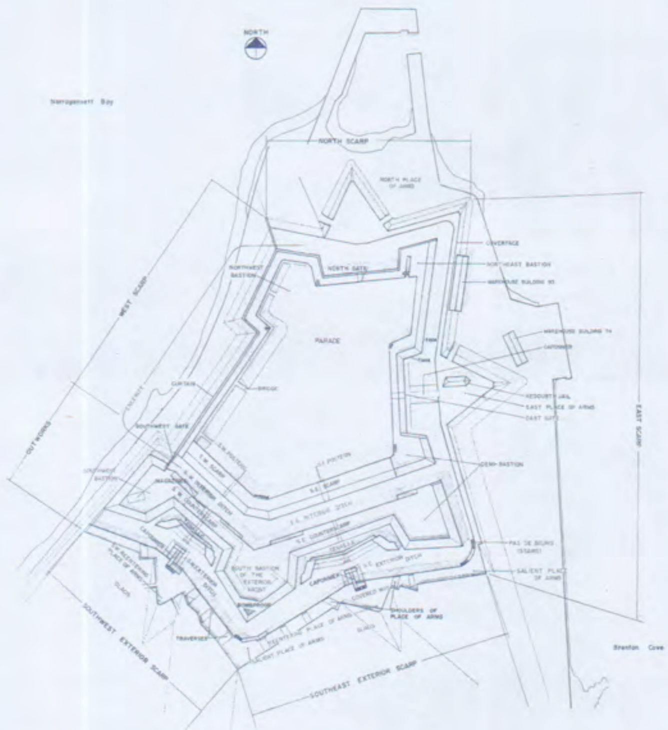
They are wrong because in 1885, the United States began a new fortification program. It was more extensive, more elaborate, more powerful, and more complex than anything that had gone before, and its products were of a distinctly different appearance. It was based on new technology and new materials, and at first glance, it is difficult to see the connection between these new concrete fortifications and their predecessors. The connections exist, and so do some of the European influences that held such great sway in the years before the Civil War. It will help our understanding if we characterize the architectural values associated with masonry fortifications, and then look at what happened to those values with the advent of the new pattern of coastal fortifications that began in the 1890s. A good place to start is with construction materials, the relationship between the fortifications and the city, and the scale of the fortifications themselves.

A New Material. From the earliest dates of recorded history to the middle of the 19th century, fortifications had been built of brick and stone. These were the same familiar construction materials associated with all building, and we have come to value them today for their individual form, texture, and color as well as the beauty they can impart when they are gathered together to form useful shapes that run from the ordinary to the bold. The fortifications built in the last half of the 19th century depended increasingly on concrete, and later reinforced concrete, as the construction material of choice. It was a dramatically different material because it took on the shape of the mold into which it was poured. As the 20th century progressed, architects would use concrete in ways we now celebrate, but to many residents of the 1890s it must have appeared as a modern but unfamiliar material. Within a brief passage of time, concrete became a frequent choice for all types of building because it was often less expensive than masonry and gave a preferable result, particularly when used for paving or where great mass was needed, as in bridge abutments or building foundations.

[8] Herman, 149; David A. Clary, *Fortress America* (Charlottesville, VA: University Press of Virginia, 1990) 125; Robinson, 132, 184. Lewis Mumford, the acute observer of people and communities, placed the demise of the art of fortification much earlier and contemporaneous with the death of Vauban; Mumford, *The Culture of Cities*, (New York: Harcourt Brace Jovanovich, 1970) 86.

Fortifications had long been a conventional part of European cities, and were as much an element of them as the cathedral and the market square. The walls wrapped the town and protected it from without; their purpose and value could be seen everyday as residents passed through the gates. In the United States, cities were open, but at the entrance to every important harbor (and some not so important) stood a rugged protector that guarded against incursion and insult. They, too, could be seen daily, albeit they were encountered in a different manner, and they, too, had a common place in our communities. It was much more difficult to become acquainted with the concrete fortifications of the late 19th century. Admittance to them was restricted in a way that access to earlier defenses was not (illustrations of the day often featured couples strolling on the parapets), and in any case, they were usually more distant since they pressed seaward from the places they were to defend. The protection was not principally for a great city, but for a region and a nation.

Residents could also comprehend the scale and the organization of masonry fortifications. Despite the great size of many of them, their origins were familiar because they were built using the same methods as any other large project of the time. Materials were assembled using little more than manpower assisted by simple machines, stone upon stone, brick upon brick. Except for the very largest, the dimensions and proportions were not much different than other big buildings, and their relationship to other buildings was enhanced by the use of familiar architectural features such as detailed entries, decorative brickwork, and on the interiors, wooden sash, and doors. In addition, the First, Second, and Third System works had in common the centralized organization of many town plans and major public buildings. The circulation was evident—visitors approached on a single road that entered the main gate and ended within the large, open parade where most of the features of the fort could be grasped in a single sweep of the eyes. There was a sense of order and a rhythm established by the repetition of the arched rear face of the casemates. Most also benefited from great symmetry of plan, and even those lacking bilateral symmetry (such as Fort Adams) had a dominant central axis.



Site constraints—and in this case, the special requirements of land defense—often determined the basic outline of Third System works. Fort Adams, Newport, Rhode Island.

Fortifications as Landscape. These three basic qualities of all masonry fortifications—familiarity of materials, familiarity of presence, and familiarity of scale—disappeared suddenly, the abrupt conclusion to centuries of building that had seen remarkably little change. What rapidly replaced them in the last half of the 19th century was a new way of defense that was still fortification, but unlike any other that had gone before. The fortress silhouetted against the evening sky remained as a romantic image, and one with little military value.

The new fortifications were not conspicuous from the sea. There was no single and obvious structure that housed the defenses in the same way that early fortifications had housed hundreds of cannon. Instead, expansive tracts of land were adapted for military use, and individual structures were built into the contours of the ground, revealing little of their location. There were also new types of buildings that had not been necessary before: position finding stations, power plants, searchlight shelters, and signal stations, all connected electrically. They were not collected behind great walls, but instead they were scattered on headlands and shores, sometimes miles from each other. The original purpose of the brick and stone fortresses had not changed; the intent was still to defend important ports. The means had not changed; the basic weapon was still heavy cannon behind a strong parapet. The fundamental shift was in the dispersal of military architecture across a landscape. The effect was to alter the harbor entrance into a vast defended area whose dimensions were equal to the range of the guns in those hard-to-see locations. The fortress of old had become atomized, and was now an aggregate of unique structures sited on clusters of islands and landmasses, a whole of many separate parts, all born of the flood of technology that washed over the western world in the second half of the 19th century.

A rear view of a new fortification of the 1890s. Compare this to the rear view of the Third System fortification on page 2.6. Fort Hancock, Sandy Hook, New Jersey.

These new structures of the defense were architectonic rather than architectural, and they took shape based on the type of ordnance to be installed in them, in itself a distinguishing feature of modern fortifications. Typically, there was only a single elevation apparent instead of a multi-sided polygon, and that elevation was visible only at the rear. They conveyed an impression of simple solids and voids that could be arranged in considerable length, in some places as much as half a mile. Details were few, and most often limited to doors of steel or wood that contrasted to great effect on the otherwise unrelieved planes of concrete.

The designers were not the multi-talented men of the 18th century, but were instead the specialists produced by the United States Military Academy at West Point, the result of that institution's emphasis on professionalism and engineering aptitude. However, the West Point graduates and their civilian counterparts who supervised the actual construction of the fortifications were as conscious of their work as were the artisans of an earlier period. For example, Jonathan Williams, inspector of fortifications as well as the first superintendent of the academy, spoke warmly in 1802 of Fort Mifflin in Philadelphia and of the "large stones perfectly cut and put together . . . a good brick revetment, with handsome white Stone Cordon."[9] The appreciation was directed toward craftsman-like work, valued for fortifications in the same way that it was valued in other construction. The builders of concrete defenses 100 years later had much the same aesthetic and also sought handsome results; they typically completed their work with a plastered finish that smoothed over the coarse outlines of the shuttering. They also made deliberate choices based on a desire for the fortifications to look right and to satisfy the emotional involvement in building that is also a quality of architecture. These choices were modest–tapering a column, changing the proportions of a room, designing an element to suggest great strength–but they were one with the ideas of Le Corbusier whose work in concrete was a lodestone of 20th century architecture.[10]

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This was a new epoch of fortification, not simply a new system, and it reflected the rapid and multiple innovations of a culture that was increasingly committed to science and invention as an unmixed blessing. The pace of change was much different than anything that had preceded it, and weaponry and the practices of attack and defense changed with equal speed. Fortification as part of that weaponry went through its own metamorphosis, and revealed itself with a more mechanical orientation.

Fortification Innovations. After the 1870 Franco-Prussian War in Europe, forts went down into the ground and in some cases under it. Little was visible, and the forts themselves were detached from the cities they were to defend. Cannon were made of steel, not iron, and mounted on devices that allowed them to move upward from the earth, firing at only the last moment. There was electric power, and searchlights to illuminate the night. These were very different fortifications from what had gone before; they were like the new steam-powered warships, "buried up to the deck-line in concrete and manned by mechanics." Herman Melville expressed a similar view of warfare in the industrial age after contemplating the USS Monitor, the most profound piece of technology to emerge from the Civil War. In the same way that fortifications were leaning toward a more complex future, the Monitor appeared to be less a warship than a floating mechanism, and the place of the sailors aboard her much reduced: "plain mechanic

[9] As quoted in Robinson, 67. Williams was the grandnephew of Benjamin Franklin, and he accompanied Franklin to France to study military science and fortification; Russell Reed Price, "American Coastal Defense: The Third System of Fortification, 1816-1864" (Ph.D. diss., Mississippi State University, 1999) 21.

[10] NARA, RG77, correspondence relating to the construction of the Coast Defenses of Puget Sound, R. H. Ober to John Millis, March 13, 1905, and W. T. Preston to Millis, January 23, 1901. The only modern fortifications to receive much attention for their architectural form have been those erected by German forces during World War II in Europe, largely because their contours appear to be akin to the works of Corbusier and Henry Moore (see for example *Architectural Forum*, November 1967). However, similarities between fortifications and civil construction is coincidental and too much should not be made of them. Certainly the builders of fortifications in the United States who prized the flat and flawless surfaces would have found little to admire in Corbusier's "béton brut." Keith Mallory and Arvid Ottar, *The Architecture of War*, (New York: Pantheon Books, 1973), 279.

power/ Plied cogently in War now placed—/ Where war belongs—/ Among the trades and artisans."[11]

Some sense of the magnitude of the change is represented in the table below, Comparison of Permanent Fortifications. The table compares the two major classes of fortifications in the United States based on their construction materials and by the technology that those materials represent. Unit materials such as brick and stone descend from pre-industrial methods that used construction materials in an indeterminate way, counting on the experience of many generations of craftsmen to ensure success. Mass material such as concrete is an opposite in every respect since its very manufacture is dependent on industrial processes, and although experience still counted for a great deal in its early use, structures built of concrete were much more determinant than their predecessors.

Comparison of Permanent Fortifications

Comparison Element	Unit Material-Based Fortifications (1800–1865)	Mass Material-Based Fortifications (1890–1945)
Designers	Few	Many
Form	Compact	Dispersed
Primary Design Requirement	Maximize number of cannon	Concealment
Secondary Design Requirement	Housing	Ammunition service
Architectural Details	Common	Rare
Primary Material	Brick and stone	Concrete
Secondary Material	Earth	Earth
Specialized Spaces	Rare	Common
Land Defense Features	Common	Rare
Auxiliary Structures	Rare	Common
Rate of Innovation	Slow	Rapid

While all of these elements have the potential for extensive elaboration, what is of interest is the time period that is not represented here. If unit material-based construction concluded about 1865 and mass material-based construction did not begin until 1890, what happened in the quarter century between? The apparent answer is very little, since fortification construction was a desultory and uninspired business after the Civil War, and not much was accomplished by way of national defense. The more comprehensive answer is a great deal, since this was a period of incubation when not only the form of the new defenses was established but so too the spirit of innovation that typified the initial and most formative

[11] Sir George Sydenham Clarke, *Fortification: Its Past Achievements, Recent Developments, and Future Progress* (Liphook, Hants, UK: Beaufort Publishing, Ltd: undated reprint of 1883 edition), 98; Melville as quoted in David A. Mindell, "Technology, War, and Experience Aboard the USS Monitor," *Technology and Culture* 36 (April, 1995): 270. The military potential of machines captured realists and dreamers alike. An 1898 novel by J. Schroeter, *Die Festung in heutigen Kriegsfuhren*, Bd II, described a fictitious land fortress in the United States. Set in the distant future of 1924, the vast underground complex was operated by automatic mechanisms with little human involvement. See Waldemar Brzoskwinia and Jaroslaw Chorzepa, "Automatyczny Fort Dwudziestego Stulecia," *Forteca* 3 (1997): 41.

Changes in Construction Technology

Manpower. Construction technology and building methods changed throughout the life of fortifications in the same way that their design changed. In the photo at right, masons in the early 1860s at Willett's Point (later Fort Totten), New York, are hard at work in a construction scene that had altered little in several thousand years. Although their tools were much improved, and the stiff-leg derricks took advantage of fittings made from iron and steel, their Roman counterparts would have recognized the job immediately.

Steampower. Building in concrete left old technology behind. By the 1890s, steam engines did the heavy work, assisted by more powerful machines, although men and horses played a central role. In the middle photo, a pair of derricks moves materials and buckets of concrete over the construction site of a 10-inch battery at Fort San Jacinto in Galveston harbor during the reconstruction of the storm-damaged defenses in 1904. Just as the old masonry fortifications had been replaced, so too had the means of building them.

Horsepower. Little more than 30 years after the photo above was taken, the once ubiquitous steam engine was gone from fortification construction, and the manner of building them had changed again just as had the nature of their design. In this 1937 photograph, a single worker uses a bulldozer to backfill hundreds of cubic yards of earth around the massive gun block that will soon hold a 16-inch gun at Fort Funston, near San Francisco. Not apparent are the multiple advances in hydraulic and pneumatic devices, soil consolidation, admixtures, and air entranement, all of which made heavy concrete construction more efficient.

decade of the new, modern works. Of all the elements of comparison in the table on page 2.10, it is innovation that reveals the most profound response to the new technology of the age, and the concrete fortifications of the United States are an exceptional example of the importance of innovation in successful military design.

The Designers. Unsurprisingly, all design begins with designers, and fortifications are no exception. All designers are called upon to create buildings that in the end are a combination of restraints and requirements, the unavoidable compromises that yield structures of varying degrees of success. Fortifications took shape under the pens of individuals who drew upon their own background and knowledge, influenced by the military technology of defense and attack, and enhanced by what they understood was happening in other parts of the world. All aspects of comparison stem from the actions of the designer. Fortifications did not emerge unbidden from the ground like mushrooms; each one had an author, although as the practice of fortification continued into the 20th century, that authorship became increasingly more anonymous.

Simon Bernard and Joseph Totten were the guiding spirits of the Third System. Barnard, a French engineer, designed 17 new fortifications between 1819 and 1835, including Fort Adams with its handsomely rendered crownwork, counterscarp galleries, tenailles, and redoubt.[12] Totten overlapped some of his career, and took over completely when Barnard returned to France. He produced about 30 designs for new works as well as plans for the renovation of other existing defenses, and remained directly involved with all aspects of fortification work until his death in 1864. So persuasive was his influence that many later engineers referred to the Third System as the Totten System.[13]

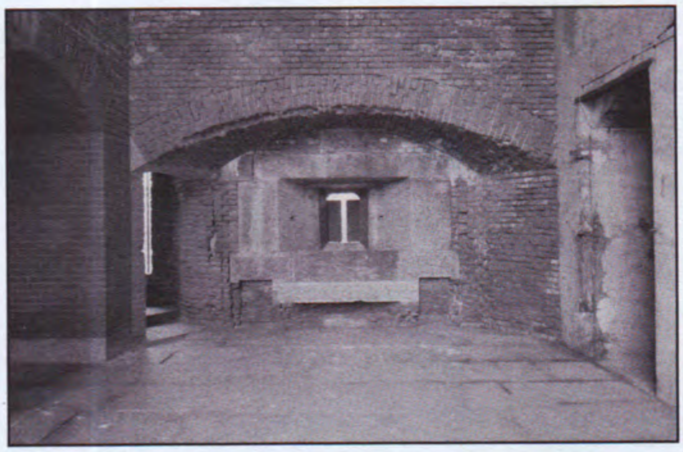
The distinctive vaulting of casemate construction. Fort Delaware, Pea Patch Island, Delaware.

Both Barnard and Totten depended on the casemate as the basic unit of their designs. The casemate was a set of masonry vaults that supported the floors above it and that made a handy place to mount cannon that could fire through the embrasure or opening in the front wall of the casemate. Casemates were an ancient feature of fortifications—they originated with the Greeks in the fourth century BC—and both men showed great skill in piling them up in a manner that allowed large numbers of cannon to be placed within a small area. The tiers of casemates worked well because they were designing within an envelope of attack and defense that had been static for several hun-

[12] Price, 66 and 81. Both Barnard and Totten had a hand in the design of Fort Adams, and one author has attributed the major role to Totten; see Herman, 160.

[13] Emanuel Raymond Lewis, *Seacoast Fortifications of the United States* (Annapolis: Leeward Publications, 1979) 38n.

dred years and there was little call to do more. Although the form of their Third System designs was often distinctive, they were not distinctly original; they had no reason to innovate further since they had no technological reason to do so. Totten has the most plausible claim on being the designer of the greatest originality since he was able to strengthen the embrasure (an opening being the weakest part of any fortification) both by successive alterations to its form and ultimately by fitting it with a shutter of iron armor.[14]



Casemate interior looking toward the embrasure that has been fitted with iron shutters. Fort Delaware, Pea Patch Island, Delaware.

Like Barnard and Totten, the designers of mass material-based fortifications were people of considerable talent since only the most able West Point graduates were commissioned into the Corps of Engineers. There were also important differences. First, there were many more of them, and almost all undertook a brief stint at fortification work as part of long and varied careers in the military that sent them all over the United States as well as across the Pacific and Atlantic. Second, they were called upon to design fortifications in a period of constant technological change. In their own lifetimes, they had witnessed the growth of telegraphy and steam power, the introduction of the telephone, internal combustion engines, the generation and efficient storage of electricity, and the wide adoption of incandescent lighting. All of these developments found a ready place in the military. Coupled with the submarine cable, the telegraph and telephone could help coordinate action among separate fortifications. In addition, the telephone became the instrument of choice for the operation of new fire control systems. Internal combustion engines powered generators that charged the batteries that held the power necessary to meet the needs for electricity in the new emplacements. It seemed as if there was no limit to what might be devised or its potential application to the demands of military technology. More would be required of these engineers than ever had been ever asked of their two well-known predecessors.

From Casemate to Emplacement. For the new fortification builders, the basic unit was not the casemate. It was instead the emplacement, which like the casemate was the structure in or on which the cannon was mounted, but unlike it in every other respect. The casemate was an architectural form closely related to the arch; its utility for defense was incidental to its ability to hold great weight from above, a quality that had many different applications. The emplacement as it developed in the 1890s and into the following century had no architectural analogs. It was pure structure. It was in its form subservient to the cannon mounted in it, and in its program supportive of the functioning of the ordnance in a way that was never expected from the casemate. While these design qualities ultimately would be praised in the abstract by architects and architectual theo-

[14] Hughes, 17; Lewis, 43-44.

rists, they yielded structures that still retain their alien appearance 100 years later.[15]

The shift from casemate to emplacement took place during the 25-year gap that appears between the two major categories of fortification as presented in the table on page 2.10. It was an incremental and cautious movement, aided by many hands, during several decades when there was little prospect of building anything significant. While other nations moved forward to construct defenses that took advantage of modern elaborations, the United States did not commit to a major rebuilding of its coastal fortifications after the Civil War, despite the deteriorated and inadequate state of the existing works and armament. Lack of funds dictated that the nation would have to make do with earlier technology, supplemented by a few modest improvements. It was just as well. Most professional soldiers understood that big guns, their carriages, and the fortifications that contained them were undergoing fundamental change, and that until the nature of those changes was thoroughly understood, it was wise to opt for no new system at all.

Waiting did not mean stagnating. During these years, drawing tables were crowded with ideas about future fortifications, for if money was in short supply there was plenty of imagination. The engineers of the post-Civil War period sketched what they knew would not be built because the exercise itself was informative and it kept their thinking sharp for that moment in the future, whenever it might be, when construction dollars would appear again. They looked in three places for their inspiration: the immediate past experience of the war, European advances in ordnance and fortification, and native concepts of the form of an American system of defense.

Union gunners breached the walls of Fort Pulaski in 1863, signalling the end of Third System fortifications.

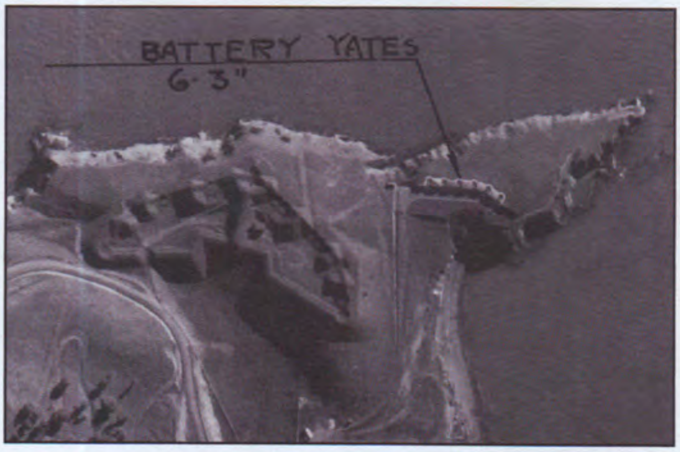
In the aftermath of the collapse of Third System principles, post-war designs emphasized economy of line and simplicity of construction so profound that the scattered defensive works of the 1870s often did not seem to be true fortifications at all. Emplacements typically provided enough space for two large cannon, sitting upon simple stone platforms and faced with a low parapet wall of brick that was protected on its seaward face by a bank of earth. An earth-covered magazine of brick and cut stone appeared on each flank. The magazine floor level was slightly below grade, and the gun platforms slightly above, continuing a practice begun

[15] Austrian architect and writer Adolf Loos (1870-1933) was one of these. Loos was deeply suspicious of ornament, and his biographer has said that Loos believed that "the only innovation legitimate for utilitarian objects is one that arises out of technical research." The person who would do that research and expand on its result was the engineer, "the genuine upholder of the ancient building tradition." In this perspective, the singular appearance of concrete fortification is appropriate, since the "silence of pure structure is the only mirror fit to reflect the absence of inhabitation." Benedetto Gravagnuolo, *Adolf Loos: Theory and Works* (London: Art Data, 1995), 48 and 216.

during the war. The period produced few memorable and important designs–all were in San Francisco–and the predominant impression of these post-war stop-gaps was of a series of large sod-covered mounds with guns between.[16]

Renewal of European Influence. Battery Cavallo was the work of Col. George Mendell, and while his inspiration for the distinctive design remains unknown, the structure has well-defined contemporary European characteristics.[17] We should not be surprised. Engineers in the United States kept a watchful eye on the development of military technology in Europe. Most European nations had quickly revised or rebuilt their fortifications as soon as more powerful ordnance had become available, even though the early rifled cannon were muzzle loaded. They also were willing to invest in new construction methods and the possibilities of strengthening older works so that they would remain useful in a new era. For the United States, Europe was a laboratory where theories and inventions were played out on a scale that could not be equaled at home.

Both the army and the navy sent observers to Europe after the Civil War to keep abreast of the rapid developments ashore and afloat. In a way that seems strange to us today, these visitors were welcomed and a great deal of information was shared with them. There was no hint of espionage, and no doubt all involved would have been offended by the suggestion. It was a different time, and military technology had a porous quality. Revealing some of it reflected well on national stature and could lead to lucrative armament sales later on.

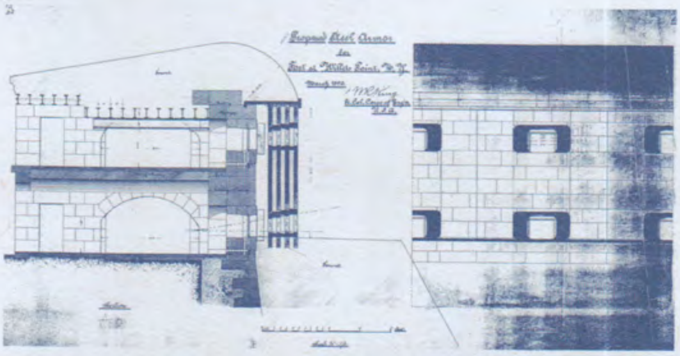


The outline of Battery Cavallo in an aerial photo from the 1930s. Fort Baker, San Francisco, California.

One appealing possibility was the artificial island, familiar enough in European fortification practice but now made more desirable through the use of iron armor as the construction material of the fort that would rise above it. Shallow harbors could be more easily defended by the iron forts, and England built several of them between 1859 and 1880. The cost of the armored forts was too large for real consideration, but US engineers thought that same idea could be adapted by attaching iron armor to the faces of existing masonry works, a technique that also had European precedents. The happy possibility meant that the investment made in early fortifications would not be lost, and that they could be converted to contemporary efficiencies. Engineers drew up proposals to show how the Third System fortifications would look clad in iron and with breech-loading cannon projecting through the embrasures meant for the simpler cannon of the 1860s. The result was not encouraging. It meant that the

[16] For a detailed historical overview of Battery Cavallo, see John Martini, "Battery Cavallo, Fort Baker: Survivor of the Plan of 1870," *Coast Defense Study Group Journal* 14 (February, 2000).

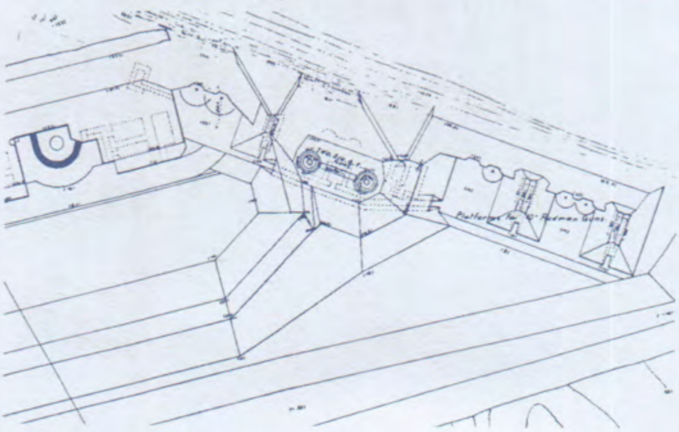
[17] Kurt Mörz de Paula, *Österreichische Militärgeschichte: der Österreichisch-Ungarische Befestigungsbau 1820-1914* (Vienna: Stöhr, 1995), 61-65; Clarke, Plate VII.



As late as 1890, Army engineers were investigating the possibility of upgrading Third System masonry fortifications with facings of iron armor. It was a solution that could yield only false economy since it would compromise the modern cannon that would be installed in the old casemates. This drawing portrays the installation of iron armor at the fort shown under construction in the top photo on page 2.11.

tall vertical walls that had been proven valueless during the Civil War would be retained no doubt to be defeated yet again in some future conflict. Moreover, the installation of modern cannon in fortifications built for now-obsolete ordnance would only compromise the new armament. "Earth is the true parapet for resisting shot," said General of the Army William T. Sherman in 1867, dismissing the idea of iron armor for coast defense and endorsing what had been learned in the Civil War about the protective value of earth.[18]

American military men were interested in European technology, not in the form of European fortifications, although they did find in one instance that they could bring both together and satisfy those who held out for the refitting of existing works.[19] The British armaments firm of Vickers-Maxim had developed a mount for small caliber cannon that could be installed in specially-built casemates. It occurred to engineers in the United States that the same idea could be used to re-arm the empty casemates formerly occupied by old muzzle-loading cannon. Two casemates (reduced from the four that were first proposed) were converted for the purpose at Fort Mott, New Jersey. Battery Edwards comprised the only casemates that were adapted to mount artillery pieces in the new defenses.[20]



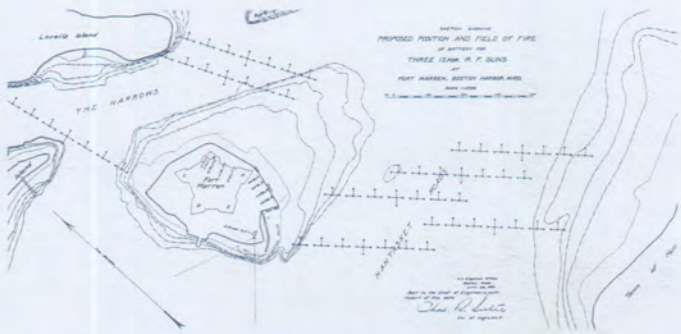
The conversion of existing works to modern gun batteries was attempted only at Fort Mott, New Jersey. Two magazines were altered to accept a mount based on the Vickers-Maxim idea, but apparently the experiment was not considered a success. The position of the casemate battery is indicated by the large V-shaped contours in this 1897 site plan.

Accompanying the Civil War lessons in fortification and the view through the European window on the future of fixed defense was a third perspective that emphasized distinctly national preferences in a coast defense system. In 1873, military planners embraced the device known as the disappearing carriage, in particular the type proposed by Adelbert Buffington, an American artillery officer. They also committed to the extensive use of special seacoast mortars,

[18] Hughes, 192; 41st Congress, 2nd Session, House Executive Document 17, "Ryan-Hitchcock Marine Fortification."

[19] European and American fortifications for cannon of small to medium caliber could resemble each other, but it was happenstance and the result of wanting to mount such weapons as economically as possible; see for example de Paula, 97.

[20] One could argue that this was a less than genuine test since the conversion involved magazines from the 1870s rather than Third System casemates; "Garrison Mounting for 3 inch [15 Pdr.] Q. F. Gun [50calibers], Vickers, Sons and Maxim, Limited, January 22, 1898," NARA, Dr 188-9-2.



Barriers of underwater mines, such as those shown in this 1900 plan for Boston Harbor, required the construction of special facilities on shore.

seen as particularly valuable in the light of Civil War experience. It was certain, too, that submarine mines would have a role, and as the years passed, searchlights, power plants, and special apparatus for accurately locating attacking vessels were also added to the list. All of these accoutrements were more or less part of defenses in other nations, but military engineers in the United States combined or manipulated them in a distinctive fashion.[21]

We can gain some sense of how much things changed during the incubation period of 1865 - 1890 by looking at the evolution of emplacement designs for the disappearing carriage. The assumption that earth and stone would be appropriate building materials carried on well into the 1880s, and it was only until the full impact of available technology had impressed the designers that these plans began to reflect growing awareness that former building materials were no longer appropriate. Although no one knew exactly what a disappearing carriage might look like, there was growing agreement that it would be mechanically complex and would require a level of maintenance not previously necessary. The emplacement would have to be clean and dry, its foundations capable of supporting perhaps hundreds of tons, and its interior adequate for safely housing explosive ammunition. Sod-covered magazines and stone platforms would not answer. The weapons brought about by new technology were so different that now the gun and its carriage determined the shape of the fortifications containing them, reversing the relationship that had held sway for hundreds of years. The cost of fortifications and weapons also reversed. Steel breech-loading cannon and their mounts were enormously expensive, and for the first time it cost more to build the cannon and its carriage than it did the structure that contained them.[22]

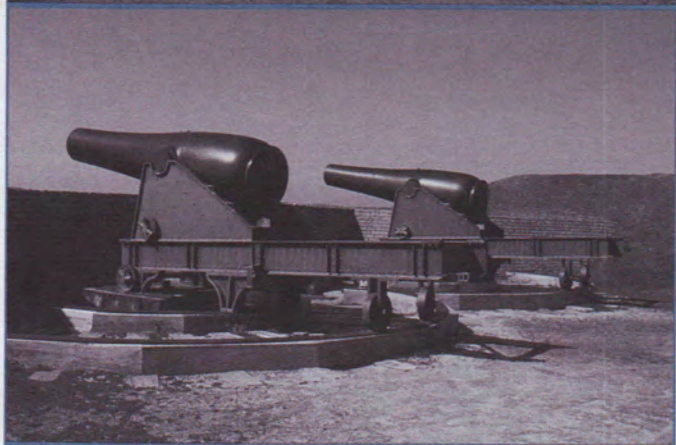
In response to the new requirements, engineers continued to modify their provisional designs. The single room of the magazine became two–one for powder and one for projectiles–and the floor elevations were dropped far below the level of the gun to provide greater over-head protection. Concrete was the construction material, but it was faced on its seaward side with a heavy bank of earth, earth having proven itself the best ally of fortification. The emplacement had become little more than a large concrete block with two hollows in its interior. By the early 1890s, the designs had progressed no further; any additional details had to await the selection of a type disappearing carriage for use in the defenses. That decision came in 1894, and as a result, the earthen bench at the rear of the emplacement that had appeared in some earlier designs was resurrected as a tall, arc-shaped platform of concrete from which the cannon would be loaded.

[21] 43rd Congress, 1st Session, Annual Report of the Chief of Ordnance, Ordnance Memoranda No. 16, n.p.

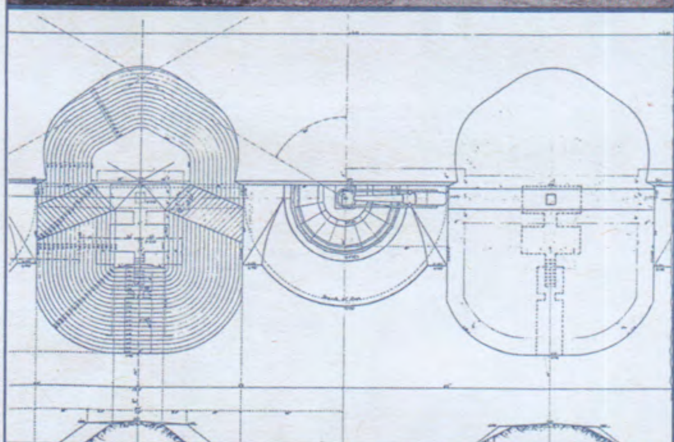
[22] Lewis, 78.

Evolution of Emplacement Design

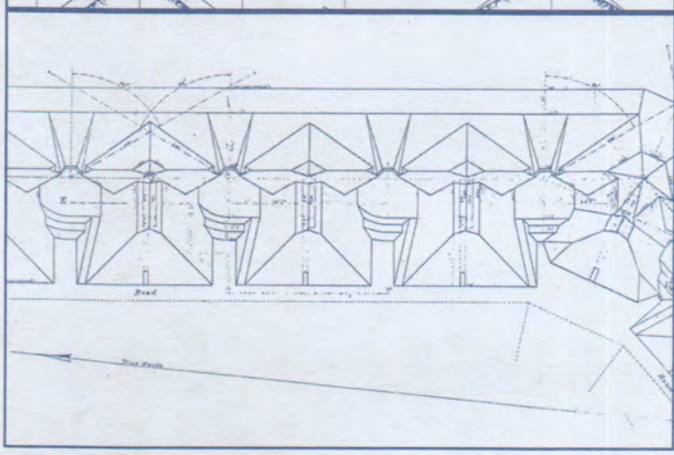
Earth. During the Civil War, many new fortifications were built of earth. Despite their apparent informality, they were functional and economical, yet intended for only temporary use. This view portrays a land battery protecting Washington, DC. Notable features include the mound-shaped magazine between the gun emplacements, the central entry to the magazine, and the lower floor level of the magazine relative to the gun emplacement.



Masonry Supplements. The modest improvements in coast defenses in the 1870s followed closely the pattern of Civil War fortifications. Doorways and parapets that had been fashioned in wood were now rendered in brick and stone masonry to achieve a greater degree of permanence. The most visible change was the practice of mounting two guns in each emplacement.

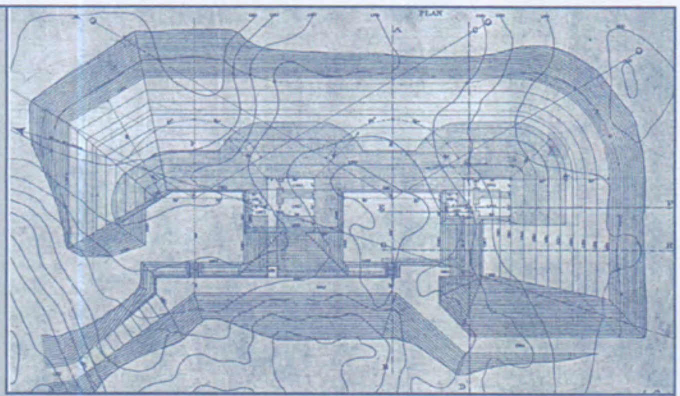


Increased Protection. Growing concern with the destructive power of ship-borne cannon and the planned introduction of breech-loading cannon in future fortifications led to manipulations to, but no real departure from, the simple outlines of the 1860s and '70s. This 1881 study retains earth as the basic construction material, but in amounts not seen before: the mounds over the magazines reach almost 30 feet above the natural surface of the ground.

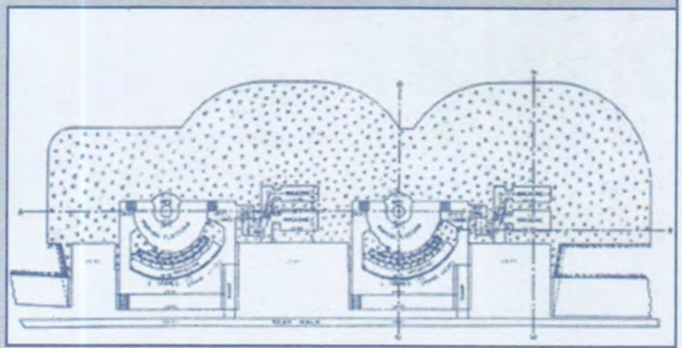


Specialized Functions. By 1884, the changes had become dramatic. The emplacement was now much larger in recognition of the growing size of modern ordnance. The overall height of the battery has been reduced by dropping the magazine below the floor level of the emplacement, creating the first appearance of the two-story design that would characterize the gun batteries of the 1890s. The magazine has also become two rooms, presumably one for powder and one for projectiles.

Growing Refinement. Changes continued over the next several years to make the emplacement less conspicuous. As shown in this 1892 drawing, the earth and concrete protection has been placed in front of the emplacement rather than on top of the magazine in recognition of the flat trajectory of naval gunfire of the time. The two rooms of the magazine have been rearranged and the loading gallery has been replaced by a shaft through which projectiles and powder will be hoisted up to the level of the gun. The large empty rectangles where the guns would sit have been left blank intentionally since at this time it was uncertain which type of disappearing carriage would be adopted.



Initial Service Standard. The United States adopted the Buffington-Crozier disappearing carriage for service in 1894, and in that same year, the Corps of Engineers completed a design for an emplacement that would actually be constructed. The only significant difference from the 1892 plan is that the emplacement has been more thoroughly detailed to accommodate the carriage. An unexpected feature is that the arc-shaped area behind the gun, not seen since the 1881 design, has reappeared. This basic two-story emplacement could be combined to create complexes or batteries of considerable length. Although it went through many improvements through the years, it was to serve as the basic format for almost all batteries with large-caliber guns.



Final Improvements. The two-story design posed a number of problems, but it was only at the twilight of the disappearing carriage that engineers abandoned its use in favor a more efficient structure. The best examples of the 1914 single-story emplacement remain intact at Batteries Osgood and Farley, Fort McArthur, near Los Angeles. This 1937 aerial photo shows those two batteries and their companions, and depicts another aspect of change common to almost all fortifications: the increasing demands for other uses on the lands they occupy.

Congress funded the new coast defenses lavishly, and construction of emplacements was soon in progress in many harbors. Almost immediately, there were calls for changes based on experience and the availability of new devices, and in response change became a constant in a way that had no earlier parallel. Two aspects of program–size and the specialized function of interior spaces–illustrate the point. In the nine years between the prototype design of 1894 for 10-inch guns and the final version of 1903, the amount of interior space devoted to rooms and corridors increased by 40 per cent. It was not just that the emplacements themselves were getting larger (the percentage of area devoted to circulation actually decreased over the same period), they were gaining new spaces for new functions. The powder room and projectile room that had been the sole original tenants were joined quickly by other spaces that provided direct support to the ordnance mounted above. Later designs included rooms for storage batteries, tools, maps and charts, oil, stores, ammunition hoists, relocating (a component of fire control), offices, and lavatories.[23]

It was not just that the emplacements themselves were getting larger (the percentage of area devoted to circulation actually decreased over the same period), they were gaining new spaces for new functions.

Although there was collaboration among the engineers engaged in fortification construction (expressed by formal guidance from the Chief of Engineers and informal correspondence between the scattered engineer officers doing the actual work) and collaboration tended to blur authorship, several individuals emerged as leaders in the field. Henry Larcom Abbot conceived and built the prototype seacoast mortar battery with its characteristic four emplacements at the corners of an imaginary rectangle, the center occupied by a common magazine. Eben Evelth Winslow achieved note as the recorder and interpreter of concrete fortifications from the 1890s though World War I. Two others attract most of our attention here because they compare most favorably with the impact made by Barnard and Totten.

Suter's Idea: Hoistless Design. Charles Suter became the engineer in charge of construction at San Francisco during the time that the construction of modern works was just beginning. He immediately recognized something that his peers had overlooked. The interior floor plans of emplacements were arranged horizontally although the greatest need was for vertical movement: the transportation of heavy ammunition from the magazine up to the gun. Carts or ceiling trolleys worked well as long as the need was limited to shifting back and forth, but they did nothing to bring projectiles and powder to where they were ultimately needed. Block and tackle, and later specially designed hoists, provided the vertical lift, but Suter's concern focussed on what might happen if that mechanical connection

[23] E. E. Winslow, *Notes on Seacoast Fortification Construction*, Occasional Papers of the United States Engineer School, No. 61, (Washington: GPO, 1920), plates XIII - XVII. The engineers believed that the rooms should be used for functions appropriate to their titles, but the artillery troops who manned the fortifications employed them with much greater freedom. For example, a 1903 inventory of rooms in the main battery of Fort Worden, Washington, lists a storage battery room housing commissary supplies, a chart room being used to store paints and oils, and a guard room used to contain the crates for transporting the commanding officer's private furniture. NARA, Drawer 103, Sheet 12 12-14.

should fail. Without a secure and failure-free method of getting ammunition to the gun, the fortifications could become useless at their most critical hour.

While others accepted hoists as a necessary evil, Suter believed that the elimination of vertical movement was the fundamental and most compelling problem in fortification design. "The abolition of lift is of so much importance as to justify almost anything," he wrote to one of his counterparts, and he committed to a series of designs in San Francisco that proved him to be both an iconoclast and a pioneer.[24]

A half-ton projectile mid-way in its journey from the lower level of the emplacement to the breech of the gun. Battery Spenser, Fort Baker, San Francisco, California.

Suter's designs pushed the two levels of the conventional gun emplacement together, placing all interior and exterior spaces at about the same level, an innovation that meant that ammunition could be delivered to the gun without a hoist. Vertical movement was gone, although the physical changes necessary to its removal did alter the profile of the emplacement. Those changes made it more visible, a disadvantage overcome somewhat by the considerable height of the fortifications above the sea. These solutions were distinctly different and not always appreciated. Several years after Suter left San Francisco, a commentator sniffed in a remark that he scrawled across a drawing for Battery Saffold at Fort Winfield Scott that this was "one of Col. Suter's plans which do not follow type at all."[25]

Others were more interested in Suter's ideas, and among them was Harry Taylor, building fortifications in Puget Sound while Suter was at work in San Francisco. Taylor was impressed with what Suter had accomplished, and tried his own hand at an all-horizontal design at Fort Worden. His was a more radical approach than Suter's, and when the artillery forces arrived in 1902 to man the seven emplacements of the main battery that Taylor had built, they were staggered by what they saw. It was too extreme, and after much debate, it was rebuilt along more conventional lines a few years later.

Suter left San Francisco late in 1898 for Boston, and Taylor joined him in 1901. More hoistless designs followed, although research remains inconclusive about the contributions of each individual. Certainly Taylor, perhaps chastened by reaction to his design at Fort Worden, devoted much of his talent to perfecting a safe and reliable mechanical ammunition hoist that was subsequently fitted to all

[24] As quoted in David M. Hansen, "'With Nearly Every Problem Solved,' The Development of Mechanical Ammunition Hoists in America's Coastal Fortifications," *Coast Defense Study Group Journal* 12 (November, 1998), 18. The discussion in this publication of the role of Suter and Harry Taylor is based on research completed for the referenced article and is not further annotated here.

[25] NARA, untitled plan dated January 24, 1905, Dr 94 Sht 127-4.

Charles Suter's seminal design for a single-story battery.

large-caliber gun batteries. The most important product of the Boston designs was that for a single-level battery for six-inch guns that, with some improvements, the Chief of Engineers adopted as a standard type in 1903. It was the ancestor of all single-story battery and emplacement designs that followed, embracing the last of the fortifications built for disappearing carriages as well as the construction of the massive and heavily protected batteries of World War II that announced the end of fortifications in the United States.

The history of permanent defense extends from the familiar to the unusual, from unit-based materials to mass-based materials, and from periods of technological stability to periods of technological change. The theme that unites these dissimilarities is the skill of the designer. That person might be a French-trained military architect building with brick and stone or a West Point military engineer building with concrete, steel, and iron, but they were one with each other in their desire to complete fortifications that were modern, functional, and handsome. The identification and protection of this unique category of resources requires an even hand, one willing to accept structure as well as architecture. It also requires the understanding that the quality of significance does not necessarily occupy the obvious, a truism that is more pronounced when we accept that a resource can be a single large unit as well as one whose components are widely distributed.

Evaluating the Resource

The discussion above about the historical progression of fortifications has been a quick overview of some of the aspects of significance that help us develop an understanding of them as resources. Every permanent fortification in the United States shares a common heritage, and some have unique attributes as well. It is the function of preservation to plan and carry out measures that will help keep intact the physical expressions of that heritage. We can comprehend significance, but we can't see it. That is why we need to care for fortifications if we accept them as being important.

As with all historic buildings and structures, fortifications have character defining-features that help reflect their importance, and it is these features that are the subject of much preservation work. Their identification is an important step, and those engaged in it use a common set of widely understood qualities that are based on familiar prototypes: houses, churches, schools, and all the other entries in the catalog of building that shapes the texture of the places we live. The character-defining features are recorded on inventory forms as the result of a careful survey. There are no such widely understood qualities for fortifications, and the survey forms developed for other building types are not suitable.

Presented in the pages that follow are three types of inventory forms that have been developed specifically for fortifications, and recognize the materials and pat-

Some fortifications include unusual character-defining features such as these "tree rings" at Fort Ebey, Washington. Although the trees that they encircled are now gone, the rings themselves are still in place today.

terns of the building type. The Historic Fortifications Field Form and Checklist is a simple tool that can help identify the important features of any concrete fortification. It was originally developed for use in the *Seacoast Fortification Preservation Manual*, published by the National Park Service in 1999; it has been expanded and revised here. The Historic Properties Condition Assessment predates the Field Form, but it is included here as the second of the three types because of its complexity. It was prepared in 1997 as part of an extensive evaluation of the fortifications managed by Washington State Parks. The last example is based on materials extracted from the Historic Fortifications Condition Assessment Workshop Report prepared in 2002 by the National Park Service for Fort Pickens, Florida. The Workshop Report is the most elaborate of the inventory form examples (and the only one that is in an electronic data base format), and is also an excellent example of translating the observed condition of a feature into a cost estimate for repair or rehabilitation.

Historic Fortification Field Form and Checklist

As the name suggests, the Field Form is meant to be completed while present on the ground and observing the subject of the form. The front page consists of a title block and Features Inventory, which lists a series of typical character-defining features. The back page is devoted to Features Condition. The form was designed and tested with the idea that those completing it would have little knowledge of or experience with fortifications; it is suitable for use with volunteers. Regardless of the level of skill, those who will be completing the form will need orientation to be sure that everyone has the same understanding of what the features are so that the forms as a collection will be consistent.

Features Inventory: The box on the left-hand side of the page identifies the subject of the form, who has prepared it, and the date the information was entered. The type of inventory—initial, follow-up, or special—allows the form to be used in several ways. The initial recording establishes a base line against which further changes in the resources can be measured. When used as a follow-up, the form is filled out again, but only the Features Condition side, since the identification of features needs only to be completed once. An annual follow-up is best, but the interval should be no longer than five years.

To begin using the form, check off the most conspicuous construction materials in the Primary Materials section. Most fortifications of the period of concrete construction several (and sometimes all) of these materials in their construction, but select only the most prominent when completing the form.

Resource Integrity is divided into two categories, Site Only and Extant. Extant means that the resource is still in place, even though it may be in poor condition. The Site Only category is for those resources that have disappeared, and may be only identified by a concrete slab or piers or perhaps a depression in the ground. The sites of buildings are important to understanding how the fortifications worked as a system, and can be the focus of special interpretation.

The inclusion of a photograph is another way to further identify what resource is being inventoried, and can also be a quick reference for changes in condition.

The form was designed and tested with the idea that those completing it would have little knowledge of or experience with fortifications.

On the right-hand side is the Features Inventory itself, a series of boxes divided into three categories: site, exterior, and interior. Check the box if the feature exists, leave it blank if it does not. Some features have lists after them; draw a circle around the features that exists. For example, there are six choices in the "iron or steel" feature. Circle doors or drain covers if they are present, and ignore sash, shutters, ladders, and railings if they are not.

Features Condition: Now that we know what features are present, use the back of the form to record the visible indicators of their condition. The left-hand side of the Features Condition page lists most of the same features identified in the inventory; those features that are listed in the Features Inventory but that do not appear in the Features Condition (additions, for example) are subsumed in other features. For each feature identified in the inventory, check off all of the Condition Indicators that apply. Not all of the Condition Indicators are likely to be appropriate; in that case, leave them blank.

The Historic Fortification Field Form and Checklist has a number of advantages: it is comprehensive, adaptable to a number of resource types, and requires a minimal amount of training to use. The Condition Indicators also lead into the solutions that are discussed in other parts of the *Handbook*. It does have limitations. The Features Inventory and Condition sections are based on concrete as a construction material, and they are an awkward fit for anything else. The Features Condition section is a place to record presence or absence, but it does not provide any method of indicating degree. In addition, it concentrates narrowly on structures, and does not include features and conditions related to historic landscapes in which the fortifications are placed. Some of these disadvantages are resolved in the next example.

Historic Fortification Field Form and Checklist — Features Inventory

Fort: ____________ Date: ________

Structure: __________ No: ________

Prepared by: ________________

Face: ______ Tier: ______ Space: ______

❑ Initial ❑ Follow-up ❑ Special

Primary Materials:

❑ Brick ❑ Stone
❑ Concrete ❑ Iron/Steel
❑ Wood ❑ Earth

Resource Type:

❑ Battery ❑ Emplacement
❑ Magazine ❑ Fire Control Structure
❑ Casemate ❑ Mine Structure
❑ Power Plant ❑ Searchlight Shelter
❑ Other ❑ Dependent Structure

Resource Integrity:

❑ Site Only ❑ Extant

Additional Notation:

Site Features Associated with the Resource:

- ❑ Berms/depressions
- ❑ Roadways/walks
- ❑ Stairways/ramps
- ❑ Retaining walls
- ❑ Significant view to water or other resource
- ❑ Gutters/drains

Exterior Features Associated with the Resource:

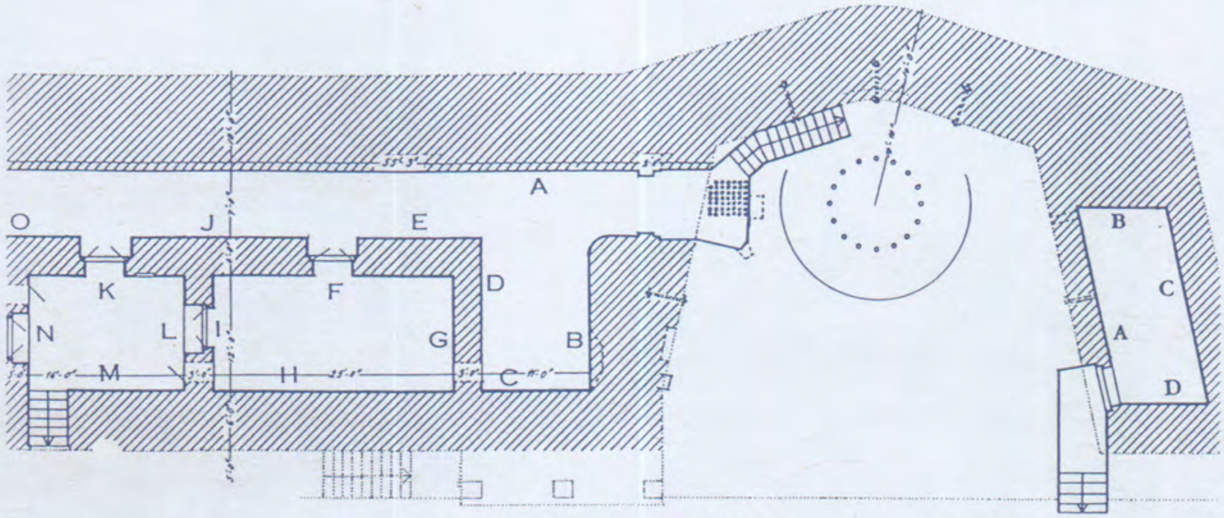
- ❑ Wall finishes
- ❑ Floor finishes
- ❑ Jointing pattern
- ❑ Earth fills, covers, or slopes
- ❑ Iron or steel doors/sash/shutters/ladders/railings/drain covers
- ❑ Wood doors/sash/shutters
- ❑ Additions (splinterproofs, platform extensions, other)
- ❑ Surviving equipment
- ❑ Historic signage/paint schemes
- ❑ Gutters/drains

Interior Features Associated with the Resource:

- ❑ Wall finishes
- ❑ Floor finishes
- ❑ Jointing pattern
- ❑ Iron or steel doors/sash/shutters/ladders/railings/drain covers
- ❑ Wood doors/sash/shelves/cabinets
- ❑ Flat/arched ceiling
- ❑ Surviving equipment
- ❑ Historic signage/paint schemes
- ❑ Gutters/drains

Historic Fortification Field Form and Checklist — Features Condition

Features/Condition Indicators	Dampness, standing water	Discoloration, efflorescence	Cracking within a material	Separation of different materials	Deflection, material failure	Settlement	Material loss, exfoliation, spalls	Missing, defaced, damaged features	Obscured views or building locations	Soil, organic accumulation	Trails, uses that degrade resource	Plant growth, mildew, fungus
A. Site Features												
1. Berms/depressions												
2. Roadways/walks												
3. Stairways/ramps												
4. Retaining walls												
5. Significant views to water, other resources												
6. Gutters, drains												
B. Exterior Features												
1. Walls												
2. Floors												
3. Earth fills, covers, or slopes												
4. Iron or steel doors/sash/railings/ladders												
5. Wood doors/sash/shutters												
6. Surviving equipment												
7. Historic paint schemes/markings												
8. Gutters, drains												
C. Interior Features												
1. Walls												
2. Floors												
3. Ceiling												
4. Iron or steel doors/shutters/beams												
5. Wood doors/windows/shelves/cabinets												
6. Historic paint schemes/markings												
7. Surviving equipment												
8. Gutters, drains												



BATTERY RANDOLF (FORT WORDEN) EMPLACEMENT ONE

Condition inventory can be raised to a higher level of detail by using a floor plan. In this example, a letter identifies the elevation of each room, making it possible to make remarks that are specific to a location.

Historic Property Condition Assessment

The Historic Property Condition Assessment was developed for use in the 1996 inventory of former coastal fortifications administered by the Washington State Parks and Recreation Commission. It is an extensive form consisting of a summary or face sheet, scoring guides for historic and architectural significance, a separate guide for evaluating condition, and an estimate of preservation and rehabilitation costs. It also includes photographs and small reference drawings, which have not been reproduced for the *Handbook*.

As the name suggests, the summary sheet contains a precise of the evaluation. Of greatest interest as an inventory form is the second line of the sheet and its indications of historic value, architectural value, condition, and the Assessment Index.

The Assessment Index is an important feature of the HPCA since it represents in a single figure the cultural value of the resource compared to its condition. Since one of the difficulties in assessing fortifications is determining their value as historic properties, the HPCA established a scale of historic and architectural attributes that would apply to all features included in the assessment. Each statement in the scale was given a range of numerical values, and the final cultural score was the sum of the values in the scales. The method avoided opinions that were subject and unconnected with any uniform system of evaluation, and it was also transparent in that the source of the values were reproduced as part of the inventory form. Condition values were based on a multiple-choice format of common aspects of deterioration and safety hazards, and these too were given numerical values. In this way the frequently haphazard classifications of good, fair, and poor were avoided in favor of a more accurate appraisal. The cultural component—the historic and architectural values—has a minimum value of 300 as does the condition component. The Assessment Index presented both figures as a single pair; and AI of 300/300, for example, would represent a fortification element that had the highest scores possible in its historic and architectural values (the first 300) and was in perfect condition (the second 300). In the example from Fort Worden that is reproduced here, the AI of 265/160 for Battery Randol indicates a significant resource that is in need of attention.

The summary form contains a third line that identifies the cost of several treatments: No New Action (maintenance level costs), Preservation, and Rehabilitation. The figures are supported by more detailed estimates that are also part of the HPCA, and emphasize that one of the primary purposes of the condition assessment project was the creation of budget estimates for future funding requests. The page also includes brief statements regarding significance and interpretive potential, as well as comments on condition.

The Assessment Index permits the rapid comparison of many different resources.

The Historic Properties Condition Assessment format has a number of strong points. It uses a method of comparing similar resources based on significance and need, an important consideration when it comes to assigning scarce dollars to preservation projects. The Assessment Index permits the rapid comparison of many different resources, also important if the resources number in the hundreds, as is the case with Washington State Parks. The multiple choice scorecard helps establish a uniform approach to significance and condition, and the format supplements the numerical values with an explanatory text. It is comprehensive and flexible within the scope of its subject matter, and indicates both the nature and degree of deterioration.

The format also has weaknesses. While it is comprehensive, it is also complex. It cannot be updated conveniently, and the budget estimates can be easily mistaken for estimated construction costs. Considerable familiarity in military architecture, preservation practice, and estimating are required for its completion; it is unlikely that non-professionals could be trained to complete the Condition Assessment in all of its parts. As with the Historic Fortification Field Form, it presumes that all of the features to be encountered are made of concrete, and it is difficult to adapt the condition statements to non-concrete structures. Perhaps the most significant compromise is the very thing that makes it unique: the creation of numerical values for significance and condition. Because the range of possible scores is so broad (from 0 to 300), the selected values become artificially precise. While the values were intended to inform management choices rather than direct them, it became confusing to look at similar resources with slightly different scores. Was the difference between a score of 260 and one of 265 important? It was not, and a simpler and more satisfactory way of describing condition (but not significance) belongs to the final example.

Historic Property Condition Assessment

PARK:	STRUCTURE NAME:	DATE:	NUMBER:
Fort Worden	Battery Randol	6/30/97	WO-08
HISTORIC VALUE:	**ARCHITECTURAL VALUE:**	**CONDITION:**	**ASSESSMENT INDEX:**
130	135	160	265/160
NO NEW ACTION:	**PRESERVATION:**	**REHABILITATION:**	
0	751,400	51,100	

SIGNIFICANCE APPRAISAL:

The main battery was built in 1898 and consisted of seven emplacements for barbette mounted guns of 10- and 12-inch caliber. The battery was designed as two pairs of emplacements and one group of three; collectively, these three sets were linked by a continuous concrete curtain wall and walkway to the rear. The original armament included an altered barbette carriage, a remnant of the early experiments with disappearing gun mounts on the east coast. The battery was rebuilt in 1905 when its experimental method of handling ammunition did not prove satisfactory, and it acquired a wholly new appearance as a result. Battery commander stations were added to the roofs of the detached structures in 1914; an iron bridge connected these stations with the battery proper. The guns of Battery Randol were removed during VAU, and those of Battery Quarles in 1941, when they were transferred to Canada. The armament of Battery Ash was removed in 1942.

INTERPRETIVE APPRAISAL:

Batteries Randol, Quarles, and Ash are among the most significant in the development of American coast defenses of the Endicott period. Their planning, conducted under the guidance of Harry Taylor, a noted fortification designer, represented an alternative albeit unsuccessful effort to eliminate the dependence upon a mechanical ammunition hoist. Unique as well is the use of separate structures to house service spaces which could not be accommodated in the battery itself. The later modification of the battery gave it a distinctive appearance that set it apart from all other gun batteries. The shifting of one of the 12-inch guns from emplacement five to emplacement seven in 1906 also represented the continuing desire to strengthen the lightly defended western approach to Admiralty Inlet. The addition of the battery commanders stations indicated the changing role for the battery commander and reflected the return of that officer to the battery under his charge.

CONDITION ASSESSMENT:

Battery Randol is a two gun battery constructed of mass concrete and is part of the Main Battery at Fort Worden. The structure is composed of two gun emplacements with a centralized powder magazine. The emplacement base and blast apron are constructed of mass concrete of 20 to 15 feet in thickness. The corridor is protected by a canopy of reinforced concrete supported on two foot square concrete columns. The B.C. station is a reinforced concrete observation station atop a concrete building with walls of approximately three feet in thickness. An iron bridge, now demolished, once connected the B.C. station with the battery.

The blast apron and interior walls have large horizontal fractures and spalling at the vertical construction joints. The interior wall has horizontal fractures at mid-height in the wall. Small cabinet doors are missing, other doors are pitted with rust. "I" beams embedded in the canopy above the corridor are pitted with rust. The delivery table for gun #1 is missing. The overhead steel track is missing. Guard rails are missing. The roof above powder magazine #I has a large fracture on the sidewall. A bitumen material has been placed in the patterned joints of the roof of the magazine.

The B.C. Station has spalled concrete at view ports, rusted shutters, and door rusted closed. Vertical fractures run through the structure below the B.C. Station. Small vertical and horizontal fractures in the concrete walls are filled with bitumen materials. Vegetation covers the superior slope of the parapet. Cranes are missing.

Historic Property Condition Assessment

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130	135	160	265/160
NO NEW ACTION:	**PRESERVATION:**	**REHABILITATION:**	
0	751,400	51,100	

	PRESERVATION	REHABILITATION
GENERAL		
Remove blast apron, excavate, waterproof, install drainage system, backfill, install new blast apron	310,000.00	
Excavate, waterproof, install drainage system, backfill add sod	60,000.00	
Clean, prepare & waterproof surface	210,000.00	
Clear gutters & drains, install drainage system	32,000.00	
Prepare & paint interior surfaces	28,000.00	
UPPER LEVEL		
Observation Station		
Clean surfaces	600.00	
Gun Emplacement #1		
Remove debris, clean surfaces	2,600.00	
Repair spalled concrete	6,000.00	
Repair & paint steel doors	2,400.00	
Replace guardrails		8,600.00
Replace missing cabinet doors		2,100.00
Corridor		
Remove debris, clean surfaces	1,000.00	
Repair & paint steel doors	2,800.00	
Replace guardrails		6,000.00
Observation Station		
Clean surfaces	600.00	
Repair ladder	600.00	
Install guardrails		6,000.00
Repair spalled concrete	6,000.00	
Gun Emplacement #2		
Remove debris, clean surfaces	2,400.00	
Repair spalled concrete	14,000.00	
Replace missing cabinet doors		1,600.00
Repair & paint steel cabinet doors	800.00	
Replace guardrails		8,600.00
Observation Station		
Clean surfaces	600.00	
Repair concrete spalls	2,400.00	
LOWER LEVEL		
Storeroom, Gun #1		
Remove debris, clean surfaces	1,200.00	
Remove graffiti	600.00	
Repair & paint steel doors	2,400.00	
Shot Galley		
Remove debris, clean surfaces	4,000.00	
Remove graffiti	600.00	
Repair & paint steel doors	4,800.00	
Replace missing cabinet doors		2,100.00

Historic Property Condition Assessment

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NO NEW ACTION:	**PRESERVATION:**	**REHABILITATION:**	
0	751,400	51,100	

	PRESERVATION	REHABILITATION
LOWER LEVEL (CONTINUED)		
Hoist Room		
Remove debris, clean surfaces	1,200.00	
Repair & paint steel doors	2,400.00	
Powder Room		
Remove debris, clean surfaces	1,200.00	
Repair & paint steel doors	4,800.00	
Remove ceiling	1,000.00	
Storeroom		
Remove debris, clean surfaces	1,000.00	
Repair & paint steel doors.	2,400.00	
Shot Gallery		
Remove debris, clean surfaces	600.00	
Replace cabinet doors		2,100.00
Powder Room		
Remove debris, clean surfaces	1,200.00	
Repair & paint steel doors	4,800.00	
Remove ceiling	1,000.00	
Hoist Room		
Remove debris, clean surfaces	1,200.00	
Repair & paint steel doors	1,800.00	
Storeroom, Gun #2		
Remove debris, clean surfaces	1,000.00	
Repair & paint steel doors	2,400.00	
Repair concrete spalls	4,600.00	
B.C. Station		
Remove debris, clean surfaces	1,000.00	
Repair & paint steel doors	2,400.00	
Repair & paint steel shutters	2,400.00	
Replace steel shutter		2,000.00
Replace iron bridge		12,000.00
B.C. Storeroom		
Remove debris, clean surfaces	800.00	
Repair & paint steel doors	2,400.00	
Plotting Room		
Remove debris, clean surfaces	800.00	
Replace steel doors	2,600.00	
Storeroom		
Inaccessible—no observation		
Latrine		
Inaccessible—no observation		
TOTALS	$751,400.00	$51,100.00

Historic Property Condition Assessment

PARK:	STRUCTURE NAME:	DATE:	NUMBER:
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0	751,400	51,100	

ATTRIBUTE SCALE FOR COAST DEFENSE RESOURCES

HISTORIC SIGNIFICANCE		
Associated with specific events or individuals of national significance within the coast defense program	121 – 150	(130)
Associated with specific events or individuals significant to the Puget Sound/ Columbia River coast defenses	91 – 120	
Associated with specific events or individuals of limited duration or impact, or of particular interpretive value	61 – 90	
A contributing site or structure whose function is documented and known, and is broadly representative of the practice of coast defense	31 – 60	
A contributing site or structure whose function is documented and known, but without association with any specific events or individuals significant in the history of American coast defense	1 – 30	

ARCHITECTURAL SIGNIFICANCE		
A prototype design or one associated with significant issues in the development of the national coast defense program, or an important example of the work of a notable engineer/military architect	121 – 150	(135)
A non-standard design that represents adaptations to particular circumstances in the Puget Sound/Columbia River coast defenses	101 – 125	
A standard design employed throughout the national coast defense program, but with modifications based on circumstances in the Puget Sound/ Columbia River coast defenses	76 – 100	
A standard design or feature characteristic of the national coast defense program, or a locally important feature of modest scale exhibiting no significant modifications	51 – 75	
The site of a building or other structure containing intact components that are significantly associated with the nature of the demolished building or structure	26 – 50	
Tile site of a building or structure that does not contain intact components sufficient to evoke the nature of the demolished building, or structure.	1 – 25	

Historic Property Condition Assessment

PARK:	STRUCTURE NAME:	DATE:	NUMBER:
Fort Worden	Battery Randol	6/30/97	WO-08
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130	135	160	265/160
NO NEW ACTION:	**PRESERVATION:**	**REHABILITATION:**	
0	751,400	51,100	

FROM A BASE OF **300,** DEDUCT (140)

Inappropriate previous repair	(5) – 10
Non-structural metalwork displays extensive rust and scaling	(5)
Non-structural metalwork rusted away or penetrated by rust	10
Structural metalwork displays extensive rust and scaling	(10)
Structural metalwork rusted away or penetrated by rust	15
Concrete surface crazed with a network of small, closed cracks	(10)
Concrete horizontal surfaces marked with cracks filled with tar or grout; filling intact (deduct 15 for missing filling)	(10)
Concrete vertical surfaces marked with visible cracks at cold joints	10 – (20)
Cracks at cold joints open and visibly weathering	15 – (30)
Cold joints open, parging broken, concrete mass visibly eroding	(20) – 40
Concrete broken or spalled away	(5) – 15
Deep, continuous vertical cracks	5 – (10)
Vegetation growing on or in structure	(5) – 10
Wooden elements or wooden structures deteriorated or interiors open to the weather	10 – 35
Notable erosion around or under structure	10 – 40
Hazard: unprotected vertical drop of more than 5 feet	(10)
Hazard: broken or disrupted walking surface	5 – 15
Hazard: obscured drop, broken concrete, or protruding metal	5 – 15
Hazard: interior vertical drops or uncovered interior openings	5 – 10
Hazard: heavy accumulation of debris	10
Hazard: standing water	5 – 10

Historic Fortifications Condition Assessment (NPS)

The Historic Fortifications Condition Assessment Workshop Report was the product of National Park Service staff from Fort Pickens and the NPS Historic Preservation Training Center in Frederick, Maryland. During a three-day period, the group developed a complete nomenclature system for the brick masonry fortification. Called the Fort Feature List, it greatly enlarged the number of traditional architectural terms used to describe fortification elements, making them more precise for the information-gathering portion of the survey and more useful as well by the inclusion of a measurement unit to help in cost estimating. The list is reprinted on page 2.35.

Several teams then examined areas of the fortification where preservation issues were known to exist. They identified the features in those areas and prepared the Feature Inventory Condition Assessment forms, collecting information for each feature in the fields on the form. Although the Workshop Report is not yet complete, several examples of the draft report are included on the following pages to give a sense of what it would look like.

The Feature Inventory Condition Assessment form portrays the results of the assessment on a single page. It includes an Historic Rating, based on classifications used by the National Park Service, but it does not contain any other discussion of significance. The Feature Description and Feature Notes sections encourage the accurate identification of the exact feature of the fortification that is being reported by the form, and the Deficiencies section provides for a more explicit description of the problems. Although not completed as part of the condition assessment at Fort Pickens, the Recommendations section is intended to suggest treatments that would resolve the deficiencies. An example of the form as prepared for the southeast bastion at Fort Pickens is reproduced below.

Feature Inventory Condition Assessment
Fort Pickens, Southeast Bastion

EXTERIOR LEFT FACE WALL SURFACE BRICK

FEATURE DESCRIPTION:

Brick masonry construction, "liverpool bond", brick projecting and corbelled cordon courses (4 courses topped with soldier course)

FEATURE NOTES:

No openings this face. Earth fill at interior of wall of bastion. Historic masonry repairs made with portland based mortar.

Feature Condition: Fair
Historic Rating: Historic
Total Inventory: SF
Priority: Serious

DEFICIENCY:

Approximately 30 square feet of spalled brick surfaces at center with large through-wall crack. Wall surface crazed with series of deep hairline cracks approximately 25 feet from NE angle. Surface spalling of brick associated with portland type mortar. Evidence of water seepage at top of wall under cordon and at bottom of wall. NOTE major crack at corner with crack monitor near Salient Point of Bastion.

RECOMMENDATION:

Materials: Labor: Quantity: Total = $0.00

National Park Service Fort Feature List

Feature Name	Meas. Unit
EXTERIOR	
EXT LEFT FACE WALL	SF
EXT LEFT FLANK WALL	SF
EXT RIGHT FACE WALL	SF
EXT RIGHT FLANK WALL	SF
EXT SCARP/COUNTERSCARP WALL	SF
BREASTHEIGHT WALL	SF
EXT BLINDAGE WALL	SF
EXT PARADE WALL	SF
CORDON	LF
COPING	LF
EXT PIER/COLUMN	EACH
EXT ARCH	EACH
EXT CEILING/CANOPY	SF
EXT CEILING/CANOPY STRUCTURE	SF
EXT CEILING/CANOPY UNDERNEATH FINISH	SF
EXT CEILING/CANOPY TRIM	LF
EXT FLOOR /DECKING	SF
TERREPLEIN	SF
BANQUETTE	SF
TRAVERSE CIRCLE	EACH
PINTLE BLOCK	EACH
GLACIS	SF
EXT RAILING	LF
EXT EMBRASURE/LOOPHOLE	EACH
EXT EMBRASURE CHEEK WALL	EACH
EXT EMBRASURE SILL	EACH
EXT EMBRASURE ARCH	EACH
EXT POSTERN	EACH
EXT POSTERN CHEEK WALL	EACH
EXT POSTERN THRESHOLD	EACH
EXT POSTERN ARCH	EACH
EXT GRILL	EACH
EXT DOOR ASSEMBLY	EACH
EXT DOOR FRAME	EACH
EXT DOOR	EACH
EXT DOOR TRIM	LF
EXT DOOR HARDWARE	EACH
EXT DOOR SILL/THRESHOLD	EACH
EXT DOOR STORM/SCREEN	EACH
EXT DOOR SHUTTER/BLIND	EACH
EXT DOOR LINTEL	EACH
EXTERIOR FINISH	SF
EXT STAIR/RAMP SURFACE/COVER	LF
EXTERIOR STAIR/RAMP STRUCTURE	EACH
EXT STAIR/RAMP RAILING	LF
EXT FORT: OTHER	EACH

Feature Name	Meas. Unit
INTERIOR	
INT LEFT FACE WALL	SF
INT LEFT FLANK WALL	SF
INT RIGHT FACE WALL	SF
INT RIGHT FLANK WALL	SF
INT SCARP/COUNTERSCARP WALL	SF
INT MINE WALL	SF
INT BLINDAGE WALL	SF
INT PARADE WALL	SF
INT PIER/COLUMN	EACH
INT FIREPLACE	EACH
AMMO STALL	EACH
INT VENT	EACH
INT ARCH	EACH
INT GROIN/BARELL VAULT	EACH
INT FLOOR SURFACE/COVER	SF
INT TRAVERSE CIRCLE	EACH
INT FLOOR STRUCTURE	SF
INT FLOOR DECKING	SF
INT RAILING	LF
INT EMBRASURE/LOOPHOLE	EACH
INT EMBRASURE CHEEK WALL	EACH
INT EMBRASSURE SILL	EACH
INT EMBRASURE ARCH	EACH
TONGUE LINTLE	EACH
PINTLE STONE	EACH
INT POSTERN	EACH
INT POSTERN CHEEK WALL	EACH
INT POSTERN SILL	EACH
INT GRILL	EACH
INT DOOR UNIT	EACH
INT DOOR FRAME	EACH
INT DOOR	EACH
INT DOOR TRIM	LF
INT DOOR HARDWARE	EACH
INTERIOR FINISH	SF
INT STAIR/RAMP SURFACE/COVER	LF
INT STAIR RAMP STRUCTURE	EACH
INT STAIR/RAMP RAILING	LF
INT FORT: OTHER	EACH

The Feature Conditions included good, fair, and poor. Whereas the Historic Properties Condition Assessment format avoided such terms because they were imprecise, they were a sound choice in the Workshop Report because the National Park Service has adopted definitions for them. Good, fair, and poor become useful classifications when there is a common understanding of what they mean. In 1989, NPS introduced the Inventory Condition Assessment Program (ICAP), a computer program designed to gather inventory and assessment data on buildings, with emphasis on maintenance, operations and planning. ICAP included condition definitions, and those were the definitions that were used at Fort Pickens. They are successful in large part because they are based on an existing maintenance program and staff that can be drawn upon to respond to the noted deficiencies. Without that grounding in an existing maintenance program, the ICAP condition definitions would have little value.

ICAP Qualitative Condition Ratings

Good

This rating indicates that:

a. Routine maintenance should be sufficient to maintain the current condition; and/or

b. A cyclic maintenance or repair /rehabilitation project is not specifically required to maintain the current condition or correct deficiencies.

Fair

This rating indicates that:

a. The feature generally provides an adequate level of service to operations, but

b. The feature requires more than routine maintenance.

c. This rating also indicates that cyclic maintenance or repair/rehabilitation work may be required in the future.

Poor

This rating indicates that the feature is in need of immediate attention. It also indicates that:

a. Routine maintenance is needed at a much higher level of effort to meet significant safety and legal requirements;

b. Cyclic maintenance should be scheduled for the current year and/or

c. A special repair/rehabilitation project should be requested consistent with park requirements, priorities, and long-term management objectives.

The Workshop Report added illustrations to provide a more accurate and project specific description of what the different levels of condition meant at Fort Pickens. In this way, all team members were able to produce more uniform condition ratings. A sample description page is found at 2.38.

ICAP also contains another useful feature that was incorporated into the condition assessment inventory form. Priority ratings of critical, serious, and minor provide a measure of immediacy to the work proposed for each feature.

Feature Inventory Condition Assessment
Fort Pickens, Exterior Wall Surfaces

Exterior wall surface in good condition.

Exterior wall surface in fair condition.

Exterior wall surface in fair to poor condition–note large percentage of open wall joints and eroded surface of bricks.

Exterior wall surface in poor condition–note use of non-lime based mortar for finish pointing of joints also eroded face of bricks.

Source: Fort Pickens, Gulf Islands NS/Historic Fortifications Condition Assessment Workshop Report. Historic Preservation Training Center & Southeast Region, Office of Cultural Resources–Building Conservation. April 2002.

ICAP Priority Ratings

Critical (Immediately/Emergency)

a. This rating defines an advanced state of deterioration that has resulted in the failure of a feature or will result in the failure of a feature **if not corrected within one year**; or

b. There is accelerated deterioration of adjacent or related materials or systems as a result of the feature's deficiencies **if not corrected within one year**; or

c. There is an immediate threat to the health or safety of the user; or

d. There is a failure to meet a legislated requirement.

Serious (Short Term/Immediately)

a. This rating defines a deteriorated condition that if not corrected **within one to three years** will result in the failure of the feature; or

b. A threat to the health or safety of the user may occur **within one to three years** if the ongoing deterioration is not corrected; or

c. There is ongoing deterioration of adjacent or related materials or features as a result of the feature's deficiency.

Minor (Long Term)

a. This rating indicates standard preventive maintenance practices and preservation methods have not been followed; or

b. There is a reduced life expectancy of affected adjacent or related materials or systems **within three to five years and beyond**; or

c. There is a condition with long-term impact **within three to five years and beyond**.

All of the information gathered during the inventory was also presented in a discussion of findings that brought together the many different parts of the process. Individual features were aggregated under more familiar architectural elements, and a three-part condition statement was also tied back to the basic architectural component as were specific observations. A sample of the discussion of findings is included on page 2.39.

As with the two previous examples of fortification inventory forms, the Fort Pickens Historic Features Condition Assessment Workshop Report has both strong and weak points. One of its advantages is that it was tailored to Fort Pickens, and the same form would be readily adaptable to other masonry fortifications of a similar type. It supports the collection of information with a high level of accuracy and uniformity, and it uses definitions for condition and priority that are based on existing National Park Service practices. It also effectively summarizes detailed information in a simple text format.

There are also drawbacks. It is complex and requires training and coaching to ensure its success. Because its fundamental purpose is to generate cost information for proposed treatments, specialized architects and engineers need to be part of its preparation. The Feature List cannot be used for defensive structures built of materials other than masonry, although certainly a different Feature List could be constructed for each kind of structure and material. It also does not offer a way to judge the significance of different historic resources.

Sample Discussion of Findings from the Fort Pickens Historic Features Condition Assessment Report: West Channel Front South End

Condition:	**50% Poor, 30% Fair, 20% Good**
Roof Status:	This section of the fort has no earthen fill and no parapet. Casemates 51–60 all have vault structures acting as watersheds. The original drainage system is not operating as intended. The "sidewalk" of the 1970s era reconstruction to the scarp wall requires repointing, resealing expansion joints. Open-face brick. Compare soil permeation rates vs. sq. footage of present water collection.
Signs of Structural Failure:	Lateral crack transversing vault structure of casemates 51–58. Casemate 57 exhibits a visible "bulge" above the left communication arch. This failure has increased within the last 8 years, according to park staff observation. This deviation may be consistent throughout all the casemate vaults. Investigate possibility of inherent structural failure due to construction change in communication arches.
Signs of Moisture Penetration:	Casemates 51–60 exhibit varying degrees of organic growth and calcium deposition on brick surfaces. All casemate vaults are directly exposed to precipitation, due to the removal of earth fill and parapet structure. Drainage system (both historic and contemporary) is not fully understood. Forty-percent of the casemates have excessive calcium deposition, thirty-percent show excessive organic growth.

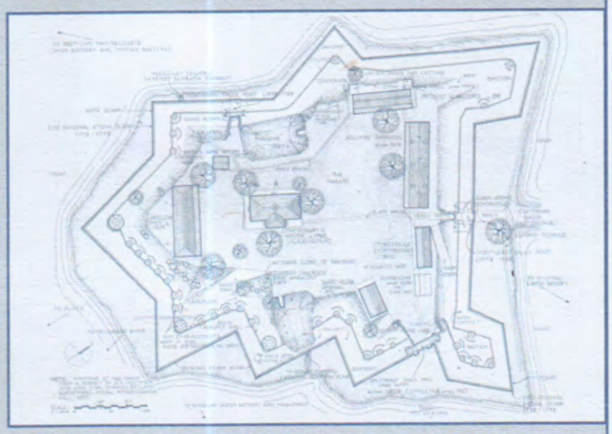
Looking at the three examples, the conclusion is that all of them do different things well, but none emerges as a preferred inventory form. The Historic Fortifications Field Form is good if the goal is to inventory the features of a concrete fortification and to gauge its observable condition. The Historic Properties Condition Assessment form offers the advantage of ranking significance and condition among like resources, and some concept of repair costs. Although it exists only as an incomplete draft, the Fort Pickens Assessment Workshop Report is the best choice for a detailed cost analysis of an historic property of known significance and where specific technical expertise is available to the assessment team.

Perhaps it is too much to try to accomplish these several tasks with a single survey. The perfect survey and inventory form for historic fortifications may in fact be a combination of several forms, each addressing a different level and purpose of inquiry in addition to materials and architectural type. Whatever that future combination might be, it must take into account fortifications as landscapes, and give credit to the distribution of resources over the land as well as physical modifications of the landscape itself to accommodate the defenses. The sensitive handling of these open areas is necessary if we are to maintain the integrity of the late generations of fortification as a complex resource. Another requirement is the introduction of a flexible, comprehensive, and meaningful method of assessing significance. The Weighted Values Matrix that is introduced in Part Three is one possible approach; it is presented there for its association with project planning, although there is little reason why it could not be employed early during the identification phase.

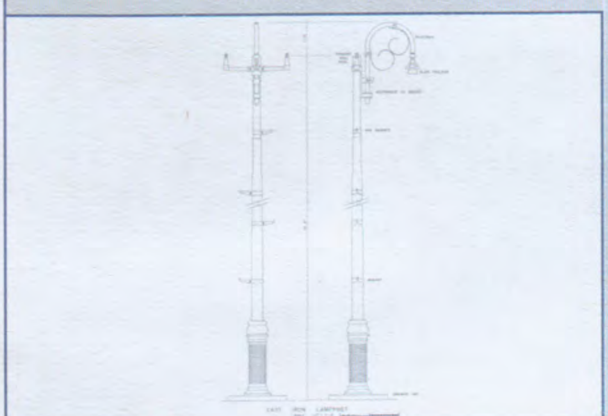
Character Defining Features and Historic Fortifications

The Comparison of Permanent Fortifications table on page 2.10 in its Comparison Elements suggests some idea of character-defining features. They can be large (the overall form of the fortification) or small (architectural details). They include construction materials (brick, stone, concrete, earth) as well as markings and signage. Because military architecture is distinguished by its simple lines and modest decorative treatment, almost all physical aspects of fortifications can be considered character-defining. The illustrations here demonstrate the variety of examples that can be expected in any fortification constructed from the 18th century onward. Not all of these features will be found in every fortification, just as there are many features that are not illustrated here. For those reasons, grounding in the historical development of a particular fortification is as necessary as a familiarity with specialized terms.

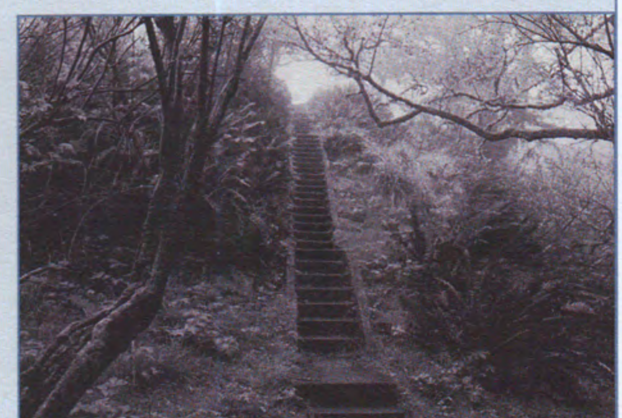
Site. The site includes all of the fortification elements and the landscape that contains them. Fort Casey, 1938.



Plan. The plan includes the outline of any fortification element. Fort Mifflin.



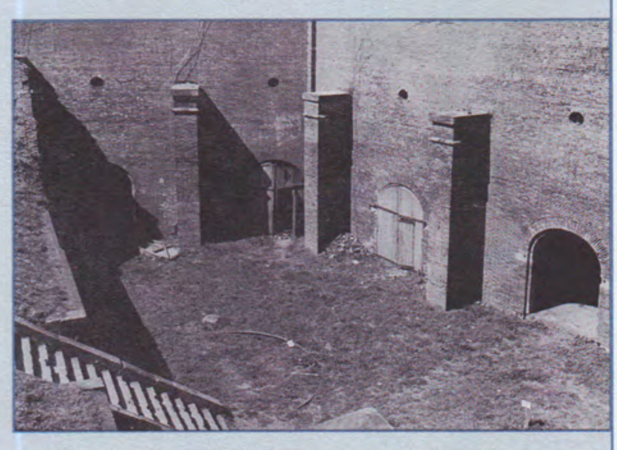
Site Elements. Street light, Fort Adams.



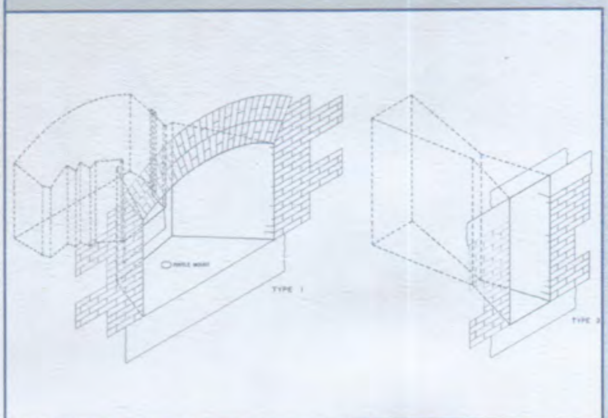
Site Elements, circulation features. Stairway to WWII radar site, Fort Canby.

Character Defining Features and Historic Fortifications

Spatial Relationships. Connected casemates at Fort Point.

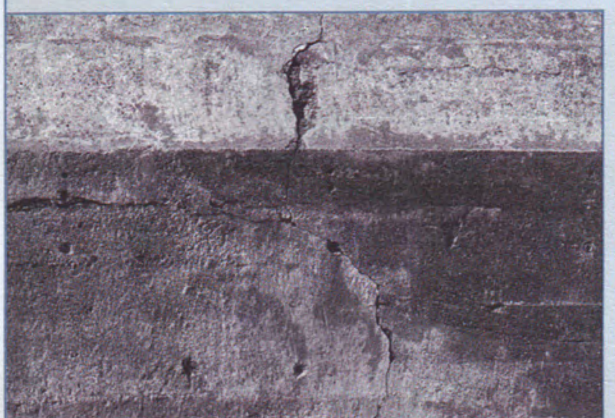


Distinctive features of military architecture. Revetments and counterforts, Fort Washington.



Distinctive features of military architecture. Casemate and embrasure types, Fort Adams.

Materials. Masonry bond patterns, Fort Moultrie.



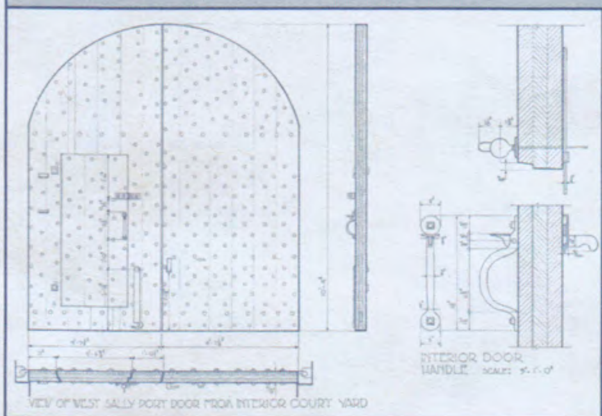
Materials. Concrete surface finishes, Fort Winfield Scott.

Materials, stone types. Coquina stone, Fort Matanzas.

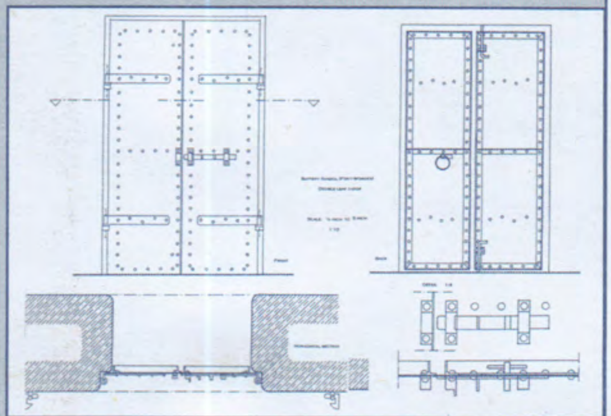
Character Defining Features and Historic Fortifications

Architectural details. Crow's nest, Battery Richmond, Fort Wadsworth.

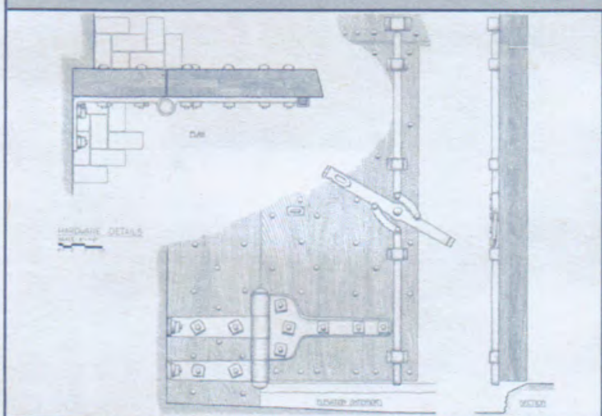
Architectural details. Stone quoins, Fort McHenry.



Architectural details. Wood plank door with iron studs, Fort McHenry.



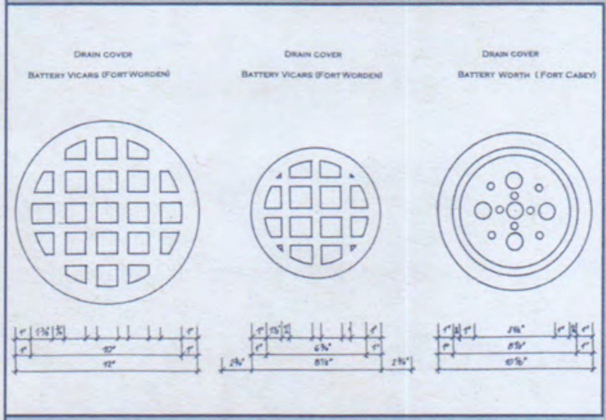
Architectural details. Steel door with riveted frame, Battery Randol, Fort Worden.



Architectural details. Door hardware, Fort Mifflin.

Architectural details. Small-scale features, stanchion and chain attachment, Battery Crenshaw, Fort Columbia.

Character Defining Features and Historic Fortifications



Architectural details. Drain covers, Battery Vicars, Fort Worden, and Battery Worth, Fort Casey.

Architectural details. Classical features, Fort Gorges.

Evidence of skilled workmanship. Spiral granite stair, Fort Point.

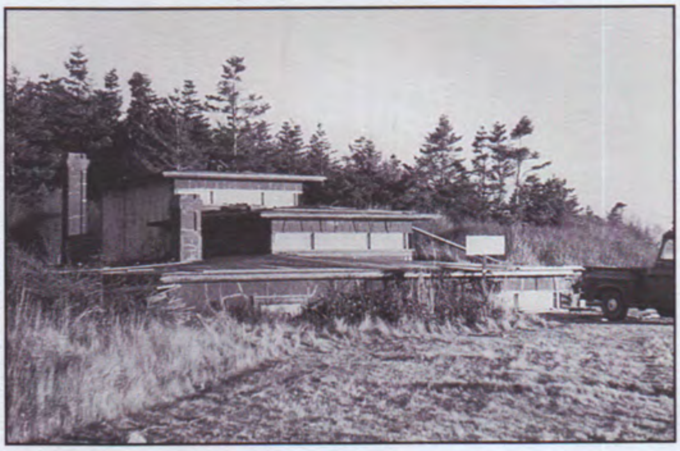
Evidence of skilled workmanship. Galvanized iron ventilator, Fort Columbia.

Intact interiors. Mine casemate, Fort Rosecrans.

Signage and markings. Searchlight symbol, Fort Worden.

The Importance of Sites

Not all the important parts of a fortification were rendered in masonry and concrete. In particular, defenses built between 1890 and 1918 almost always included some lightly-built wood or metal frame structures that housed such necessary functions as power plants, dormitories at distant locations, fire control stations, latrines, and plotting rooms. Few of these resources have survived the general neglect of fortifications as historic properties, and as a result, the landscape appears to have fewer structures than was in fact the case. The only remnant might be a foundation or floor slab, built into a depression or placed behind a berm of earth. It is just as important to inventory sites as it is standing structures.



Although these features are not intact as structures, they can have a role to play in the adequate interpretation of the complex as a whole. They would be good candidates for reconstruction, although as noted in Part One, reconstruction is often not the best choice. An alternative to reconstruction that can have similar interpretive value is the erection of ghost structures.

Ghost structures represent the form of the building by outlining its general shape in structural steel square tubing or channel. The result provides visitors with a sense of what was on the site with a greater impact than a photograph or drawing. Although no ghost structures have been erected at any historic fortifications, a comprehensive program of their construction could help restore the appearance of the historic landscape.

Illustrated on this page is a proposal for such a structure at Fort Casey, Washington. The top photo (taken about 1956) depicts a distinctive three-tier building that housed important fire control and command functions. The building deteriorated and collapsed, and for many years its location has been marked only by a large depression with three concrete columns. The bottom view depicts what the site might look like after the outlines of the vanished building have been re-established.

Selecting Base Maps

Basic survey and inventory work includes the collection of available resources, particularly site maps of the area to be inventoried as well as plan views of individual resources. Public works in general are among the best documented of historic property types, and fortifications are no exception. From the period of initial design to the time that the defenses were no longer necessary, the builders carefully detailed what was in place, what was to be done, or what was to be modified.

Most of these records are reposited in the National Archives and Records Administration. Almost all cartographic materials are housed in the complex known as Archives II, in College Park, Maryland, although correspondence regarding the drawings and further aspects of construction and maintenance is often located at regional archive branches in other areas of the United States. On occasion, state and local historical societies and archives can be sources of some useful information, but it is not common.

Public works in general are among the best documented of historic property types, and fortifications are no exception.

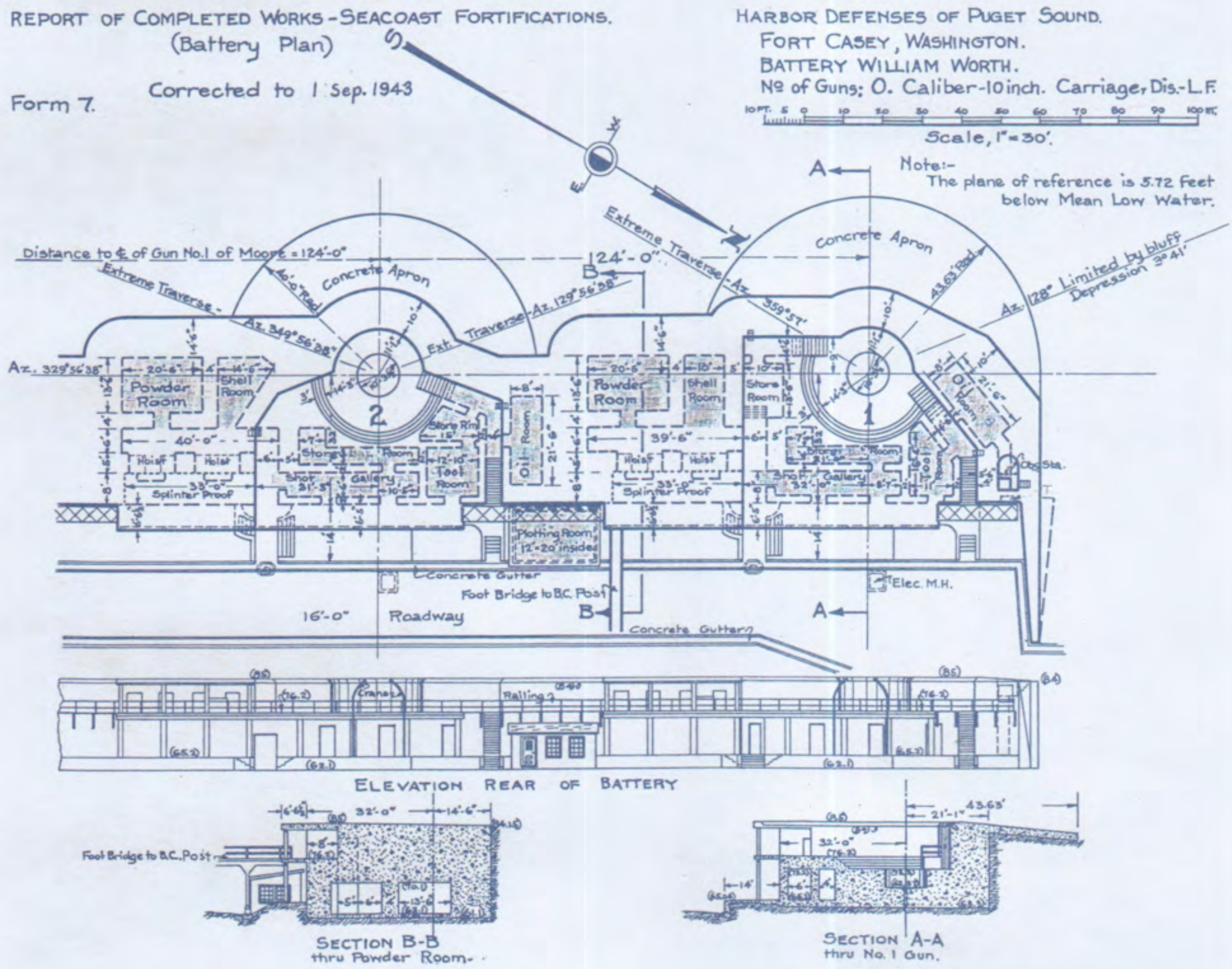
The extent of the drawings maintained by the National Archives varies by time period. The masonry fortifications of the 18th and 19th centuries are most often represented by large drawing sheets, but these almost always represent the preferred design rather than constructed works. Some changes that are conspicuous in the field may not be further depicted by drawings; some drawings also can be very sketchy, and reveal little about the structure.

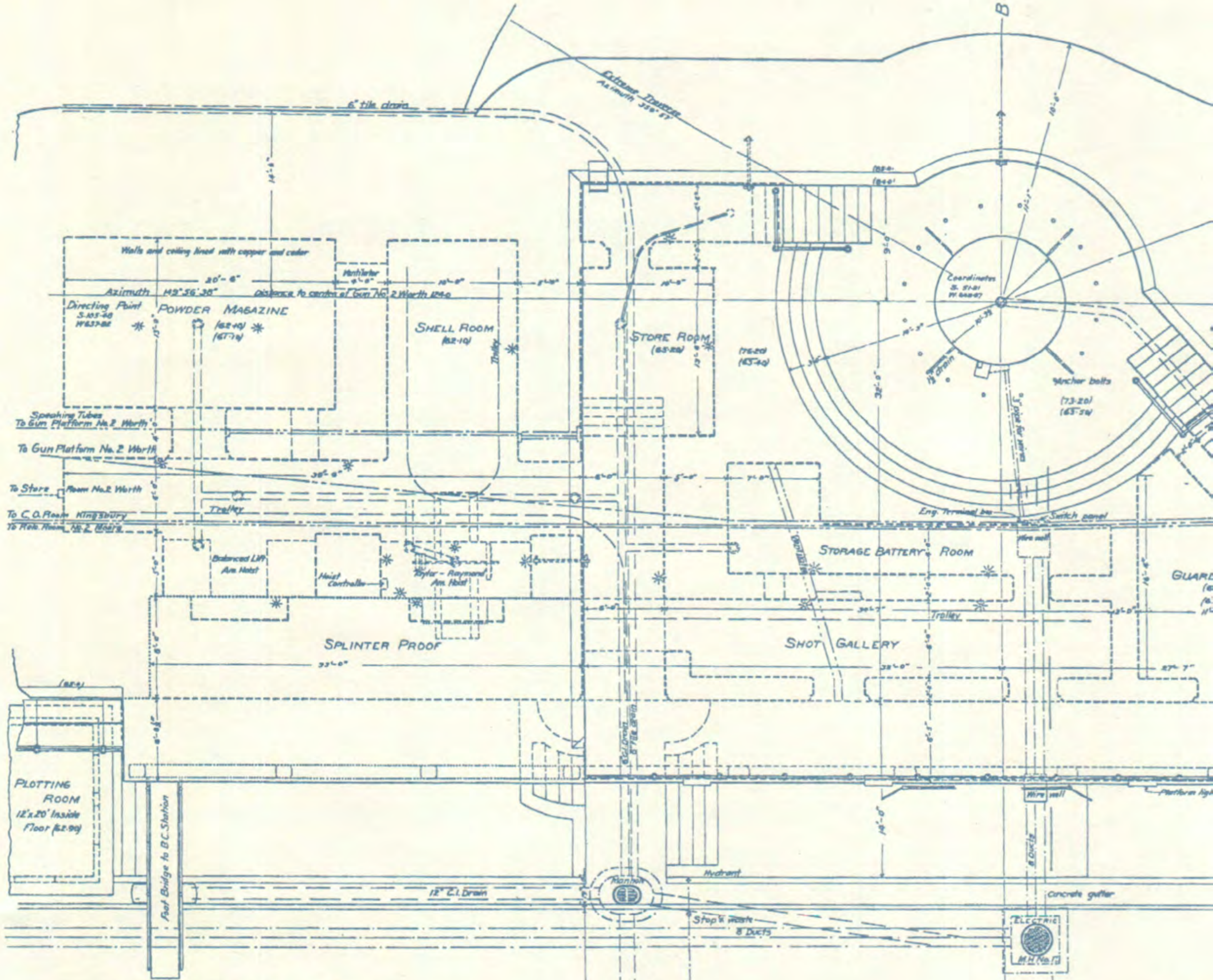
Many fortifications of this period have been recorded by the Historic American Buildings Survey, which began in the 1930s and continues to this day. HABS drawings are detailed and based on accurate measurements taken from the fortification itself, so that they portray the "as-built" condition. As a result, they are among the best drawings available of Second and Third System works, and often superior to historic drawings for their clarity and precision.

Many more drawings are available for the defenses built after 1890. Base maps cover different periods and functions during the useful life of the fortification, and construction drawings detail initial building and later modification. A unique record set also depicts the defenses of this period. The Reports of Completed Works provided a format for the recording of important data and elements of the defenses, and included a page-sized blueprint of each structure. The reports are now easily available, thanks to the efforts of the Coast Defense Study Group enthusiast organization, and the drawings they contain are frequently offered up as an adequate depiction of the resource.

The disadvantage is that the drawings date from 1919 and after, and do not directly reveal earlier configurations. They do not contain structural information. They are also of a size that is too small to be of much help in recording condition, and because the copies are usually several generations removed from the ink-on-linen originals, they contain distortions that are magnified if they are enlarged to a more appropriate size. It is worth the effort to obtain large-scale drawings that have a higher level of detail at the outset, and as a result, can be the basis of modern drawings that will be necessary for any notable level of preservation work.

Three drawings reproduced here illustrate the differences. The first is the small drawing that is included in the Report of Completed Works for Battery Worth, Fort Casey. It is called a Form 7 after its place in the sequence of documents that compose the Report of Completed Works. The next is a reduction of a much larger sheet for emplacement one of Battery Worth. This particular drawing dates from 1917, and includes all of the changes made to the emplacement to that time, guidance regarding the care required for the emplacement, and the location of utilities. As an historical record, it contains much information that is of interest, and it can also serve as the origin of a modern drawing to better suit preservation needs. The third drawing dates from 2003. It has been prepared for use in the restoration of Battery Worth, and displays a number of conditions in the concrete that will need to be addressed in the project. The size of the drawing allows for the accurate depiction of conditions and will enable engineers and contractors to accurately estimate the cost of the repair.





NOTES AND INSTRUCTIONS FOR THE GARRISON IN CARING FOR THESE EMPLACEMENTS.

All open drains or gutters shall be carefully swept and all rubbish removed at least once a week; care being taken that the sweepings are deposited in such place that they will not be carried back into the drains by wind or water.

All inlets or drains shall be carefully inspected and cleaned at least once a week; care being taken that the strainer covers are in place and free from obstructions.

Underground drains shall be inspected at least once a week at all accessible points, all sediment removed from manholes and catch basins, and any tendency to clog immediately remedied.

No waste, rags or rubbish shall be dropped into counter weight wells or inlets and they shall not be used as spittoons.

Trolley stops shall be kept securely clamped on the free ends of all trolley-beams.

Only toilet paper shall be used in latrines.

In freezing weather the water must be shut off from loading platforms and outside doors of latrines kept closed.

No person shall be allowed to walk up or down the earth slopes at any time except when necessary to inspect, repair or care for them.

2" water main

Concrete Gutter

DEFE

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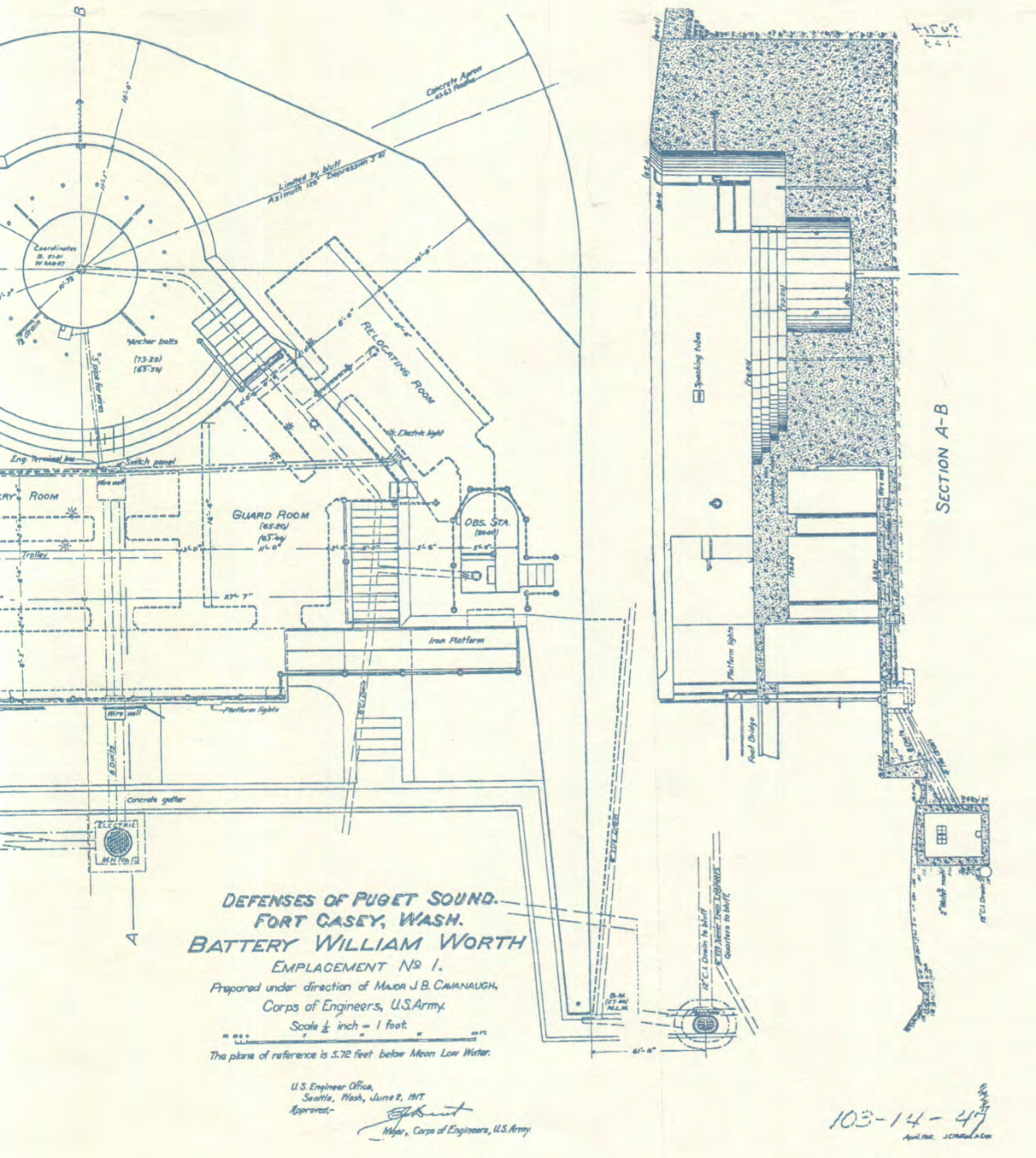
BATTER

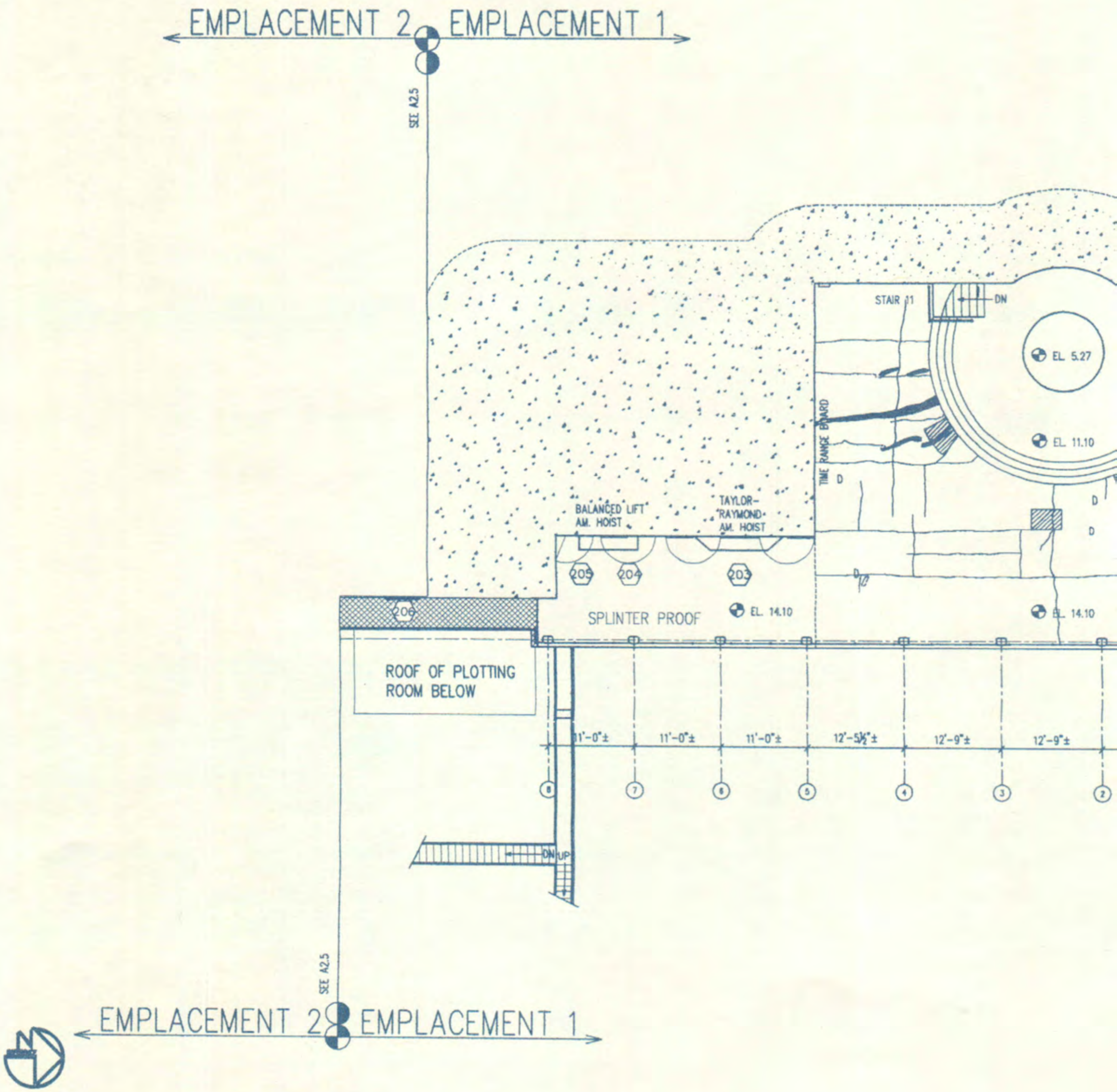
Prepared u

C

The plans of

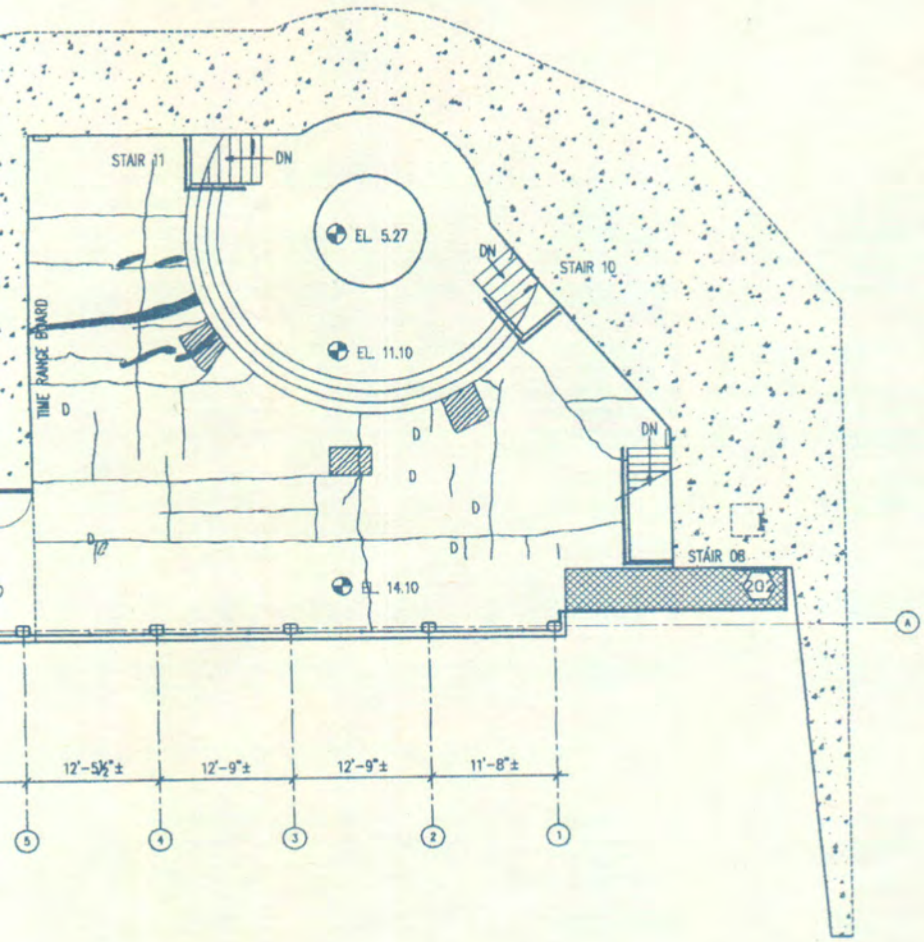


Concrete Apron
Limited by bluff
Azimuth 120 Depression 3°45'
Coordinates
Anchor bolts
(73.20)
(65.50)
RELOCATING ROOM
Electric light
Eng. Terminal box
Switch panel
Wire well
ROOM
Trolley
GUARD ROOM
(65.50)
OBS. STA.
Iron Platform
Platform lights
Concrete gutter
ELECTRIC
M.H. No. 1
Speaking tubes
Platform lights
Foot Bridge
SECTION A-B
12" C.I. Drain to bluff
12" C.I. Drain
DEFENSES OF PUGET SOUND.
FORT CASEY, WASH.
BATTERY WILLIAM WORTH
EMPLACEMENT No 1.
Prepared under direction of MAJOR J. B. CAVANAUGH,
Corps of Engineers, U.S. Army.
Scale 1/4 inch = 1 foot.
The plane of reference is 5.72 feet below Mean Low Water.
U.S. Engineer Office,
Seattle, Wash., June 8, 1917.
Approved,-
Major, Corps of Engineers, U.S. Army.
103-14-47



1 A2.4 GUN EMPLACEMENT 1 – LOADING PLATFORM LEVEL

0 2 4 6 8 FEET



SHEET X OF X

CAD NO. XXXXX-X\TEST		
		DATE
		APP.
		INT.
		REVISIONS
		NO.
ACTION	BY	DATE
DESIGNED		
DRAWN		
CHECKED (FIELD)		
CHECKED (HDQTS.)		

PROGESS SET - NOT FOR CONSTRUCTION

JAN. 24, 2003

PROJECT ARCHITECT

WASHINGTON STATE PARKS AND RECREATION COMMISSION

WJE Wiss, Janney, Elstner Associates, Inc.
Architects, Engineers, Material Scientists
83 South King Street, Ste. 600
Seattle, Washington 98104
206 622 1441

FORT CASEY STATE PARK

BATTERY WORTH RESTORATION

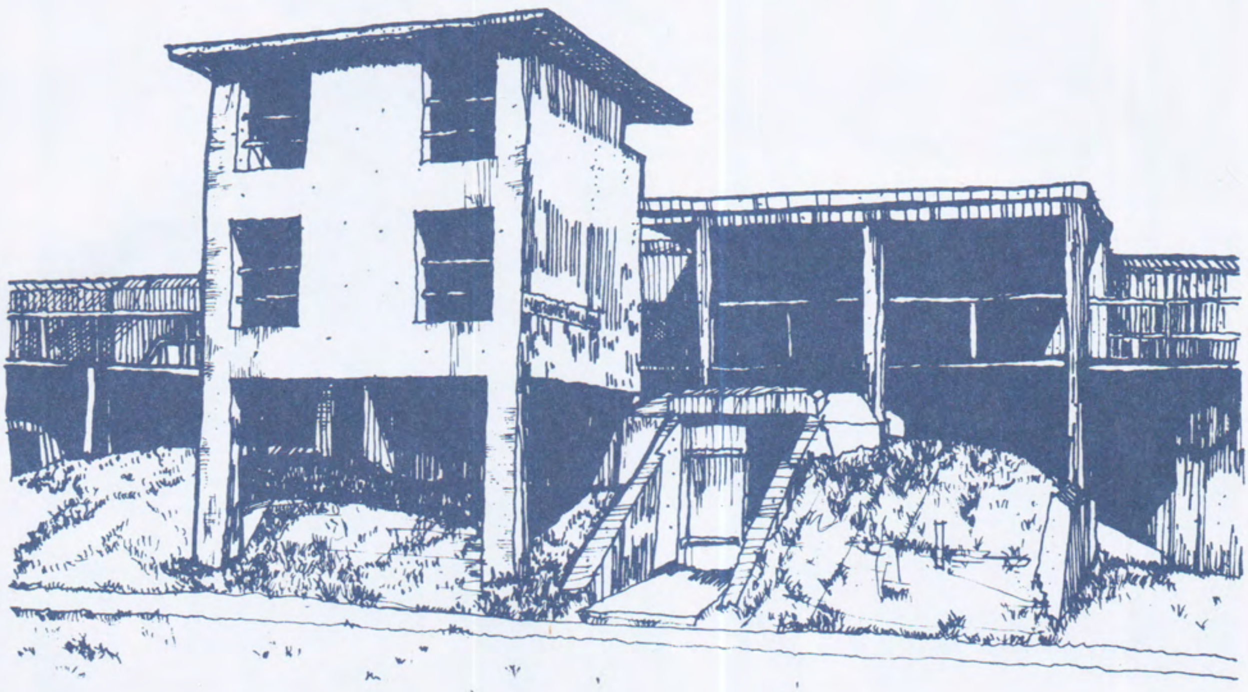
FLOOR PLANS

SCALE

A2.4

FILE NO.

Part Three: Problems and Treatments



Challenges to Preservation

Fortifications suffer from their own set of difficulties, and the majority of causes settle into three categories: original design detail, site limitations, and effects of the environment. Most preservation work in fortifications has to address one–and frequently all–of these categories. In almost every case, the agent that exploits any underlying weakness is water.

Design details that seemed appropriate at the time of construction have not always proved durable. The casemate roofs at Fort Adams functioned as part of a water collection system and diverted rainwater to cisterns for storage. It was a common feature of many third system defenses, and today at Fort Adams and other locations, the design has failed, leading to saturated substrate below the terreplein, increased lateral pressure on the walls, and accelerated loss of interiors. The deterioration of a circular stair also at Fort Adams could well be the result of improperly designed footings, particularly since the same type of stair at Fort Knox, Maine, survives without apparent problems. In concrete structures, the dependence on narrow internal drains has promoted decay, an odd circumstance since the sub-surface drainage in these same resources is typically excellent.

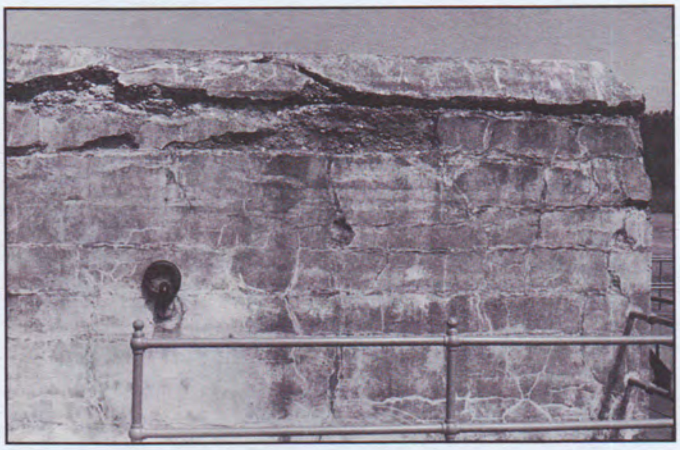
Fortifications were always built where they were needed, not necessarily where there were good building sites. Where the defenses could be founded upon rock or other sound material, the results have been admirable. Less favorable sites, such as those for Fort Pulaski and Fort Delaware, required the construction of a massive timber grillage or heavy piling before work on the tall brick walls could begin. The longevity of these resources is dependent on the continued integrity on the site-stabilizing underlayment. Elsewhere, advancing beaches on the Atlantic and Gulf coasts have undermined a large number of the structures built on those locations.

Local environment has an impact on every type of building, and fortifications especially so. The great majority of the defenses in North America were built on the seacoast, and subject to destructive weather and the slow influence of salt-laden mist. Storms have placed the parade ground at Fort Sumter under as much as eight feet of water; Fort Jefferson has been buffeted by hurricanes since its inception; and at Fort Barry, California, hill-side concrete observation stations have sloughed with their foundations intact toward the ocean after torrential rains.[1] Earthen slopes and berms also erode in the face of hard weather, and steel and iron are wasted in the corrosive atmosphere.

Extreme winter weather conditions have caused severe spalling in this battery at Halifax, Nova Scotia.

[1] James N. Ferguson, "An Overview of the Events at Fort Sumter, 1829–1991," *Historic American Buildings Survey*, November 8, 1991, 46; Louis Anderson, "Historic Structure Report, Architectural Data Section: Fort Jefferson National Monument," USDI/NPS, April, 1998, 56.

Several varieties of biological growth thrive on mortars in warm environments. San Cristobal, Puerto Rico.



Long regarded as the result of freeze/thaw cycles, this linear spall appears to be more the product of poorly mixed and placed concrete. Fort Casey, Washington.

In addition to these common variables, there are two others that are more random but have their own impact on condition: workmanship and maintenance. Workmanship is generally of high quality in masonry works (unexpected perhaps since both slaves and military convicts were sometimes used in their construction) but suffers in the transition to concrete. The reason is almost certainly unfamiliarity with the new material and large-scale concrete construction, a deficiency that the supervising engineers tried hard to overcome. The defects appear to us today usually in the form of isolated failure. For example, a long spall along the line of a cold joint at Fort Casey, Washington, appears to be the result of inadequate mixing since the exposure reveals poorly sorted aggregate and little paste. Cyclical or even periodic maintenance could do much to prevent or repair such problems. However, since maintenance of any kind is often a stranger at most historic fortifications, a minor fault left untreated can become an established lesion that spreads steadily.

Although we can label and categorize shortcomings here as if they are truly individual and conspicuous, in real life they occur in multiples and in ways that are difficult to decipher. Often there may be no indication that a subsurface problem is developing until the damage has advanced to material failure. In other instances, problems stemming from a questionable design feature can be unintentionally enhanced by shortcomings of the site, abetted by unseen faults in the material, and exploited by the challenges of the environment. The approach to complicated preservation problems is the same for fortifications as it is for any other historic resources: understand the resource, gather information, evaluate the evidence, develop a plan for the work, do the job, document what has been done, and follow up with an evaluation of the results of the treatments. In addition, the preparation of a preventive maintenance plan and the commitment to put it into effect will help avoid major problems in the future. The table below summarizes the steps and what can be learned from each of them. Part Four provides more information on maintenance plans that should follow the completion of any project.

Outline of Fortification Preservation Procedures

Action	Results
Plan the Preservation Work	
Plan and Organize	An inter-disciplinary team is organized. A "Weighted Values Matrix" is established for the fortification and used to help establish goals and objectives of the preservation project. Activities are prioritized and scheduled. The schedule, organized as an outline or bar chart, will probably change and evolve as more information becomes available.
Investigate and Evaluate	
Investigative Research	The goal is a complete record of the structure; its construction (period, sequence, methods, materials), history of damages, repairs, maintenance and preservation treatments.
Condition Survey	A complete and detailed record of all features and their readily discernible existing conditions.
Evaluation	A complete and integrated analysis of the physical history and observation of the existing conditions to determine a plan for further assessment.
Technical Investigation	A planned program of testing that is based on the evaluation and uses the scientific method to provide an improved understanding of the physical structure and conditions at a more in-depth level. Data is more specifically identified and quantified.
Evaluation/Documentation	At this stage, all known information is analyzed and evaluated. The results of all investigations are used to test various hypotheses on probable causes of problems. That activity leads to determinations on how systems function and the physical/chemical sources and processes that are causing or contributing to deterioration. All the investigation work completed to date is captured in one or more reports that describe the testing methodology and related data. The documentation also includes research sources, bibliography, and team members.
Treatment	
Proposed Treatment Plan	The team proposes its treatment only after it has completed the preceding steps. In addition to the prescribed technical preservation treatment(s) required for the structure, the plan includes estimated budget requirements and schedule for use in implementation. The plan is then prepared or reviewed by people with specific technical expertise in the materials, problems and treatments.
Project Implementation	The treatment plan is implemented and closely monitored. Field documentation (notes, daily diaries, photographs) is performed.
Follow Up	
Documentation/ Completion Report/ Evaluation of Treatment	All records of the project are archived for safe-keeping. The project is described for publication and dissemination to the technical preservation community. Treatment results are monitored and evaluated for success and durability over time.
Maintenance/Documentation	A maintenance plan is developed and implemented, and the condition of the structure is monitored. The fortification is maintained to prevent the need for major treatment projects in the future.

Plan and Organize

Most people responsible for the care of historic structures are familiar with management tools and techniques. Thus, suffice it to say here that the best project management practices are important to the success of a preservation project of any type. Preservation is a complex activity that involves numerous multi-disciplinary practitioners and interested parties who will all likely influence the decisions made over the course of a project. Historic fortifications, like most historic structures, will have more preservation needs than funds available for implementing them. Difficult choices must be made throughout the preservation process. To effectively handle the issues, to synthesize the critical relevant information, and to guide the decision-making process to make the most of the opportunities available, requires consistent and clear focus on core preservation principles, values, and goals.

The technical side of preservation can be compared to detective work and applied forensic science.

Establishing and making explicit the purpose and intent of the investigation up front helps define what investigative work is needed to answer unknowns. Emphasis and focus will also help ensure that the efforts made and the resources expended are effective and necessary. As the investigation proceeds from broad to specific, the core purpose and goals help focus the direction of further investigations.

One specialized tool that can be used for establishing and documenting the purpose and goals is a "Weighted Values Matrix"[2]. Matrices are often used by architects and planners to visually organize and manage a set of detailed data. The values inherent in the fortification and its particular place in the context of the relevant fortification history, in our case the United States, can be analyzed, evaluated, and documented into a matrix. Knowing what is being preserved and why is the essential pre-condition that enables us to make sound decisions regarding investigations, evaluations, and treatments. The Weighted Values Matrix is based on the significance of the defenses in their historic context. It can also help guide the decision-making process during all stages of the project.

Investigation

The technical side of preservation can be compared to detective work and applied forensic science. It uses similar methodology and often the same techniques. Like detectives, the preservation team has evidence of a condition before them, and must uncover, analyze, and follow many clues that will enable them to discover the cause. It is critical to complete the investigative and analytical steps before deciding on a specific treatment for the historic fabric.

Investigative Research. *Investigative research* includes the review of primary sources such as original engineering and construction records, historic photographs, newspapers of the day, maintenance reports, weather records, as well as

[2] Deborah Marcella Rehn, "Managing the Scientific Conservation Process: Theory and Practice," Master's Thesis, Columbia University, New York, NY, 1992.

Hypothetical Weighted Values Matrix Applied to a Fortification

	Age Value	Historical Value	Aesthetic Value	Cultural Value	Economic Value	Technological Value	Military Architecture Value
Sally Port	●	●	•	•	○	•	•
Scarp Wall, left face	●	●	○	○	○	•	•
Scarp Wall, right face	●	●	•	○	○	•	•
Firing Steps	○	○	•	○	○	●	●
Gun Tracks	●	•	○	•	○	●	•
Casemates 8-20	●	●	•	•	•	●	●
Bastion A	●	●	●	●	●	●	●
Officers' Quarters	○	○	○	○	●	○	•
Embrasures	●	●	●	•	•	●	●

Quantifiable Criteria (less often debated)

Age Value—weighted by actual authenticity.

Historical Value—weighted by events that happened at the site or by established statements of historic significance pertaining to the resource. The weighting can also change if the structure can be considered as having local, regional, national, or international significance.

Technological Value—weighted by the uniqueness or technological importance represented by the feature.

Military Architecture Value—weighted by the capacity of the feature to represent important design aspects of fortifications.

Perceived and Often Subjective Criteria (more often debated)

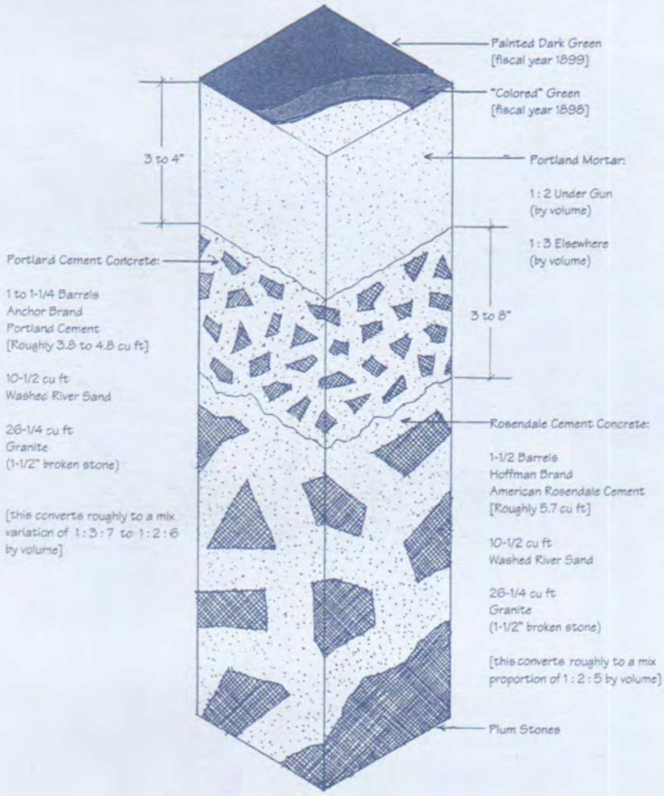
Aesthetic Value—weighted by general or consensual perception of the aesthetic value of the feature. This item can be established more accurately if there is supportive and persuasive analysis of the feature's aesthetic qualities.

Cultural Value—weighted by general or consensual perception of the value to the culture.

Economic Value—weighted by general or consensual perception of the dollar value of the feature (income generating potential or replacement costs), or for the larger impact of the project on the local economy.

● = Most important • = Less important ○ = Least important

secondary sources such as books or published articles that are accurate and verifiable. The research will help reveal the physical history of the fortification, which itself is necessary to develop an understanding of the structure. The physical history includes configuration of the original construction, sources of materials, later modifications, damage, repairs, and problem areas. The information can date both features and fabric, and is also an aid in determining the significance of specific portions of the fortification. For properties held by the National Park Service, useful information complied by previous researchers may be found in an Historic Structure Report, but more often the necessary level of detail is available only in primary source materials. Even books about the construction of fortifications in general, and the one under scrutiny in particular, can yield valuable pieces of knowledge. Archival research into original drawings, bills for materials, correspondence, or military orders can uncover much useful information on the historic fabric used for construction, the conditions during construction, or decisions made and why, any of which may be affecting durability and could lead to discovery of the root causes or components of deterioration. This investigation is also called documentation, as it identifies the documents and sources of information that are relevant to the fort.



The results of research can be used to prepare a probable construction sequence, as in this example from Fort Mott, New Jersey.

Conditions Survey. A *conditions survey* is a hands-on investigation of the fort, the results of which are documented in a conditions survey report. Several types of such a survey are described in Part Two of the Handbook. The methodical gathering of evidence is analogous to the detective work done at the "scene of the crime." Investigators gather, note, and organize a host of primary multi-sensory data, including visual, tactile, sound, and smell. This surface investigation can yield major indications and clues about the true condition of the fort. The value of this first-hand intensive physical study of the fort and its conditions reveals itself in two important ways. First, the conditions survey report is a thorough record of the conditions at a specific point in time, and will help guide the initial work. Second, the documentation that constitutes the report becomes a baseline that adds to the body of knowledge about the structure, and will help inform others well into the future.

Evaluation. *Evaluation*, or the comprehensive review and analysis of the information that is now available from the investigation and conditions surveys, allows the project team to more fully understand the fortification and its various systems as originally designed, as they have been modified, and as they currently function. The evaluation also focuses on any problem areas identified in the conditions survey. This better understanding will lead to well-supported reasoning and a clear path to determine the nature of any additional investigation that may be needed.

The preservation team's previous experience with historic structures can enhance or hinder its work on fortifications. Because fortifications are made of common building materials, they display many of the problems that occur wherever those materials are used. However, the design of fortifications is different than all other buildings in the United States, and as a result, typical hypotheses about problems and their causes that have proven correct on many structures may be wrong when applied to fortifications. Until more is learned about deterioration of fortifications generally, it behooves us to be especially cautious before coming to conclusions about the causes of problems, and before proposing treatments.
Evaluation can be compared to the work of a scientist, as the best results will be achieved when the scientific process is used to evaluate the information. At this point in the project, many unknowns will exist, and we will need a set of controls to help methodically eliminate variables.

The Scientific Method

1. What do you want to find out? (Purpose, problem definition)
2. What is already known about this? (Related information, previous case studies)
3. What do you think will happen as a result of the examination? (Hypothesis)
4. What do you need to use? (Materials, equipment, tools)
5. What will you do to find out? How will you measure the results? (Procedures, performance criteria)
6. What happened? (Results)
7. What did you learn? (Evaluation, conclusions)

The review and analysis of the information gathered in the investigation and conditions survey will yield one or more hypotheses for the various problems found in the structure. These hypotheses should be tested according to the process above and the results recorded. The most complete picture of the causes of deterioration derives from the evaluation of the results combined with further testing as necessary until all hypotheses are proven. On the following page is an example of how information gathered to this point was organized for a project at Fort Mott.

Testing. *Testing* includes physical and chemical investigation of the fabric of the structure according to a well-conceived testing plan. Initial tests often include those for the porosity, hardness, and material content of a mortar, brick, or concrete sample, or the measurement of moisture content with a probe. The methods increase in complexity and cost from these simple examples, which should always be considered for their applicability first, to more complex, invasive, and costly techniques. Regardless of cost or impact, testing methods are referred to as "materials investigation." They are covered in detail in the pages that follow under several problem areas. The benefit of testing is that it provides quantitative data that can allow calculations and reasoning to establish more precise information about existing conditions and materials.

Data Evaluation and Documentation. The data collected from the tests is organized and evaluated against the previously gathered information. This encompasses knowledge of the specific structure and general building type, knowledge of historically available local construction materials and methods along with a general background knowledge that can serve to augment a dearth of local information. The results of the evaluation are then documented in a report that contains background information on the testing project, purpose of the tests or the hypotheses being tested, specifics on the methodology and instruments used, results of the testing, evaluation of the procedure, the findings or conclusions, and list of investigators and contributors along with a bibliography as applicable. This material forms the background for development of the treatment plan.

Sample Concrete Summary Table

Condition	Cause	Effect	Historical Note	Design Criteria	Possible Solutions	Limitations
Water Infiltration at Cracks and Joints in Horizontal Surfaces Battery Gregg Main Battery	• Cracks due to differential thermal expansion between two masses • Cracks due to thermal expansion within a constrained mass • Cracks due to shrinkage of mortar facing • Differential settlement cracks	• Water in concrete beyond entry surface • Migration of cement matrix and deposition of cementitious materials on vertical surfaces at exodus • Potential ingress of de-icing salts and atmospheric pollution	• Some surfaces coated originally or soon after construction • See theoretical stratigraphy	• Reduce liquid water penetration at cracks and joints • Allow for movement in active cracks	• Seal joints • Bridgejoints • Do nothing	• Traffic subjects joint sealers to abrasion • VOC compliance of sealers • Joint sealers will be visible
Water Infiltration at Horizontal Surfaces Battery Gregg Main Battery	• Natural permeability of concrete • Inadequate drainage of horizontal surfaces	• Water in concrete beyond entry surface • Migration of cement matrix and deposition of cementitious materials on vertical surfaces at exodus • Potential ingress of de-icing salts and atmospheric pollution	• Some surfaces coated originally or soon after construction • See theoretical stratigraphy	• Reduce liquid water penetration • Do not reduce vapor permeability of surface • Do not change appearance of surface	• Historic coating • Water repellent: • Siliconatcs • Silicone resin • Silane • Siloxanes • Damp-proofing coating • Do nothing	• Traffic subjects surface sealers to abrasion • Surface preparation should be minimal • Seater compatibility with earlier treatments • VOC compliance of sealers
Water Infiltration at Cast-in Gutters Battery Gregg Main Battery	• Concentration of water on horizontal surfaces • Insufficient or interrupted drainage	• Water in concrete beyond entry surface • Potential ingress of de-icing salts and atmospheric pollution	• Some surfaces coated originally or soon after construction • See theoretical stratigraphy	• Reduce liquid water penetration • Improve drainage • Do not reduce vapor permeability of surface	• Coat • Seal • Treat the same as horizontal surfaces	• Traffic subjects surface sealers to abrasion • Surface preparation should be minimal • Sealer compatibility with earlier treatments • VOC compliance of sealers

Treatment Plan

The results of the completed investigation and evaluation are collected in the *treatment plan*. This plan documents the recommendations created by the collaboration of several disciplines and their integrated, logical, and well-reasoned approach to understanding the structure and the causes of its problems. The plan may also include immediate remedial action or stabilization, to be followed by major or minor treatments, depending on the specific needs of the structure.

Documentation

All of the treatment work should be laid down in a format that can become a permanent, easily retrievable, and usable record of the methods and materials employed. The documentation can be in the form of written narratives, drawings, and photographs that are readily available for reference and guidance for maintenance management, staff, and those planning for future treatments. They should also be archived to avoid loss. The procedures and results ideally should be shared with other preservation professionals and property managers. Sharing information can take place in the form of a paper presentation at a conference, an article for publication, a completion report, or other means of distribution such as the internet. Part Four contains a description of what records should form a documentation set, and contains several examples.

The treatment plan is an integrated, logical, and well-reasoned approach to understanding the structure.

MATERIALS, TESTING, AND TREATMENTS

This part of the *Handbook* looks at different types of common materials used in fortification construction, how and why they fail, and ways in which they can be repaired. The repair of historic building fabric has produced a deep literature, and what is presented here has drawn extensively on that library, adding to it examples that relate directly to fortifications. Our understanding of the behavior of materials and our skill in extending their useful life continues to build as a result of tests and project experience. News of the results typically appears in technical publications and the papers of specialist organizations as part of the treatment documentation. Often they are condensed, supplemented, and made ready for a non-specialist audience by the National Park Service through its broad and helpful Preservation Briefs series (available on the internet at www2.cr.nps.gov/tps/briefs) or widely available publications such as the *Old House Journal*. European internet sources can also be helpful, such as www.buildingconservation.com, as can the Historic Preservation Technical Procedures available from the U. S. General Services Administration at www.gsa.gov/web/p/hptp.nsf. It is unlikely that any existing sources will address the complexities of fortifications, but they will continue to have information that will help the stewards of historic fortifications keep current with new developments that can supplement the guidance in the *Handbook*.

The information presented here examines the three categories of materials employed most frequently in fortification construction: earth, masonry and concrete, and metals. The subject is narrow: how to fix historic fortifications. Other important concerns—maintenance, interpretation, risk management, and safety—appear in Part Four, Management of Historic Fortifications. The objective in this part is to preserve the integrity of historic fabric and character-defining features.

Section One: Earth

The earth fill behind this masonry wall has been removed. The wall was not designed to stand alone, and it is now unstable and vulnerable to collapse. Fort Pickens, Florida.

Earth includes any type of soil material used in a permanent fortification. Apart from the natural undisturbed soil on which the foundation may rest, most common construction uses of soil include the formation of parados, berms, depressions, terrepleins, glacis, as well as floors in parade grounds, casemates, and moats. Earth served as a cushion to absorb the impact of naval gun fire, and after the 1890s, as a disguise to protect the fort from view by enemy vessels, and later, aircraft. An integral aspect of the discussion of soils is plant growth as a means to secure the soil layers in place.

Earth used in fortification construction typically was readily available local soil obtained from adjacent excavation for the construction of foundations, covered ways, mining tunnels, or drainage lines and swales. The Unified Classification System identifies 15 soil types that range in character from impermeable cohesive clays to silts to organic peats to sands and various blends in combination. The qualities of soil as a construction material include compactibility or compressibility, permeability, shear strength, and workability. Different soils reflect these qualities in different ways. For example, a well-drained sandy soil and an impermeable clayey soil will have divergent capabilities, and they will behave differently in the amounts of shrinkage, expansion, compaction, or drainage that they may experience in various situations.

The interconnectedness of soil qualities means that there can be a host of causes that can lead to a network of unwelcome conditions. Soil problems can develop in fortifications because of factors such as native moisture retention, compaction, excessive root growth below or into adjacent sub-structures, and erosion.

Analysis and Testing

A geotechnical or soils investigation is essential to understanding earth composition and behavior. This information is needed before designing a solution to earth related problems. The investigation will include a review of soil surveys and other data available for the area, drawings and information on the fortification, and a site visit to establish existing conditions. If necessary, the decision may be made to perform test borings. The sampling will lead to test results and recommendations from soils engineers that are based on their knowledge of soil types, soil series, soil classifications, and the corresponding soil behaviors and capabilities for the earthen features of the fortification structures. They will provide a geotechnical investigation report on the composition and structural qualities and capabilities of the soils in, on, and around the fortification. Typical geotechnical and foundations tests might include moisture, density, tri-axial, direct shear, consolidation, permeability, unconfined compression, specific gravity, organic content, liquid limit, plastic limit, split tensile (rock), or resilient modulus, among others. The report should also contain recommendations for solutions to the problems inherent in the structure. These recommendations should be evaluated and considered by all the members of a multi-skilled project team before determining the final treatment plan.

The geotechnical properties of soil were not thoroughly understood when many fortifications were built. An environmental mat helps stabilize the soil on this steep slope. Battery Gregg, Fort Mott, New Jersey.

Typical Problems and Treatments

Tree growth can disrupt and damage historic fabric as well as structural underpinnings, leading either to costly repair or the loss of the resource. Fort Jackson, Louisiana.

Removing trees and brush from around and on top of fortifications is a sound preservation practice. Battery Richmond, Fort Wadsworth, New York.

Vegetation Growing in Earthen Features

Vegetation in the earthen portions of a fortification may not be as damaging as that growing directly upon or out of the masonry portions of the structure, and the plant material may have existed historically. Documentation exists that shows trees planted on top of the ramparts at Fort McHenry. That same practice is present in other locations. For example, trees currently prosper along the massive walls that surround the ancient town of Lucca, Italy. Depending on the scale of the fortification, the depth of earth, the distance from the foundations, and interior wall structure, these plantings and their root conditions may not create problems. However, there is an increased risk that they will.

Grass is common on terrepleins and glacis, and before the advent of concrete fortifications, carefully trimmed and sodded slopes were highly prized. In and of itself, grass usually has a positive effect by preventing erosion of the soil, and taking up some of the moisture that would otherwise percolate down into any structure adjacent or below. However, the high level of care required for grass should be evaluated for its potential risk to the fortification. How are mowers brought to the terreplein? How much compaction is occurring in the soil because of routine maintenance over a long period of time? Is irrigation water saturating the soil and increasing the potential for rising damp or exacerbating a condition that is already present? Historically, goats and sheep helped keep the grass down, and it may be appropriate to consider them again in some applications.

In the event that grass was not the original plant material, give consideration to alternatives that require less intensive maintenance. Local landscape architects, sustainable landscape designers, or agricultural extension services may be able to identify native or other ground covers that could be a successful substitute.

Some vegetative cover is necessary since earth will erode without it. There can be challenges to establishing healthy growth. When the defenses were first built, the soil horizon may have been reversed, burying the topsoil, and if subsurface soils such as clay or gravel end up on top, there will be insufficient nutrition available for vegetation. To correct such a problem, soil chemistry can evaluate the soil. Treatments can then be designed that add nutrients to improve the soil quality.

Other options are native ground covers or grasses with strong, extensive, shallow root mats that demand fewer nutrients and help stabilize the soil against erosion. Again, local agricultural extension agents or landscape architects can assist in identifying appropriate planting materials.

Grass prospers now in areas that were once rendered almost bare from heavy military use. Grass is often an appropriate cover if properly maintained. Fort Macomb, Louisiana.

When the defenses were active, plants would struggle to survive in areas of frequent or heavy use, such as the parades to the rear of many defenses, although they were commonly sown with grass. Today, visitors generate much less traffic than soldiers in the past, and grass does well in these same locations. If there is a desire to maintain the appearance of bare earth for interpretive purposes, soils can be modified by stabilizers, as presented below under soil improvements.

Moisture Control and Management

Moisture problems are complex, and all aspects of their nature must be considered before determining treatments. Basic requirements include a complete grasp of the qualities of the soils, the growth habits and water retention capabilities of plant materials present, and the original design of the fortification. Treatment solutions emerge from this comprehensive understanding of the close relationship between the site and the combinations of soils and plant materials. A collaboration among specialists–botanists, soils experts, landscape architects, historians, and archaeologists–can help strike the right balance and avoid those proposed solutions that are ineffective and costly.

Sometimes, the problem is caused by an existing condition or design that can be readily improved by re-grading slope to drain or minimizing excessive slopes. Others may require intervention with the installation of a waterproof coating or membrane between the earth and the affected structure.

Some recent work at Fort McHenry provides a good example. There, excessive moisture penetration and retention was damaging the masonry walls. Studies theorized that the combination of foot traffic of visitors and resulting compaction of the soil was causing reduction in native drainage capability and thus increased moisture retention in the soil. Foot traffic was eliminated, and the earthen terrepleins on top of the walls were modified by the addition of a relatively impermeable layer of clay soil. Unfortunately, because of their physical structure, the clay soils took on water, reached saturation, and began to slip and slide. As a result,

Poor construction sites become poor historic sites, as demonstrated by the persistent high water table at Battery Forse, Fort St. Phillip, Louisiana.

some of the terrepleins began sliding towards the edge of the walls. This solution was later modified by removing the clay and replacing it with a stable, well-drained soil on top of an impermeable membrane.

Vegetation Management

Research and documentation of the specific use of plants and trees in the original fortification design is the prerequisite basis upon which a vegetation treatment plan can be devised. Existing conditions and historic illustrations may indicate the use of trees and lawns on the top or alongside fortifications, but documentation of when and why they were planted is necessary. After their useful life as defenses ended, many fortifications became monuments and parks for contemplative or interpretive use. The park designers and developers likely had ideas of their own about visitor amenities and esthetic presentation of the now historic structures.

If it is determined that roots threaten the fortification, they should be removed.

Once a history of vegetation is established, problems and conditions can be identified and potential treatments can be evaluated. In some cases the root structure may be holding the earth in place, in others it may be forcing the interior masonry out, or it could be doing both at the same time. Careful study and analysis of the conditions is warranted before determining treatment. Consultation with agricultural extension services or arborists can aid in the identification of tree species and knowledge of the root structure.

Vegetation Removal

If it is determined that roots threaten the fortification, they should be removed. Remove vegetation growing to excessive size or of the type that generates roots that are threatening to the structure. To prevent damage, large plants should be cut, and roots allowed to remain. After removal to prevent re-growth, poison the stumps. Monitor and observe the condition. After the root deteriorates and softens, removal and patching repair can be implemented.

Improving Vegetative Cover

Chemical nutrients or fertilizers can be applied or mixed into soil to improve the soil quality for plant growth. Or, native ground covers or grasses with strong, extensive, shallow root mats that demand fewer nutrients may be available to adhere the soil to prevent erosion. Again, local agricultural extension agents or landscape architects can assist in identifying appropriate planting materials.

Soil Improvements

According to the conditions, problem soils can also be improved by use of soil stabilizers. These stabilizers such as lime, petrochemical, or other man-made materials are commonly used in the construction of foundations and in road building. Depending on the specific qualities of the soil, some act as consolidants to improve cohesion, others add voids in the soil structure to improve its drainage capabilities.

An alternative solution to any problem soil may be to replace the earth that contributes to deterioration due to incompatible qualities with the requirements and conditions of its location. This must be preceded by archeological review. An investigation or monitoring may also be required.

Sea-front Erosion

Fortifications located on shorelines may have erosion problems that are wholly different than those described above. Defenses built upon headlands of well-compacted aggregates or cemented soils are at a disadvantage when compared to similar works erected upon the heights of weather-resistant rock. Wave action can weaken such soils and undermine batteries or auxiliaries if those features are close to an active bluff face. The original act of construction can also weaken a bluff by intercepting natural drainage paths or by redirecting surface water flows. The practice of routing drains to daylight at steep banks with little vegetative cover can also accelerate local loss of material, particularly if the drain line has developed leaks that saturate the soil beneath.

At low-lying sites, there are impacts from other types of soil movement. Subsidence or advancing beaches can result in the flooding of entire structures, weakening foundations and exposing easily damaged materials to accelerated loss. Storms or the transport of sands by currents can also lead to the isolation or loss of historic resources. Accretion can also take place, which by adding material around a fortification can protect it from erosion, although the distancing of the historically defended waterway will make interpretation more difficult.

Erosion of a high site or the subsidence (or washing away) of a low site usually share a common conclusion: loss of the resource. There are few practical, affordable, and environmentally compatible methods to stave off the loss of a fortification when its underlying site is subject to a fundamental change in its nature.[3] Often the only response can be to record the feature and document its loss.

Erosion and deposition can take place simultaneously. This World War II casemate is being exposed on the left as it is being buried on the right. Guernsey, Channel Islands.

Bluff erosion can undermine structures and pose significant preservation challenges. Battery Kinzie Primary Station, Fort Worden, Washington.

The erosion of low sites is an equally difficult problem. Fort Livingston, Louisiana.

[3] At Ship Island on the Gulf coast of Florida, the National Park Service removes accreded sands from one side of the island and redeposits them on the opposite side in order to build up the eroding beach adjacent to Fort Massachusetts.

Preservation of Earthen Features

Recommended	Not Recommended
Obtaining complete soils investigation for the fortification and utilizing multi-disciplinary teams to evaluate the information before devising treatments for problems with foundations or earthen features.	Making changes or repairs to foundations or earthen features without adequate information or evaluation.
Researching historic conditions and development of earthen features and related plant materials before devising and implementing treatments.	Treating or modifying earthen features or related plant materials without adequate historic documentation.
Replacing non-historic lawns inside or on top of fortifications with historic or native plant material.	Planting or improving and maintaining non-historic lawns inside or on top of fortifications.
Constructing trails and trail structures so that they do not cross earthen features.	Constructing trails and trail structures that cross or intersect earthen features that were not accessed by trails historically.
Responding to erosion, settling, or slippage in order to maintain historic contours.	Neglecting erosion, settling, or slippage so that historic contours continue to degrade.
Recognizing the importance of earthen features such as berms, parados and depressions so that their integrity is acknowledged and maintained.	Failing to recognize the importance of earthen features so that berms and parados are used as barrow sites, and depressions are used as refuse pits or are otherwise filled.
Maintaining historic vegetative cover where such cover exists, or re-establishing such cover as the result of a program of research and evaluation.	Failing to maintain historic vegetative cover so that new plant materials intrude to the detriment of character-defining features, or planting a new ground cover, the choice of which is not the result of a program of research and evaluation.

Section Two: Masonry and Concrete

Masonry and concrete are here together because they share some common qualities. Concrete is man-made rock. Its closest natural analog is graywacke conglomerate, and the natural world offers silty clay as the doppelganger of hardened cement paste.[4] Concrete is a low-cost replacement for natural stone in buildings. Bricks, too, are an alternative to building stone. When molded and baked, sand-laden clay placed into forms or extruded and cut to size, provides a material that is shaped to replace rock, and offers the advantages of uniformity of weight and size. Given the similarities of their composition (and ignoring at least momentarily the significant differences), it should come as no surprise that the way in which they fail and the manner in which they can be repaired are also similar. Spalls, cracks, surface deterioration, efflorescence, and subflorescence intrude upon masonry just as they do concrete. Patching, composite repairs, consolidation, and waterproofing treatments do equal service in both. Concrete and masonry share a final important characteristic: each is durable, neither is eternal.

For preservation purposes, the major differences among older brick masonry, newer brick masonry, the various stone, and various concretes are found primarily in their hardness, strength, density, porosity, permeability, and durability. These qualities vary greatly because of the source materials used in their manufacture, the manufacturing process itself, and the effects of aging over time. The nature of the materials and conditions in each masonry or concrete fortification is more or less unique, and understanding them is basic to the creation and application of appropriate treatments.

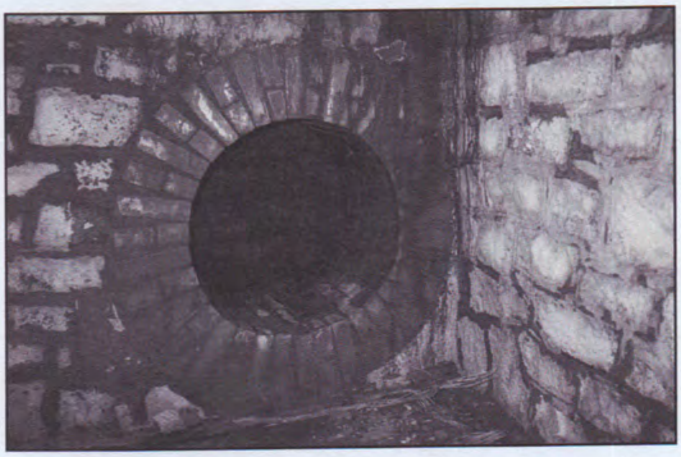
Types and Uses of Masonry

Granite was the preferred building stone for fortifications. Dense and hard with low porosity and permeability, it could resist attack from the weather just as it could defeat the impact of cannon balls. Because of its great weight, it was difficult and expensive to transport, and as a result, its use as a major building material was restricted to areas of the East Coast where granite quarries were relatively close by. Although distance may have precluded its extensive use in some locations, it was still required in smaller quantities for stones to secure the pintles and traverse rails for the gun carriages; foundation blocks to support the walls, steps, and weathering; and structural features such as cor-

The rock-faced granite ashlar of a bastion at Fort Schuyler, New York, conveys an impression of both power and solidity in this 1934 photograph.

[4] Katharine Mather, "Petrographic Examination," in *Significance of Tests and Properties of Concrete and Concrete-making Materials*, ASTM Special Technical Publication No. 169-V, (Philadelphia: American Society for Testing and Materials, n.d.), 125.

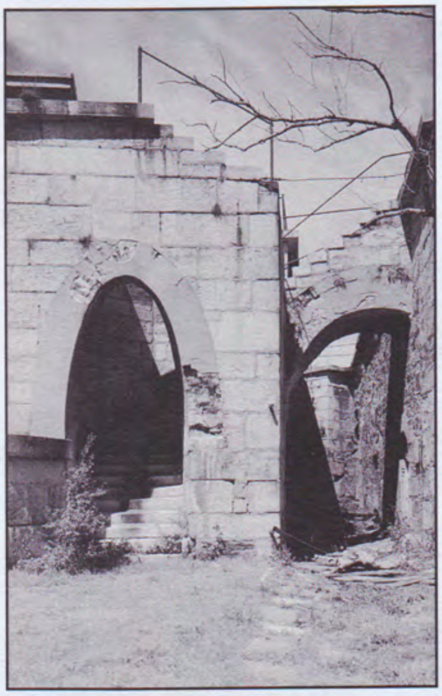
dons, copings, lintels, and quoins. Some granite also found its way into early concrete batteries as decorative detail or as anchor blocks for hinge hardware.



Both brick and stone masonry were used to form this ventilator opening in the otherwise concrete construction of Battery Thompson, Fort McKinley, Maine.

Sandstone was used as an interior backing stone for brick and could also be carved for details. Bluestone, a slate-like sandstone, was often called for as a paving material in the casemates, probably because of its exceptional wear resistance. Sandstone was used in some concrete batteries of the 1890s for many of the same purposes as granite.

Brick took the place of granite on the southern Atlantic, Gulf, and Pacific coasts, and countless millions of bricks formed walls, vaults, and piers. Brick also still had great purpose in fortifications built primarily of granite, as at Fort Monroe where brickwork constituted much of the masonry facing the interior parade. It could also be used in more subtle ways. The notable catenary arches of Fort Adams were made of brick, not of stone; the humble material was parged and detailed to resemble the adjacent granite blocks.



A common practice in non-military architecture, the bricks forming this arch have been parged to match the surrounding stonework. Fort Adams, Rhode Island.

A challenge in the preservation of brick is that there are many different types of brick, each with its own characteristics. In the earliest of days, bricks for fortifications were handmade. These materials were manufactured locally, often on-site, using the materials and technology available at the time. Some brick molding machinery was available in the early 19th century, but economies of scale, unreliability of the equipment, and inexpensive or free military or slave labor encouraged reliance on production by hand.

Wood-fired ovens were used to bake the molded clay into fired brick. The variation in temperature within the simple ovens produced bricks of varying colors and hardness. Bricks that had been burned closer to the fire in the kiln were harder, and as a result, they were used as facing brick. Interior wythes were constructed of "common" softer brick that resulted from the lower temperatures in other parts of the kiln. The fortifications built from these materials and methods were strong and solid for their time, with compatible brick and mortar components. However, they are very much softer and more flexible than fortifications built later of comparable materials manufactured with improved technology that produced brick and mortar of uniform strength and hardness, as well as Portland cement concrete.

These older bricks and mortars are also relatively permeable to moisture, resulting in a structure that in its ideal equilibrium has a degree of "breathability".

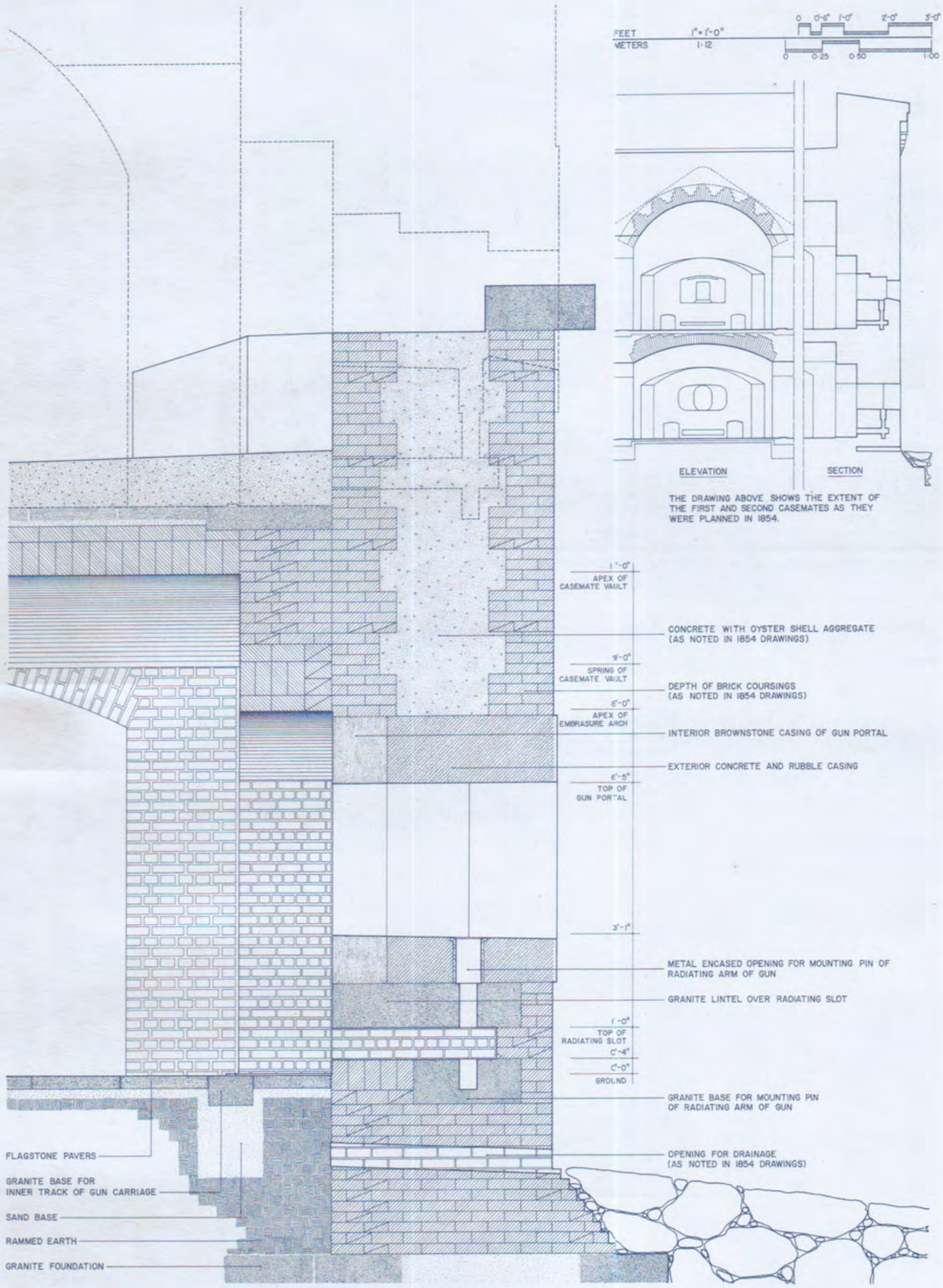
Moisture is absorbed into the surface, then evaporates out. Because of this, the durability of such a structure is especially dependent upon proper design for drainage. Excessive moisture can leach lime from mortars, causing disintegration of the mortar and eventually leading to loss of integrity in the structure. The further development of manufacturing technologies in the mid-1800's led to machine formed, molded, and extruded bricks; advancements in the control of the chemical composition of clays; and more consistent and higher firing temperatures. Factories also began to produce and distribute hydrated lime and later, Portland cement, to use with the new harder bricks. These materials were also a central component of masonry fortifications of the Third System and post-Civil War period, and have very different properties than the older brickwork. The modern materials are harder and less permeable than their predecessors, and thus, not entirely compatible. Because of these changes throughout the century, knowledge of the manufacturing history used at the fortification or in the locale can help us understand the qualities of the materials in a particular fortification. The need to identify and date later modifications or repairs is a continuation of the concept that the structure will have its own story to tell to future stewards.

All materials weather or age, including the hardest of stone. Chemical and physical changes work to break down the components of materials into their basic elements and carry portions of those components away. The local climate will affect the qualities of the original materials, often softening them, increasing their porosity and thus reducing their durability. This effect is more dramatic on materials that were soft to begin with. Wind-driven sand or salt water, rain, freeze and thaw cycles, hurricanes, and earthquakes all take their toll. The impacts are not always restricted to materials that are less resistant. Even modern bricks or harder stones can undergo chemical and physical changes that render them soft, porous, and easily damaged.

After careful visual observation of surface bricks and mortar, the most accurate and directly applicable information is obtained by scientific testing of the materials. Tests can be made on carefully selected representative samples to determine such qualities as porosity, permeability, and hardness. This information can be used to compare and match appropriate repair and replacement materials.

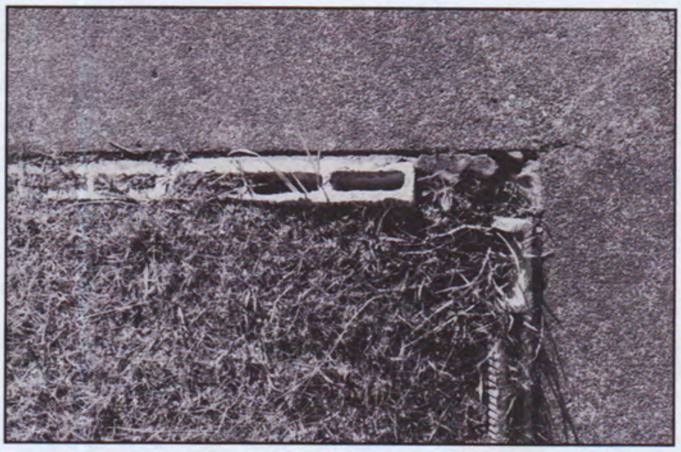
This fire control building at Fort McKinley dates from the early 1900s, and demonstrates the continued use of masonry in the transition to concrete fortifications.

Brick remained in limited use in the 1890s, a period when most fortification construction was completed in concrete. Some small structures, usually fire control stations, were built of brick masonry, while the same design at another location might appear in concrete. The reason for brick at one spot and concrete in another may be related to the existence of a functioning concrete batch plant: where such a plant was in operation, the buildings were made from con-



A sectional elevation of Fort Sumter, based on an 1854 drawing. The foundation of other fortifications may not have been constructed as neatly as depicted here. The excavation of a portion of the scarp wall footing at Fort McHenry revealed two courses of heavy stones and a haphazard middle course that was "a hodge-podge of smaller stones. Gaps between the stones are the norm, very few stones are flush, and the gaps are as wide as five inches." As quoted in "Fort McHenry National Monument and Historic Shrine, The Comprehensive Plan: Fabric Analysis and Treatment Recommendations," National Park Service, 1992, 4.

crete; when no plant was available, brick became the simpler choice. Perhaps more perplexing was the continued use of brick and stone masonry for partition and bearing walls in early concrete fortifications. Masonry has a higher per unit cost than poured concrete, and it is difficult to understand the use of more expensive building techniques by the cost-conscious Army engineers.



Looking down at the ends of hollow tile that face the walls of a concrete structure at Fort Baker, California. The tile cladding was intended to divert water from the interior.

Hollow tile and ceramic tile show up in some specialized applications. Hollow tile appears both as an original and a retrofit waterproofing material for sub-surface applications, and was also employed to help reduce condensation by isolating concrete walls. Ceramic tile occasionally was put up as a wall covering, presumably to increase the reflectance of available light in dimly lit spaces.

Coquina stone appears in the earliest fortifications built by the Spanish, such as the Castillo de San Marcos. Because of its unique nature and its very limited use in fortifications, it is not treated in the Handbook. Other building stones such as limestone and marble that were widely used in many building applications were not a part of fortification construction.

Granite, sandstone, and brick show up in virtually all domestic masonry fortifications, with each type being selected for its individual qualities that would satisfy the needs of a particular requirement. Many of these qualities were the same as those sought in brick. Porosity, permeability, strength, and hardness were aspects of stone that were well understood in the 19th century, even if the scientific measurement of them was not available at the quarry or the building site. Getting out the stone, finishing it, and installing it introduced other variables that could have an effect on the basic physical properties. So, too, could the environment, and the action of water in particular. Tight-grained granite is impervious to moisture, but the same cannot be said for sandstone and brick. The problem is not moisture itself–most brick and sandstone could remain fully submerged for long periods without adverse effect–however, freezing and subflorescence can produce forces that exceed the strength of these materials. Moisture can also produce efflorescence on exposed surfaces. It is at least unsightly, and there is a difference of opinion on the part of materials experts as to the degree of harm that it may cause.[5]

[5] "Diagnosis: A Procedure," RESTORE Workshop on Formulating Composite Repair Materials for Masonry: Mortar Analysis, Pointing, and Composite Repairs, course readings, 2001, Section A, 68; W. H. Dukes, "Conservation of Stone: Causes of Decay," Section B, 2.

Types and Uses of Concrete

The earliest use of concrete in the fortifications of the United States dates to the Spanish colonial period and the construction of the Castillo de San Marcos in 1672. It was a simple form called tabby. Lime and sand were combined with shells and gravel, and mixed with water, producing a material that could be poured into forms and tamped in place.

Lime is a manufactured product made from heating limestone. At a certain temperature, the oxygen content in the stone is burned off, leaving only lumps of pure calcium. This material is generally called "quicklime" and is chemically unstable. It must be slaked by adding water. In what is referred to as the Lime Cycle, the water slowly evaporates, the hydrogen dissipates, the oxygen recombines with the calcium, and eventually, the limestone is reformed. Adding aggregates creates a concrete or mortar mix. The aggregates are more readily available and easier to acquire than lime, so they serve to stretch the material by taking up space in the mix, and they also provide some flexibility and workability before it hardens.

This lightly compacted mixture of a tabby-like material provides in-fill for the masonry walls of Fort Livingston, Louisiana.

As the building of fortifications progressed in the 18th and 19th centuries, lime-based concrete remained an essential part of the work, although little of it is apparent now. Its greatest use was as in-fill material in the center of scarp walls, and it was probably of indifferent quality: the concrete fill at Fort Sumter was of sand and shell, and not significantly different than tabby. More interesting is the extensive use of concrete at Fort Jefferson, whose construction began in 1846. Concrete here was used for underwater work, and that required a cement with hydraulic properties. Since only natural cements were available at the time, and natural cements are not always known for their hydraulic properties, it was an interesting innovation and surprisingly successful. The same cement was amended with unslaked lime and mixed with a coarse aggregate of coral and shell fragments to form the concrete mix that was used for above-water construction.[6]

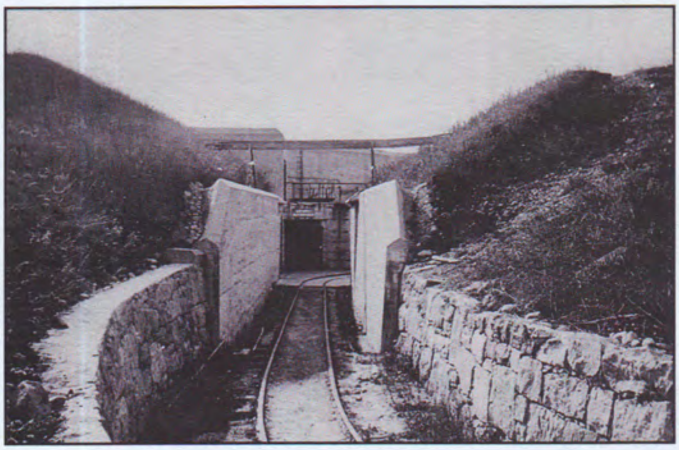
Pure lime mortars can obtain hydraulic properties in several ways. The Romans used "pozzolans" as additives to their lime mix. Pozzolans were fine clays. In the early fortifications crushed brick or brick dust was added. These would have been most effective by using the softest bricks from the lowest temperature locations in the kiln. They had not been burned as hard, and thus maintained the original properties and benfits of the clay content. Other pure lime mortars can be made from naturally hydraulic lime. This material is manufactured using limestone that naturally contains some clay content.

[6] Ferguson, 11; Anderson, 12.

By the 1870s, Portland cement was widely regarded as superior to natural cements, but it was available in quantity only from Europe, and it was expensive. When the nation was ready to build its new system of concrete defenses, army engineers turned to natural cements as a familiar and economical alternative. They soon regretted the choice since it was an inferior product for fortification work, and they rapidly replaced it with Portland cement as soon as it began to be available in commercial quantities. Some batteries built from concrete made from natural cement were partially rebuilt with Portland cement concrete.

The original Portland cement was manufactured from portland stone, a natural limestone with both clay and some metal contents named for the quarry location in England. When burned at high temperatures and by applying a series of additional processes, the stone was transformed into a hydraulic cement. Scientific analysis of the contents and chemical changes that occurred in this new material allowed the effects from portland stone to be replicated and refined at manufacturing plants throughout the world during the 20th century. By combining various mixtures of clays and metals with different types of local limestones, the manufacturing process has controlled and standardized the quality of the generic product called Portland cement. Portland cement is mixed with sand to form mortar; coarser aggregate is added to form concrete. These modern materials are harder, denser, generally more durable, and have varying properties depending on the specific chemical composition.

Concrete steadily displaced masonry. Stone and brick then had almost no purpose except decoration, and even those limited applications fell away as the building of the defenses became more sophisticated and sensitive to cost and efficiency. The earliest batteries and adjuncts of the defense were built of mass concrete, and featured round-arched interior spaces; later versions had structural steel or iron shapes embedded in the ceiling. Most of the large-scale construction was complete by 1910, at about which time army engineers began to introduce round and deformed bars, indicative of the wide-spread shift to reinforced concrete in civilian as well as military applications. Big fortification projects were still ahead in overseas locations such as Hawaii, Panama, and the Philippines, and as additional defenses were built in the years after World War I, reinforced concrete began to contain more steel, and more knowingly placed.



As the shift to concrete construction became more complete, masonry was relegated to a minor role as represented in this 1908 photograph of the retaining wall at the entry to Battery Butterfield, Fort H.G. Wright, New York.

The Growth of Reinforcement

The first concrete batteries had no reinforcing, and structurally were piles of concrete indifferently placed. The Galveston hurricane of 1900 made apparent what the absence of reinforcing could mean. In this view of a battery taken after the storm, it is easy to see the nature of unreinforced mass concrete. Inundated by a series of storm waves with an energy estimated at two million pounds each, the batteries shattered and their surrounding sites disappeared. They were subsequently rebuilt.

The introduction of reinforcing to fortification practice followed the same outline as its use in other building specialties. Beginning about 1905, new fortifications (or improvements to existing work) were put up with first smooth and then deformed bars. The initial understanding of placement was not well developed, which left the reinforcing vulnerable to carbonation and chloride attack, but that knowledge improved steadily. In this view of Fort Drum, Manila, taken in about 1914, the dense array of bars and load-bearing beams is typical for heavy construction of the period.

The rapid advance in the power of weaponry first evident on the battlefields of World War I continued through the 1920s and 30s. Fortifications erected in the years prior to World War II responded to the need for ever stronger resistance to bombardment. The amount and size of reinforcing steel increased, and contributed to greater percentages of the volume of the structure. An example is this view of Battery Townsley, Fort Cronkhite, California, with its thicket of bars and deep riveted truss over the opening of the gun emplacement.

Unreinforced and reinforced concrete were the only types used in fortifications, and they were always cast in place. Pre-cast and pre-stressed techniques were not employed.

Guidelines for Preserving Masonry and Concrete

Masonry and concrete features and surfaces are important in defining the historic character of fortifications. While they are among the most durable of historic building materials, masonry in particular is susceptible to damage by improper maintenance or repair techniques and by harsh or abrasive cleaning methods. The following tables are derived from *The Secretary of the Interior's Standards for the Treatment of Historic Properties*. Approaches, treatments, and techniques that are consistent with the Standards are listed in the Recommended column, and actions that may adversely effect the historical character of a fortification are listed in the Not Recommended column.

Preservation of Brick and Stone Masonry

Recommended	Not Recommended
Identifying, retaining, and preserving masonry features that define the overall historical character such as scarp walls, parapets, sally ports, embrasures, copings, and cordons; and details such as tooling and bonding patterns, joint and unit size, and color.	Removing or altering masonry features that are important in defining the overall historical character of the fortification so that, as a result, the character is diminished.
	Replacing or rebuilding a major portion of masonry walls that could be repaired so that as a result, the integrity of the fortification is impaired and appears to be essentially new construction.
	Applying paint or other coatings such as stucco to masonry that has been historically unpainted or uncoated.
	Removing paint or coatings from historically painted or coated masonry.
Stabilizing deteriorated or damaged masonry as a preliminary measure, when necessary, prior to undertaking appropriate preservation work.	Failing to stabilize deteriorated or damaged masonry until additional work is undertaken, thus allowing further damage to occur.
Protecting and maintaining masonry by providing proper drainage so that water does not stand on flat, horizontal surfaces such as paved or earthen terrepleins and parade grounds.	Failing to evaluate and treat the various causes of mortar joint deterioration such as subsurface moisture sources, improperly or inadequately maintained drainage systems, differential settlement, capillary action, or extreme weather exposure.
Repairing masonry walls and other masonry features by repointing the mortar joints where there is evidence of deterioration such as disintegrating mortar, cracks in mortar joints, loose bricks, damp walls, or damaged plasterwork.	Removing non-deteriorated mortar from sound joints, then repointing large areas to achieve a uniform appearance.

Preservation of Brick and Stone Masonry (continued)

Recommended	Not Recommended
Removing deteriorated mortar by carefully hand-raking the joints to avoid damaging the masonry.	Using electric saws and hammers rather than hand tools to remove deteriorated mortar from joints prior to repointing.
Duplicating old mortar in strength, composition, color, and texture.	Repointing with mortar of high portland cement content (unless it is the content of the historic mortar). This can often create a bond that is stronger than the historic material and can cause damage as a result of the differing coefficient of expansion and the differing porosity of the material and the mortar.
	Repointing with a synthetic caulking compound.
Duplicating old mortar joints in width and in joint profile.	Changing the width or joint profile when repointing.
Repairing masonry features by patching, piecing in, or consolidating the masonry using recognized preservation methods. The new work should be unobtrusively dated to guide future research and treatment.	Removing or replacing masonry that could be repaired, using improper repair techniques, or failing to document the new work.
Applying new or non-historic surface treatments such as water-repellent coatings to masonry only after repointing and only if masonry repairs have failed to arrest water penetration problems.	Applying waterproof, water-repellent, or nonhistoric coatings such as stucco to masonry as a substitute for repointing and masonry repairs. Coatings are frequently unnecessary, expensive, and may change the appearance of historic masonry as well as accelerate its deterioration.
Evaluating the overall existing condition of the masonry to determine whether more than protection and maintenance are required, that is, if repairs to the masonry features will be necessary.	Failing to undertake adequate measures to ensure the preservation of masonry features.

Preservation of Concrete

Recommended	Not Recommended
Identifying, retaining, and preserving features that are important in defining the overall historical character of the fortification such as walls, parapets, slopes, jointing marks, recesses, and steps; and details such as form and mold markings, textures, finishes, and colors.	Removing or altering features that are important in defining the overall historical character of the fortification so that as a result, the character is diminished.
	Replacing or rebuilding a major portion of concrete feature that could be repaired so that as a result, the integrity is reduced and the feature has the appearance of new construction.
	Applying paint or other visible coatings such as stucco to concrete that has been historically unpainted or uncoated.
	Removing paint or visible coatings from historically painted or coated concrete.
Stabilizing deteriorated or damaged concrete as a preliminary measure, when necessary, prior to undertaking appropriate preservation work.	Failing to stabilize deteriorated or damaged concrete until additional work is undertaken, thus allowing further damage to occur.
Protecting and maintaining concrete by providing proper drainage so that water does not stand on horizontal surfaces such as traverses, platforms, and floors.	Failing to evaluate and treat the various causes of concrete deterioration such as subsurface moisture sources, improperly or inadequately maintained drainage systems, differential settlement and cracking, capillary action, or extreme weather exposure.
Repairing features by repairing joints or cracks where there is evidence of deterioration such as disintegrating concrete, cracks, spalling, detachment, or similarly damaged surfaces.	Removing deteriorated sections or features, then replacing large areas to achieve a uniform appearance.
	Repairing minor hairline cracks unless after study such a repair is considered necessary to halt other and more detrimental conditions.
Repairing structural cracks with epoxy injection methods under advice of structural engineer after structure has been stabilized.	Excessive use of epoxy injection when cracks are not structural in nature or when cracks are active (moving).
Repairing deflection or conditions resulting from shifting or movement only under the direction of a structural engineer.	Attempting to repair deflection or other unstable structural conditions by unqualified personnel.

Preservation of Concrete (continued)

Recommended	Not Recommended
Under the direction of a structural engineer, selectively replacing rusted and deteriorated reinforcing steel and wire mesh with epoxy coated steel or alternate materials where structural integrity is threatened and/or rust jacking is creating loss of historic concrete.	Failing to replace corroded reinforcing steel before initiating concrete repair or replacement.
Duplicating old concrete in strength, composition, color, and texture.	Patching or repairing with concrete of higher strength than the original or using a bonding agent between the old and new work. This can often create a bond that is stronger than the historic material and can cause damage as a result of the differing coefficient of expansion and porosity of the materials.
Repairing concrete features by patching using recognized preservation methods. The new work should be unobtrusively dated or otherwise noted to guide future research and treatment.	Removing or replacing concrete that could be repaired, using improper repair techniques, or failing to document the new work.
Applying new or non-historic surface treatments such a water-repellent coatings to concrete only after repairing and only if repairs have failed to arrest water penetration problems.	Applying waterproof, water-repellent, or non-historic coatings such as stucco to concrete as a substitute for concrete repairs. Coatings are frequently unnecessary, expensive, and may change the appearance of historic material as well as accelerate its deterioration.
Evaluating the overall existing condition of the concrete to determine whether more than protection and maintenance are required, that is, if repairs to the concrete features will be necessary.	Failing to undertake adequate measures to ensure the preservation of concrete features.

Some of the practices above involve cleaning surfaces as a part of other treatments. The following table contains additional guidance regarding cleaning.

Cleaning Masonry and Concrete

Recommended	Not Recommended
Cleaning only when necessary to halt deterioration or remove heavy soiling.	Cleaning surfaces when they are not heavily soiled to create a new appearance, thus needlessly introducing chemicals or moisture into historic materials.
Conducting surface cleaning tests after it has been determined that such cleaning is necessary. Tests should be observed over a sufficient period of time so that both immediate and long-range effects are known, thus encouraging the selection of the gentlest method possible.	Cleaning surfaces without testing or without sufficient time for the testing results to be of value.
Cleaning surfaces with the gentlest method possible, such as using low-pressure water and detergents and natural bristle brushes.	Blasting surfaces using dry or wet grit or other abrasives. These methods of cleaning permanently damage f the material and accelerate deterioration.
	Using a cleaning method that involves water or liquid chemical solutions when there is any possibility of freezing temperatures. Cleaning with chemical products that will damage masonry, such as using acid on limestone or marble or leaving chemicals on masonry surfaces.
	Applying high-pressure water cleaning methods that will damage historic masonry and the mortar joints.

Causes of Deterioration

Environmental factors, materials and workmanship, and improper handling of materials can contribute to premature or accelerated deterioration. Moisture and moisture-related problems are the most prevalent cause of destruction. Moisture penetration can destroy seemingly strong material through expansion during freeze/thaw cycles, by corroding embedded metal, or by leaching soluble salts to the surface. Concrete is especially susceptible to moisture-induced deterioration. Poor materials and workmanship are another cause of concrete problems. Porous coal cinders and crushed brick were sometimes used as aggregates, resulting in greater water absorption and retention, and therefore ultimately weaker concrete. This practice may have been experimental with the new Portland cement concrete, for when these same materials are added to traditional lime mortars, they add hydraulic capability to the mortar, resulting in greater strength and durability. Even when gravel was the aggregate, improper grading or incomplete distribution in the mixture reduced the strength of the pour. Early concrete was not vibrated after being poured, which meant that the cured concrete had more voids and weak spots and a minimum of entrained air. Entrained air is necessary to resist the effects of temperature cycling.

Keeping in mind the essential role of water as the agent for most deterioration, the following table details three types of deterioration, how each manifests itself, and the nature of the deterioration.[7]

Deterioration	Manifestation	Effect
Chemical	Pollutants	Acid rain attack on calcium carbonate stone, calcareous sandstone.
		Cement paste reaction.
		Calcium sulphate (gypsum) formation, with subsequent spalls.
	Soluble salts	Exfoliation, spalling, efflorescence, unsightly appearance.
	Alkali-silica reaction	Gel formation, internal micro-cracks.
	Leaching	Removal of calcium compounds, formation of stalactites.
Physical	Dimensional change	Cracks, spalls, delamination.
	Wind-borne solids	Erosion of soft stone or brick.
	Impact	Spalls, cracks.
	Subsidence	Cracks, differential settling, loss of structural integrity.
Biological	Algae	Slippery surface, can lead to formation of lichens.
	Mold, mildew	Unsightly, indicates presence of organic materials
	Lichens	Growth habit penetrates surface and weakens it; secrets some amount of acid. Changes visual character of materials.

[7] Based on D. H. Dukes, "Conservation of Stone: Causes of Decay," Technical Study 1, *The Architects' Journal Information Library* (August, 1992).

Evaluation and Assessment Techniques

As outlined in the beginning pages of Part Three, no treatment should be undertaken without first considering the whole structure in the identification of the problem. Discovering the cause of the failure and taking measures to correct it is as important as the specific repair, since an expensive repair may prove only temporary if the underlying cause is not resolved. For example, if water movement has led to spalling and delamination on the surface of a masonry wall, patching or consolidating the damaged areas may not prevent future loss if water content within the wall is not controlled first.

Depending on the severity of the deterioration or the complexity of the problem, a complete examination of the condition and quality of masonry and concrete may require the assistance of one or more professionals, including preservation architects, architectural conservators, structural engineers, materials specialists, petrographers, and chemists. To reach their conclusions, they can turn to a number of examination methods. These fall into two groups–destructive and non-destructive. With our emphasis on the retention of historic fabric, we are most interested in non-destructive testing methods. Almost all non-destructive tests, however, are of limited applicability in fortifications.[8]

Discovering the cause of failure and taking measures to correct it is as important as the specific repair.

Non-Destructive Procedures

Surface Examination. Looking carefully is often one of the best diagnostic procedures. Most of the symptoms of deterioration–cracks, spalls, efflorescence, exfoliation–are visible on the surface. A regimen of testing should be prepared only after a thorough examination of the surface, and with the understanding that the tests are intended to yield information that cannot be gained in other ways.

Impulse Radar. Operators push or pull a transducer over the surface, yielding a scan that can be interpreted to identify features such as beams, girders, pipes, and voids within the area examined. It can penetrate several feet, which may not always be sufficient for fortification work, but it can be useful where only one surface is available. It is expensive, and a high level of expertise is necessary to operate the equipment and interpret the results.

Impact Echo or Acoustic Impact. A method that can be as simple as dragging a chain over a surface and listening for the hollows within the material or as complex as much more sensitive (and less subjective) electronic equipment. A hammer test or sounding for masonry serves much the same purpose. An experienced person tapping on a masonry unit can reach some conclusions about the

[8] The summary of non-destructive and destructive procedures is based on Marilyn Kaplan, Marie Ennis, P. E., and Edmund P. Meade, P. E., "Non-destructive Evaluation Techniques for Masonry Construction," *Preservation Tech Notes*, Number Four, (Washington, D. C.: Department of Interior, National Park Service, 1997 reprint); "Guide for Evaluation of Concrete Structures Prior to Rehabilitation," American Concrete Institute, ACI Committee Report 364.1 R-94, 1994; "Strength Evaluation of Existing Concrete Buildings," ACI Committee Report 437 R-67, 1991; "Basic Principles of Architectural Conservation," RESTORE course readings, 2001, Section A.

The sub-standard condition of this parge coat could have been detected by simple acoustic impact tests. Battery Cavallo, Fort Baker, California.

condition of the individual stone or brick and the quality of its bond by virtue of the different tones made by the impact. In the most sophisticated electronic versions of the method, it can produce good data for granite and sandstone walls and columns that are less than two feet thick. It can give excellent results in detecting stone cracking parallel to the surface, but it is limited where there are multiple layers of material. Successful operation of the equipment requires training as well as material reference standards. Another technique–spectral analysis of surface values–uses the same equipment and can detect similar faults.

Ultrasonic Pulse Velocity. Provides estimates of uniformity, quality, and compressive strength of concrete; it is also useful for determining the thickness and relative soundness of granite and sandstone columns. Low frequency signals can provide good results in brick walls with multiple mortar joints, although the same level of frequency cannot detect small-scale damage. A considerable amount of training and facility is required for its operation. It is a standard ASTM test for concrete; access to both sides of the material is required.

Cover Meter, Pachometer, Electromagnetic Detection. Useful in locating steel and iron members in masonry up to nine inches in depth, although it is not considered reliable in concrete for cover depths greater than four inches. The equipment is portable and easy to operate, although training is required to interpret the results. It should be used with other tests to detect hidden reinforcing or other metal objects.

Infrared Thermography. Intended to detect internal flaws, crack growth, delamination, and voids, although in practice the actual capabilities seem more limited. Its efficacy depends on a high temperature differential between the surfaces being examined, and significant expertise is required to interpret the results. The promise is large since it should provide an inexpensive method for the quick and accurate detection of defects over large areas.

Fiber Optics. Allows the viewing of interior voids with a fibrescope (flexible) or borescope (rigid). The technique is of obviously limited value in solid walls, but it can be used to good effect in the examination of the interior walls of core locations or drainage systems. The equipment is expensive but easy to use; a camera can be coupled to the scope in some applications.

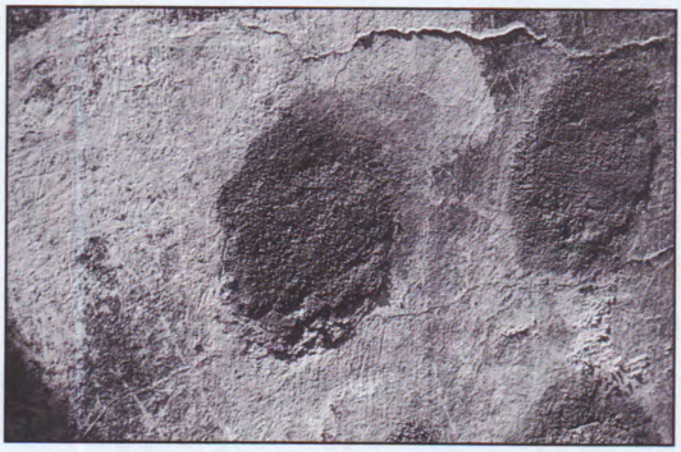
Rebound Hammer. Produces a rebound number as the result of a spring-loaded hammer striking the surface being tested and the distance of the rebound as measured against a scale. It provides an indicator of the compressive strength of concrete, but the rebound number is not directly related to compressive strength. It also is too dependent on conditions of the test site to provide empirical data that can be generalized to the structure as a whole. It can be used only on concrete, and it cannot provide any useful information about the compressive strength of masonry.

Non-destructive methods can be valuable exactly because they are non-destructive. However, they do not often provide direct and useful detail about the physical character and composition of concrete and masonry, and they cannot yield valid results regarding the compressive strength of the materials under investigation. The best information comes from identifying and evaluating the material through close, methodical visual assessment; measurement with instruments; chemical tests; and examination under a microscope, and to do that, a sample must be removed from the structure. The methods of removing a sample fall into the category of destructive procedures.

Destructive Procedures

Core Sampling. The process of extracting a cylinder of concrete and subjecting it to tests is called core sampling. It is a well-known and widely-used technique, and not all authorities classify it as destructive.[9] It is regarded as destructive when it is used on historic properties because it mars the surface appearance. The test leaves a hole several inches in diameter and up to several feet deep, as well as additional smaller holes necessary to attach the coring machine to the surface of the structure. The holes can be filled, but the surface is permanently altered.

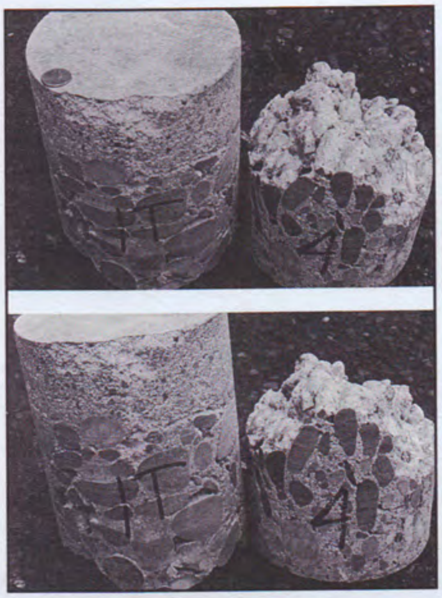
Both water and power are required to operate a coring machine. Battery Worth, Fort Casey, Washington.



Removing core leaves a large hole that must be repaired. This repair needs to be resurfaced so that it will better match the surrounding historic fabric. Battery Worth.

Core sampling is important because it is the only way to acquire accurate information about the compressive strength of concrete or some sense of the internal character of masonry construction. It can also be the first step in identifying the physical properties of concrete; in most fortifications, arriving at an understanding of those qualities is often as valuable as determining the compressive strength. The samples do not offer this information directly, but only after the cores are subjected to physical and chemical analysis. Chemical tests can determine such important information as cement content, the content of soluble salts and chlorides, and alkali-silica reactivity. In most instances, petrographic examination will provide a more and varied perspective than is available through chemical tests alone.

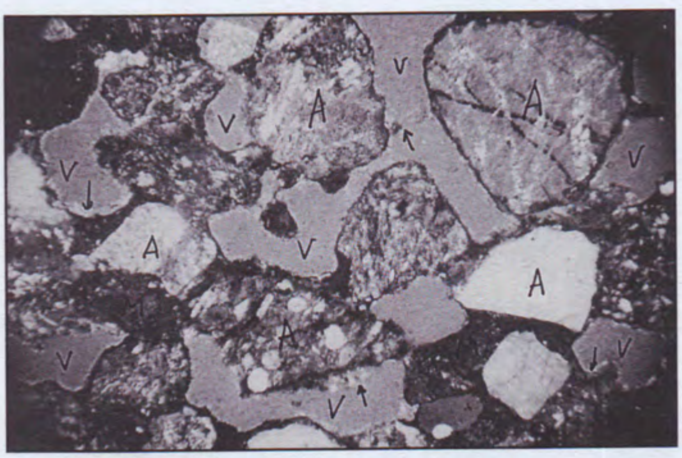
[9] It is not considered destructive because coring does not alter the serviceability of the structure. See Randall W. Poston, A. Rhett Whitlock, and Keith E. Kesner, "Condition Assessment Using Nondestructive Evaluation," *Concrete International*, (July 1995), 36. For a discussion of the value of coring in historic masonry, see David W. Boyer, "A Field and Laboratory Testing Program," *APT Bulletin* (Vol XIX, No. 4), 1987.



Once removed, the core can be used for a number of chemical and physical tests. Note the layer of finer aggregate bonded to the heavier aggregate below; this is a common profile for early concrete roads. Battery Worth.

Test Panel. Testing based on core samples is less effective in masonry construction, although the strength information gathered as a result of testing one or more masonry units can offer some sense of the strength of the wall of which they were a part. More useful as well as more damaging is the removal of a test panel. In this method, a section of masonry wall is carefully cut free of and removed from the parent wall. It is transported to a laboratory where technicians subject the panel to a number of tests that can be used to determine the physical properties (especially compressive strength) of the wall. There are a number of serous shortcomings. It is unsightly, multiple test areas are required for the analysis, the structure may be weakened by the removal of the panels, and the results may vary so much that no real information is gained.[10]

Petrographic examination–the direct study of the physical aspects of a concrete or mortar sample–is done in a laboratory by skilled technicians using a variety of specialized equipment. It can help reveal the history of the sample, the how and why of its life, and the reasons that it acted in a particular way. Petrography can also estimate the age of cracks and also determine if the material will continue to deteriorate and at what rate. The examination can also provide descriptions of the size and color of the aggregate; these features are of key importance because they largely determine the color of the finished concrete.



A microscopic view of the concrete from Battery Worth. The areas marked with a 'V' are voids that contribute to weakness and porosity.

Understanding what petrography can reveal should help guide the selection of the area that will be the site of core sampling. A valuable sample will be one that intersects a cold joint because the quality of the bond between lifts is an aspect of the strength of the structure as a whole. It may be easier said than done. Cold joints may be effectively masked by parging, and visible joint lines may be in the facing layer rather than in the mass concrete behind it.

It may be that none of the tests outlined here are necessary. If the initial investigation and condition survey indicate that the structure is in sound condition and there is no reason to believe that hidden defects exists, there is no requirement to test. The need to investigate the nature of concrete or masonry arises when there is insufficient information about the materials, or when it appears that defective materials are present. If sampling is necessary for any of the tests, resist the temptation to offer up broken concrete, mortar, or masonry as a means of preserving the integrity of the fabric. Loose fragments are unevenly weathered, and may not

[10] J. Stanley Rabun, *Structural Analysis of Historic Buildings*, (New York: John Wiley and Sons, Inc., 2000), 462.

accurately represent conditions in the structure from which they are detached. If the circumstances call for tests based on coring, then coring should be done; a small side benefit is that coring dust can be gathered and used as source material for chemical tests to determine chloride content. However, avoid using the dust for cement content analysis.[11]

Typical Problems and Treatments

There is more than ample guidance in preservation literature about the conservation and repair of architectural stones, especially limestone and sandstone, and no effort will be made here to duplicate those easily available resources. There seems to be little reason to do so in any case, since as we have seen, these stones have limited applicability in fortification work. The concerns of this section of the Handbook are with granite, brick masonry, and concrete, and the remarks that follow refer to these materials as they are used in permanent defenses. There are, however, few examples of the treatment of granite masonry, perhaps because of the smaller number of fortifications built of granite or the more enduring quality of the material itself.

Dirt and Discoloration

Decades and centuries of exposure to rain, dust, and pollutants produce an accumulation of dirt on any building, fortifications included. Concrete and masonry are materials that hold up well, and their structural response has little to do with how clean they might be. However, getting through the grime can extend the life of the materials just as it can improve their appearance.

General cleaning requires a specific justification. Fortifications, especially large fortifications, went through a series of appearance changes during their active lives, and the risk is to make them more bright and attractive than they were ever meant to be. The construction episode in Third System works was so extended that the stone and brickwork of completed sections would begin to change color while work was still in progress on other areas. The result was a mottled appearance, not a uniform one. The same is true for concrete defenses. They were often painted when new to relieve the brilliance of the almost white surface, but there was no uniform program of repainting. The worn paint layer was altered by the application of various water-proofing treatments and crack sealants. Some were repainted in camouflage tones during World War II, adding another element in what had

This historic view of Battery Wheeler, Fort Mills, Philippine Islands, shows that the new concrete has been painted a dark color to reduce glare from bright sun.

[11] ACI Report 364.1R-94, 6.2 and 6.5.1.3; William G. Hime, "Analysis for Cement and Other Materials in Hardened Concrete," Chapter 29, ASTM Standard Technical Publication 169C, 1994, 316.

The camouflage is distinctive and clear in this 1943 photo, but such patterns can still be distinguished today, and would be lost in a program of comprehensive cleaning. Battery Reed, Fort Amezquita, Puerto Rico.

become a chaotic layering of surfaces. The blotched pattern of many different and subtle hues is a combination of surviving paint fragments, surface treatments, organic growth, and dirt. To clean is to clean it all; there is no method that can remove only organic growth and dirt, and leave intact other visible traces of the long life of the fortification.

There remain good conservation reasons for cleaning in some circumstances. As noted previously, lichen can cause surface deterioration, and moss grows on dirty surfaces. Removing lichens and moss is a worthwhile practice, and sometimes what appears to be help can come from an unexpected quarter. When rainwater dissolves atmospheric sulfur dioxide, which is present as a pollutant, it forms acid rain. The positive effect is that acid rain kills lichen. The disadvantage is that sulfur dioxide can also form a crust of gypsum when it comes into contact with calcium-based materials such as mortar and concrete. The gypsum can build up below the exterior surface, blocking the normal movement of water vapor, and which consequently leads to the creation of spalls.[12]

Sulfur dioxide can also come from a point source. In the recent past, the diesel-powered generators at the Fort Jefferson historic site exhausted through embrasures in the lower tier, staining the adjacent masonry with combustion by-products including sulfur dioxide. Dry brickwork absorbs sulfur dioxide. When the brickwork becomes wet, the sulfur dioxide goes into solution as a mild sulphic acid. It then combines with salts in the atmosphere to create a sulphate that is corrosive, expansive, and potentially very damaging. Although the rate and degree of deterioration in this instance cannot be determined, good practice calls for the revision of the exhaust system and the cleaning of the surface stains.[13]

Solutions for Dirt and Discoloration

Water Wash. Cleaning with water may be the least destructive and most economical technique available. Water washes vary from scrubbing with water and a brush, to low-pressure washes, to steam washes. High pressure washing is ultimately damaging, and is not acceptable because water is forced into cracks and mortar joints where it can contribute to spalling or efflorescence, as well as the saturation of interior fill materials. Detergents or chemicals may be incorporated into the wash, depending on the material being cleaned from the surface. A fine mist of water positioned on an area over an extended period of time has proved successful in loosening hardened dirt deposits. The technique is useful in areas of deep relief, like column capitals and detailed cornices, and as a result, is of limited applicabil-

[12] M.K. Hurd, "Cleaning concrete," Concrete Construction, (November, 1992), 791.

[13] Anderson, 54.

ity in most fortifications applications. The rule of thumb is to always use the gentlest means possible.

Any water washing must be carried out after the threat of frost or freezing has past. Trace amounts of minerals, such as iron and copper, within the water used for washing may also cause surface discoloration. Proper testing and observation should be conducted prior to any extensive cleaning.

Chemical Wash. Cleaning with detergents or chemicals dissolved in water may hasten the loosening and removal of dirt, but must be used with caution. The chemicals may react with the masonry or other building elements. Since chemical cleaning is usually applied through a water solution, it is subject to the same cautions as water washing, and must not be used with high pressure or under freezing temperatures. The chemicals themselves should be used only after testing them for a reaction with the surface to be cleaned. Brick is especially susceptible to damage from hydrochloric (muriatic) acid, a common cleaning chemical.

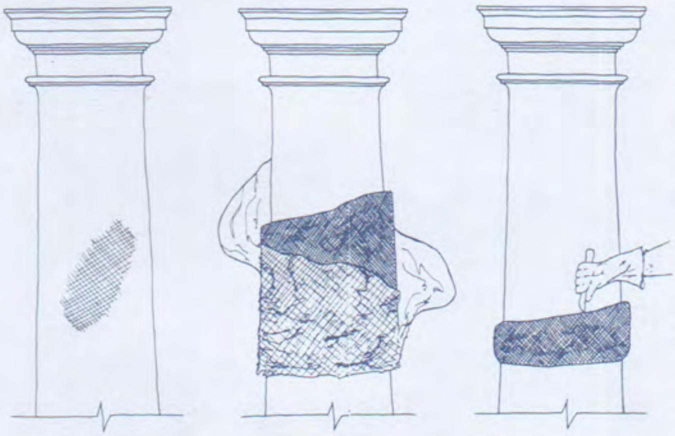
Rust stains can be particularly difficult to remove, although good results have been obtained removing stains from the brickwork at Fort Barrancas using Rust-Aid, a product sold at large home supply stores. For concrete, another option is a toxic solution of one pound of oxalic acid dissolved in one gallon of water. The solution is mopped on to the surface, and scrubbed off two to three hours later with stiff brushes or brooms while the surface is rinsed with water. The cleansing action can be made more rapid by adding one-half pound of ammonium acid flouride, but the solution is then even more toxic.

Heavy rust stains mark the exterior of Battery Townsley, Fort Cronkhite, California.

Deep stains can be removed with a chemical poultice made of 11 ounces by weight of sodium citrate in two quarts of lukewarm water, to which is added two quarts 12 ounces of glycerol. Make a stiff poultice with diatomaceous earth or talc, apply it to the stained surface, and leave it in place for two or three days. Remove the poultice, and repeat the process if a stain still remains.

There is one more method, to be used with considerable caution: acrid fumes of sulfur dioxide will be emitted when sodium hydrosulfite comes in contact with moisture. Good ventilation is essential.

Dissolve 22 ounces by weight of sodium citrate in one gallon of lukewarm water and saturate a bandage with it. Apply the bandage to the surface for 30 minutes, or as an alternative, apply the solution with a brush at five to ten minute intervals. If the stain is on a horizontal surface, sprinkle a thin layer of sodium thiosulfate over the surface and moisten the crystals with a light mist of water. Cover the area with a poultice of diatomaceous earth or talc. For a vertical surface, place some of the poultice on a trowel, sprinkle the thiosulfate crystals on the



The poultice material is applied and wrapped with plastic to slow evaporation. Once the material has dried out, the plastic is removed and the dried poultice scrapped away.

poultice, moisten them as before, and trowel the poultice into place so that the crystals are in contact with the stain. Remove the poultice after an hour and repeat if necessary with fresh materials. When complete, thoroughly scrub the surface with water.[14]

Be sure to read all of the cautions on any chemical products and take all of the precautions recommended by the Material Safety Data Sheet, especially when the solutions are potentially harmful.

Abrasive Cleaning. Grinders, sanding disks, and grit blasting are not considered appropriate methods for cleaning historic fortifications. Mechanical cleaning removes dirt by removing a thin layer of the historic fabric itself. This becomes especially problematic when the hardened, protective surface layer is removed from brick, allowing water penetration. Since masonry materials vary in durability and hardness, softer materials like brick and sandstone are more easily damaged.

Abrasive cleaning results in the erosion and softening of carved or cast details, shuttering, surface tool marks, sharp corners and edges, and the uniformity of parge coats. The effect will alter the appearance, and may weaken the historic structure by providing a new or improved path for water infiltration. Grit blasting will produce pitting, either microscopically or visible to the eye, and a better surface for the adhesion of dirt and pollutants. The only appropriate use for abrasive grit blasting is in the creation of a clean and roughened surface in preparation for a composite repair or concrete patch.

So Now What?

Given all the preceding cautions, it may seem that any type of cleaning regimen is so girded by them that it would be impossible to put it into practice. If the determination is made that surface cleaning is necessary, a simple and safe program is outlined below. To judge the effectiveness of any cleaning method, try it out on a test patch about three feet square in an out of the way location. Use a separate test patch for each technique in this sequence:

Water with a stiff fiber brush (not metallic);
Water, brush, and mild soap;
Water, brush, and stronger soap;
Water, brush, and stronger soap with ammonia;
Water, brush, and stronger soap with vinegar.[15]

[14] Hurd, 796. In the last example, the thiosulfate may turn brown stains black. In that case, oxidize the stain to brown again by treating the surface with hydrogen peroxide, and repeat the thiosulfate applications as described in the text.

[15] Hurd, 793.

Moss can be removed by substituting bleach or a biocide for the ammonia or vinegar in the above solutions. Heating the water can improve the cleaning action, and in some cases, so can a low-pressure water spray. Low pressure is less than 50 psi, which is about that of most house-hold water systems.

Graffiti

Graffiti makes preservation efforts difficult because if it is not removed, its presence suggests that the structure it adorns must be both derelict and without significance. Removing the graffiti quickly indicates that the structure is of value and that maintaining its appearance is a worthwhile goal.

Many fortifications are good targets for both casual and elaborate graffiti because they are frequently located in areas that have limited visibility and few visitors. Graffiti is also a cultural phenomenon, and its spread over the last several decades owes much to social change. As late as the 1970s, west coast fortifications showed few traces of the practice while their peers on the Atlantic coast had already become frequently visited canvases.

With few exceptions, the removal of graffiti applied to fortifications follows the same practices that are used to remove graffiti from other types of concrete and masonry structures. For that reason, the discussion here is based on National Park Service Preservation Brief No. 38, "Removing Graffiti from Historic Masonry." To select the best method for removing graffiti, we first need to identify the marking material and the type of surface; choosing the wrong cleaning method may not remove the marks or may lead to damage of the surface. The materials used in fortifications fall into three groups with various chemical sensitivities, as shown in the table below.

Graffiti that reflects the historic use should be retained intact and not repaired, as in this example from the Advanced Redoubt, near Fort Barrancas, Florida.

Material	Sensitivity	Cleaner Acidity
Limestone, calcareous sandstone, glazed brick, concrete	Acid	Alkaline (high pH)
Slate, most granites, unglazed brick	Non-acid	Acidic (low pH)
	Alkali	Acidic (low pH)

Ranger Todd Jensen experiments with a commercial graffiti remover during cold-weather tests at Fort Worden, Washington. These preparations are often caustic, and protective clothing should be worn.

Some granites, many sandstones

All of the techniques and cautions presented in the preceding section in regard to cleaning to remove dirt are applicable to the removal of graffiti. The difference is emphasis: washing away dirt is a process that is applied to the entire structure, while eradicating graffiti is specific to the immediate area of the marking. There are also some different techniques–the use of poultices, for example–and greater reliance of commercial products specifically formulated for graffiti removal. However, testing any technique or product before using it remains fundamental.

A few words about commercial products are in order here. There are a great many of them, and their effectiveness varies widely depending on climate, the surface to which the product is applied, the chemical formulation, the type of marking material it is intended to remove, and other variables. Make sure you know the pH of the product so that you can avoid unwanted reactions with the masonry, mortar, or concrete surface. Also, make sure that you read and understand the Material Safety Data Sheet that should accompany each product, and follow the protective measures outlined in the MSDS.

Sometimes graffiti is applied over historic signage or graphics. In that instance, it is best not to use any of the methods described here. The proper course is to contact a conservator with the expertise necessary to remove the marking material without disturbing the historic paint layer beneath.

There is another method of treating graffiti that has been applied to concrete fortifications, and that is simply to paint it out. Painting over the marks with latex paint has several advantages. The over-painting requires little skill and equipment, and it is less expensive than commercial graffiti removers. It also tends to attract other graffiti to the painted surface. That seems nonsensical as an advantage, but in providing a clean area for the next graffiti artist, there is less risk that any new marking will be applied to an original and undisturbed surface. Thus, painting over can limit the physical extent of graffiti in a fortification by encouraging it in areas where it has already appeared. The layers of paint can be easily removed as can the accompanying layers of graffiti. This method is not recommended for masonry structures because of the difficulty of removing the paint from the historic fabric.

Painting over graffiti applied to concrete is a quick fix, and one that can help control its spread to previously unmarked areas of the structure. Battery Randol, Fort Worden, Washington.

Suggestions for Removing Graffiti from Masonry and Concrete

Marking Material	Removal Technique	Health and Safety Cautions
Pencil	**Erase** with non-abrasive pencil eraser. **Wash** with water and non-ionic detergent.[a] **Rinse** with water.	None.
Chalk/pastel (not wax or oil based)	**Brush** off with bristle brush. **Wash** with water and non-ionic detergent. **Rinse** with water.	None.
Paint (enamels, lacquers, acrylics)	**Poultice**[b] with paint remover, organic solvent[c], or petroleum-based compound. **Rinse** with water, denatured alcohol or mineral spirits. **Wash** with water and non-ionic detergent. **Rinse** with water.	Consult the product manufacturer's guidelines and the Material Safety Data Sheet for health and safety cautions. Some may require protective clothing, eye protection, and plentiful air supply or outdoor use only. If lead-based paints are suspected, test and dispose of according to local environmental guidelines.
Permanent marker (felt-tip)	**Wash** with water and non-ionic detergent. **Poultice** with bleach, paint remover, organic solvent or petroleum-based compound. **Wash** with water and non-ionic detergent. **Rinse** with water.	Bleach is corrosive, causes chemical burns, and forms toxic gases (chloride). Wear proper respirator, gloves, and eye protection.
Water soluble marker (felt-tip)	**Wash** with water and non-ionic detergent. **Poultice** with bleach. **Wash** with water and non-ionic detergent. **Rinse** with water.	Bleach is corrosive, causes chemical burns, and forms toxic gases (chloride). Wear proper respirator, gloves, and eye protection.
Ballpoint pen	**Erase** with non-abrasive pencil eraser. **Poultice** with organic solvent or petroleum-based compound. **Wash** with water and non-ionic detergent. **Rinse** with water.	Consult the product manufacturer's guidelines and the Material Safety Data Sheet for health and safety cautions. Some may require protective clothing, eye protection, and plentiful air supply or outdoor use only.
Crayon, lipstick, shoe polish	**Poultice** with denatured alcohol, paint remover or organic solvent. **Wash** with water and non-ionic detergent. **Rinse** with water.	Consult the product manufacturer's guidelines and the Material Safety Data Sheet for health and safety cautions. Some may require protective clothing, eye protection, and plentiful air supply or outdoor use only.
Carved or incised graffiti	Hand sand the area to remove shallow marks that have been scratched into the surface. For deep marks in plaster or whitewash, apply a fine slurry of the original material sufficient to in-fill the damage. If the damage is to brick, use a mixture of lime, brick powder, and sand as an in-fill materials.	Wear proper respirator, gloves, and eye protection when sanding.

[a] Non-ionic detergents are non-soap, synthetic surficants with low toxicity. They are preferred in cleaning masonry and concrete because they do not contain soluble salts. Some commercial product names are Orvis, Photo-Flo, and Triton X100.

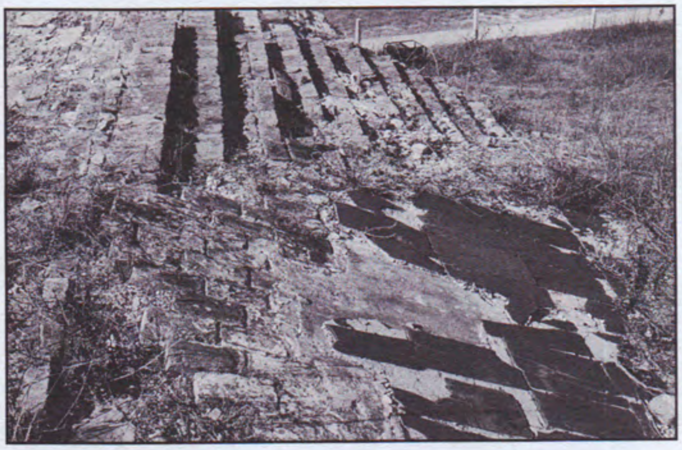
[b] A poultice is made from diatomaceous earth, shredded paper, or talc as inert ingredients. Sources of poultice materials include industrial minerals suppliers and paint manufacturers.

[c] Organic solvents include paint thinner, mineral spirits, turpentine, and acetone.

To be effective aesthetically, the paint must be a consistent color with a neutral tone that is appropriate to the base color of the historic structure. A patchwork of different colors applied with random strokes of a brush or roller can be just as distracting as graffiti itself.

Wet Interiors

In any moderately rainy climate, fortifications share a common trait: the interiors are damp, and in many of them, they are just plain wet. Walls drip with condensation, ceilings leak the percolation that has penetrated the layers of material above, and floors disappear under pools of standing water. Where the water table is high, or where drainage systems no longer function, water can collect to a point where it becomes at least hazardous and possibly dangerous.



Roofing slates set into mastic above the casemate vaults at Fort Pickens, Florida, are part of the original efforts intended to shed water away from the interior.

The potential for these conditions to exist was known to the builders of the fortifications, and they took steps to direct water away from the structures. Upper surfaces were sloped, the slopes leading to drains or scuppers. Since all but the most modern fortifications were essentially open and not easily capable of being made weather tight, interior spaces were fitted with floor drains. Water was collected in a subsurface drainage system or sometimes diverted to a french drain along the line of the footing. If the water table was high, the builders typically tried to improve site drainage prior to construction so that there would be positive flow away from the structure.

Our current difficulties with wet interiors are not the result of neglect on the part of the original designers to anticipate that water disposal would be a requirement. Unless the original drainage system has deteriorated and failed, the difficulties are more related to the unanticipated movement of water within the masonry or concrete mass, the ease with which water penetrated construction materials, and the variable nature of condensation.

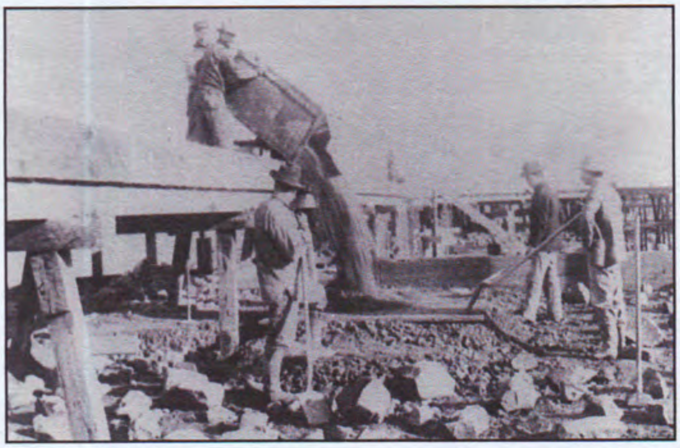
Many methods were used to prevent water from seeping in from the outside, including diversion membranes of sheet tin or lead as well as exterior water proofing treatments. The tall, free-standing defenses of the Third System apparently received no exterior waterproofing, and the same was true for the earliest concrete batteries.[16] The roofs of these structures in particular were left untreated, with the result that the earth cover had to be removed and a waterproofing material (usually tar) applied when the ceilings began to leak. As the builders acquired more experience, they began using a facing system of tar and hollow

[16] Some Second System works were parged or otherwise coated, perhaps as much for the sake of appearance as the desire to establish and maintain a dry interior. Fort McHenry Comprehensive Plan, 9.

clay tile for vertical walls that were to be covered with backfill, an effective practice that continued through the construction of fortifications in World War II.

The edge of a sheet metal diversion membrane is visible above the lath and plaster ceiling of this casemate interior at Fort Gorges, Maine.

Brick and stone masonry tends to separate at the contact surface between the mortar and the masonry unit, and thus seldom appears to be watertight. The contact cracks developed at the time the structure was built and they are often very shallow. They admit relatively little water. Eroded mortar, on the other hand, results in much greater opening of the wall, so that if mortar erosion continues unabated, the wall will become much more porous.[17] Such are the circumstances of most historic masonry fortifications today. Water penetration through early concrete was more dramatic. Concrete construction was poorly understood or implemented, at least in its application to fortifications. Incomplete mixing, inadequate compaction, and the introduction of anomalies into the concrete mass made for a structure that had the appearance of strength but was riddled with pores and fissures.



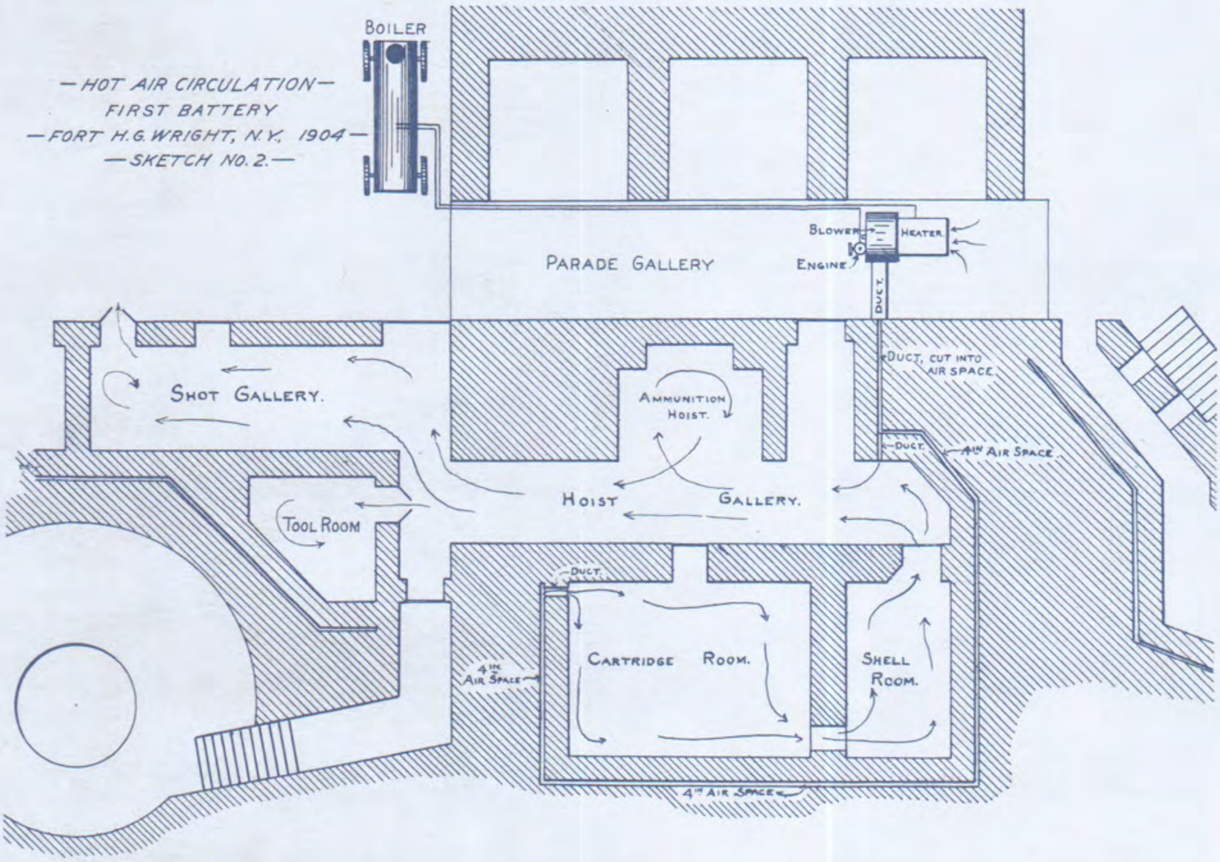
Concrete is being poured in this 1897 photograph. Note that the supports for the wooden scaffolding rest within the area of the pour, and were likely left in place as the concrete set. Fort Stevens, Oregon.

Condensation varies with temperature and humidity, and variation in temperature and humidity is dependent upon the climate at different locations. The more stable the temperature and humidity, the less potential there is for condensation to form. For reasons that are not fully understood, masonry fortifications tend to exhibit less condensation than do fortifications of concrete. It may be that the thermal properties of their brick-and-fill walls and vaults in combination with smaller mass yields a more uniform surface temperature than the more dense mass of concrete batteries.[18]

Wet interiors are not only unsightly, they are often indicators of more serious deterioration that is taking place within the interior mass. The deterioration occurs in the form of leaching and saturation.

[17] Jerry G. Stockbridge, "Repointing Masonry Walls," *APT Bulletin* (Vol. XXI, No. 1), 10-11.

[18] Another explanation is that the stones or bricks are better able to absorb and hold the condensed water droplets; alternatively, they may provide more effective insulation between a water-laden atmosphere and the cooler temperature of the interior mass that is typical of fortifications in areas of seasonal temperature fluctuation. Both of these possibilities are influenced by porosity, or voids in the material, as well as permeability, or the ability of water or water vapor to move through the material.



Engineers tried various methods to reduce moisture and condensation in early concrete batteries, as shown in this 1904 heating system planned for a battery at Fort H.G. Wright, New York.

Leaching is the process of water percolating through concrete or mortar, and dissolving the calcium from the cement binder. When the solution reaches an exposed vertical or horizontal surface, the water evaporates, leaving a deposit of calcium carbonate. These deposits appear as stalactites when overhead or as white streaks on vertical surfaces. In either case, binder is being removed from the cement paste, and shortening the life of the structure. Leaching occurs only when saturation has taken place.

Masonry fortifications, especially those of more than a single tier or story, are prone to saturation of the fill material between the scarp and the parade wall. If left untreated, the wall can take itself apart from the inside out. A good example is the partial collapse of the northwest demi-bastion at Fort Washington, Maryland. A 1957 survey reported an outward deflection or bulge of five inches in the masonry wall; the deflection had increased to more than seven inches by 1985, with the collapse of several wythes in January, 1999. The proximate cause of the failure was that the interior hydrostatic pressure exceeded the structural capacity of the heavy wall (a little less than eight feet thick) to resist the lateral load placed upon it. The ultimate cause of the failure was a deficient drainage system (both in design and maintenance) and a terreplein that lacked any diversion for rainfall; the result was an almost continual saturating of the fill material.

In addition, leaching weakened the lime mortar and freezing weather also contributed to the formation of the bulge. Saturated fill below the terreplein was also a cause of less dramatic deterioration at other locations, including the Castillo de San Marcos, Fort Adams, and Fort Jefferson.[19]

Stalactites and a heavy deposit of calcium carbonate coat the walls of this vault at Fort Macomb, Louisiana.

Most typical preservation guidance suggests several methods to identify the presence of excess moisture in buildings, but they become irrelevant in fortifications. Common indicators such as musty odors, cupped or warped wood, and flaking paint occur at several orders below the level of moisture that exists in many fortifications. Some sources recommend the use of a moisture meter to determine the extent and origin of moisture on interior wall surfaces, but little would be gained in the exercise. Pin-type meters are made for measuring the moisture content in wood and are typically not calibrated for concrete or masonry. Resistance-type meters produce relative readings rather than true assessments of water content. The meter can do little more than indicate that one location of a surface is more or less wet than another; further conclusions are left to the user. Moreover, readings even in an apparently dry fortification can be off the scale.

Loose in-fill between the vaults of masonry fortifications provide an ample reservoir for water that can steadily percolate to the interior even in dry weather. Fort Pickens, Florida.

Recording hygrometers could be useful, especially if left in place for extended periods of a year or more. After establishing base-line data, further readings can indicate the success of efforts being made to reduce the level of moisture in the structure. The difficulty here is that the equipment is costly, and loss of or damage to the equipment is likely unless it is placed in a very secure location or in a structure to which there is no public access. A humidity card is a much less expensive and less visible alternative, although readings from the card will be less accurate than those from an instrument.

Determining with precision the exact interior humidity levels of any fortification is probably not necessary. Unless the interior is to be rehabilitated for a specialized function, the real need is to make some reduction in the visible quantity of

[19] "Stabilization and Repair Report, Northwest Demi-Bastion Wall of Fort Washington," Department of the Interior, National Park Service, 1999, 4; "Rehabilitation Plan: Fort Adams, Newport, RI, ", Fort Adams Trust/Newport Collaborative Architects, Inc., 2001, 22; "Design Analysis: Stabilize the Castillo de San Marcos," Department of the Interior, National Park Service, 1988, 3; Anderson, 4.

moisture rather than to make a reduction to levels that can be detected by a scientific instrument. Our question is how dry do we want it to be? The answer is dry enough to prevent deterioration of the historic fabric. This usually will require it to be drier than it is now, but sometimes, after careful analysis of the conditions, a balanced moisture/humidity level may be the best solution.

If water is standing on the floor because a drain is plugged, the appropriate action is to open the drain, not to begin the collection of humidity data. Wet interiors were a feature of many fortifications from the date of their completion, and it is unlikely that we will be able to completely ameliorate the condition within the constraints of economy and our concern for historic fabric. Given the difficulty of effectively preventing water from entering these structures, it would be well to keep our expectations in check. However, it is also wise to take actions that will reduce water penetration in any degree because it is a necessary pre-condition for corrosion, efflorescence, subflorescence, and other indicators of a material undergoing change.

If water is standing on the floor because a drain is plugged, the appropriate action is to open the drain. . .

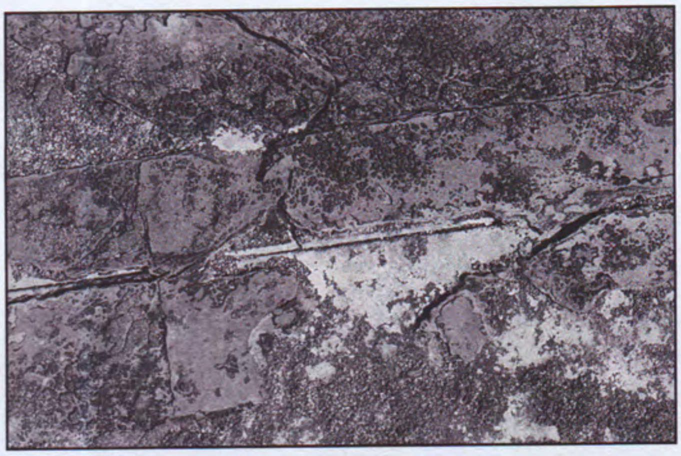
Under military ownership, routine maintenance helped to reduce water penetration. Some idea of how keen the army was in keeping a watertight structure can be gained from the record of repairs to the scarp walls for Fort McHenry. The walls were completed in 1800, yet in 1805 their condition was reported as "wretched." Repointing and replacement of damaged masonry was recorded in 1829, 1837, 1839, 1842, 1845, 1856, 1883, 1884, and 1891. They were in "very bad condition" by 1929, and the National Park Service continued the tradition of repair when it gained control of the property three years later.[20] The concrete batteries of the 1890s and early 1900s received the same intensive attention with practices that were appropriate to the material. Surface cracks were chased, cleaned, and then filled with cement grout or tar; if those methods did not produce improvement, whole horizontal surfaces might be covered with a layer of tar. These repairs were all effective to a degree, but repairs have a life span and must be renewed to remain useful. Many–perhaps even most–fortifications have received no routine maintenance at least since the time of their transfer from the military. As a result, many previous repairs have failed, and it is certain that fortifications today are more wet and more saturated than at any time in their history.

Solutions for Wet Interiors

Do Nothing. Moisture will continue to collect in interior spaces. Cement products will leach from mortars and concretes, weakening their structural bond. Chloride attack on ferrous metals will continue, eventually reducing them to nonexistence. Rooms will become hazardous as water accumulates on floors, as well as denying any useful access.

For brick and stone masonry fortifications, repointing and repair remain the most effective actions that can be taken to ensure a water-tight masonry wall, and both are treated later in this section. Traditional trade practices that produced

[20] Fort McHenry Comprehensive Plan, 7-9.



The remains of tar and roofing felt on this battery at Fort Winfield Scott, California, are ample testimony to the continuing quest for dry interior spaces during the period of historic use.

good masonry joints at the time of construction are still the best repair methods in almost every instance. The same cannot be said of the practices in place during the early period of construction for concrete batteries. The results were inconsistent, and success lay in the happy but unpredictable combination of good materials, knowledgeable workmanship, and thoughtful oversight. Where those three conditions were obtained, the result was a concrete structure that survives in respectable condition today. Where they were not, we are left with a highly porous and fractured body with a wet interior. Cracks in concrete were also repaired, and it would be possible to duplicate the historical fixes in the same way that we continue to use repointing for the replacement of eroded mortar in masonry structures. However, the repairs made to concrete to eliminate water penetration were not satisfactory, and unlike masonry construction, there is little reason to repeat them today. Water-repellant coatings and crack repair will provide the best means for arriving at a drier interior.

There are many cautions about the use of coatings, and all of them are worth considering as part of a treatment regimen designed to limit water entry. An even more basic measure, and one that needs to be taken before the use of coatings, is the repair of surface concrete defects. Commercial concrete coatings seem to appear without number, and the lack of experience with most of them makes it difficult to know which brand and what formulation is the best choice. We can make some interpretations about the characteristics of coatings generally, and that should make the future selection of particular products somewhat more clear. Two types of coatings are appropriate for concrete fortifications: penetrating sealers and surface sealers.[21]

Penetrating Sealers. As the name suggests, these products sink into the substrate and form a barrier within the material rather than on the surface. The depth of penetration varies with the product and the nature of the concrete, and is to some extent affected by surface preparation. Because penetrants are below the surface, they are protected from deterioration by abrasion or ultraviolet light. They impart little to no change in surface appearance, and because they are transparent, they do not obscure the surface of the concrete. They have a small molecular size, and for that reason they do not bridge cracks or otherwise prevent water penetration through cracks.

[21] The discussion of penetrants and surface sealers is based on Martin S. McGovern, "A Clear View of Sealers," *Concrete Construction*, (January, 2000); "Water Repellants for Concrete Masonry Walls," TEK 19-1, National Concrete Masonry Association, 1995; and Jay H. Paul, P.E., S.E., "Protection of Historic Concrete."

Deflection is a complex problem that absolutely requires the assistance of structural engineers who can analyze the structure. In the case of concrete, information must be obtained on the existence, quantity, size, and spacing of reinforcing bar, both as designed and as constructed. Historic drawings usually contain sectional elevations that can help identify the structural design, but they must be verified by on-site examination to confirm the actual results of construction. Often changes are made during the building process that are not reflected in the plans, and over time the changes may have an impact on the condition of the structure. Once the existing condition is ascertained, calculations can help to determine inadequacies and to guide the design of permanent corrective measures.

Historic drawings usually contain sectional elevations that can help identify the structural design, but they must be verified by on-site examination to confirm the actual results of construction.

Do Nothing. If the deflection is not active and it has become stable as result of the transfer of loads to elsewhere in the structure, it may be possible to leave the deflected feature as it is. Some type of repair will be necessary if it is not stable and poses a threat to the integrity of the historic resource or the public's safety.

Jacking or Subsurface Injection. Jacking requires access to several points for the insertion of jacking equipment, which in itself may be as old and dependable as hydraulic pistons or as new as flat jack systems that can be inserted into the joints of a masonry wall. If the downward tilt of a slab is matched by the upward tilt of an opposite corner or side, there is no assurance that the upward portion of the slab will settle at the same rate as the downward tilt is corrected. The result can be the production of new cracks in the surface.

Subsurface injection is effective, but the cost is difficult to estimate. The opening of injection ports in the surface of historic concrete may also be objectionable, and there is the possibility that concrete may crack while being injected. The possibly adverse effects of injection need to be weighed against the goal of retaining historic fabric.

Shoring. Shoring is a possible solution, and depending on the visual quality of the shoring material and system, it may be appropriate in historic fortifications. Shoring is especially useful in the treatment of sags. Because sags are presumed to be the result of inadequate structural strength, moving them back into position will place additional forces on an already weakened material, and its loss is almost a certainty. Shoring does not solve deflection; it accepts the deflected character as the condition to be supported. It adds new structural elements beneath the sagging feature that are sufficient to support dead loads and any live loads that may be anticipated. Because shoring should be considered a permanent fix and a new feature that is introduced into the historic structure, special attention must be given to its design to ensure compatibility.

Demolition and Reconstruction. This is the least desirable alternative. The approach calls for the removal of the deteriorated feature and then reconstructing it to match its historic appearance. Although it has the advantage of introducing better design, improved materials, and modern methods, the technique has the real disadvantage of bringing about the complete loss of historic fabric.

Boiled linseed oil was a common penetrant in the 1890s, and it is still visible in protected locations in some fortifications. Today there are many more choices, and products within the generic classes of silanes and siloxanes achieve depths of penetration sufficient to be called sealers. Other classes, such as silicates and siliconates, do not reach as deeply into the concrete and they also do not repel water as effectively. Because silanes penetrate deeply, they are resistant to abrasion and will function well where the treated surface is also a walking surface. Abrasion tests of sealers indicate that silane-treated concrete offers a 40 to 92 percent improvement over untreated concrete in time spans of up to 14 years.[22] Silanes have an added advantage in that they can be applied over slightly damp surfaces.

Products within the generic classes of silanes and siloxanes achieve depths of penetration sufficient to be called sealers.

When considering a penetrating sealer, be sure that it is a siloxane or silane-based product with a high solids content. Avoid silicons and siliconates, a goal made difficult by confusion in the marketing of these classes, although they are not equivalent in performance.

Surface Sealers. Surface sealers do not penetrate into the concrete, but form a film or layer on the surface. Many of these products yield a noticeable surface sheen, and others reduce the permeability of water-vapor, both qualities that are undesirable on historic structures. Useful surface sealers that can be considered appropriate for historic fortifications are those with a thickness of 10 mils or less. While some surface sealers are transparent, most are paints. Paint or paint-like products can be used as a sealer when applied to previously painted surfaces when the treatment of the historic resource calls for its restoration to a period when it was painted.

Paints are opaque coatings that come in a number of formulations. During the military period of ownership, oil-based paints were the only choice when any painting was called for, although exterior color coats were seldom selected for their water repellent characteristics. Latex paints are an excellent substitute since they have good repellency, durability, and breathability. Epoxy and rubber paints are not alternatives because they form an impervious moisture barrier; they block out water and they also prevent the escape of water vapor. They also do not have UV resistance that is equal to penetrating sealers and they do not perform as well on walking surfaces.

High-build coatings are those from 10 to 30 mils in thickness. They provide excellent water repellency and durability, yet they are of limited utility in historic fortifications because their thickness obscures surface detail. Examples include fill coats composed of latex, acrylic latex, or polyvinyl acetate mixed with portland cement; cementitious coatings such as stucco and bonding mortar; and cement-based paints.

Asphaltic emulsion is in a class of high-build coatings that may be appropriate if the intent is to reproduce the appearance of tarred horizontal surfaces. They should not be applied, however, without a thorough understanding of how vapor

[22] McGovern, 57.

transference will occur after the emulsion is in place. Breathability will be limited to vertical walls or other untreated surfaces, which may not be adequate. Although the army did use tar as a water repellant, vapor transfer did not appear to be a concern, and since the layer does not seem to have been durable, lack of transfer may not have manifested itself as a noticeable (or measurable) problem. Currently available emulsions will have performance superior to the historic tar coatings, and will establish a more effective barrier to water vapor and one that will be less likely to degrade, so cautions are necessary.

Cracks

Cracks are fissures in a material. They may be narrow or wide, active or dormant. They may be nothing to worry about or the evidence of important changes in the health of a structure. They are often the first-detected symptom of deterioration.

Some fortifications exhibit so many cracks that the tendency is to accept them as another problem to be lived with and to consign their repair to the list of good ideas that are unlikely to happen. However, repairing cracks can restore strength and stiffness, improve structural performance, increase watertightness, enhance the appearance and durability of concrete surfaces, and reduce the potential for water-induced preservation problems.[23]

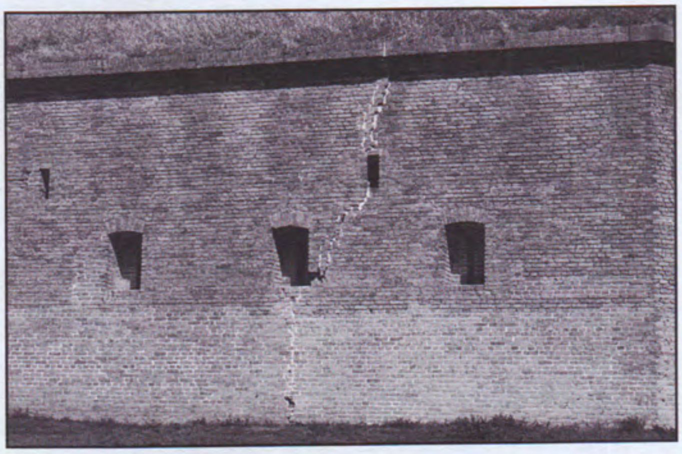
Vertical and horizontal cracks, efflorescence, and chloride deposits are characteristic of concrete fortifications of the early 1900s. Battery Harker, Fort Mott, New Jersey.

Cracks form in masonry as a result of structural movement or the settlement of a fortification on its building site. They can also appear as a result of poor detailing or improper construction, such as inadequate bearing for lintle blocks or pintle stones. A crack can split a stone or brick masonry unit, or it can create a zig-zag pattern as it follows a plane of weakness along the mortar joints.

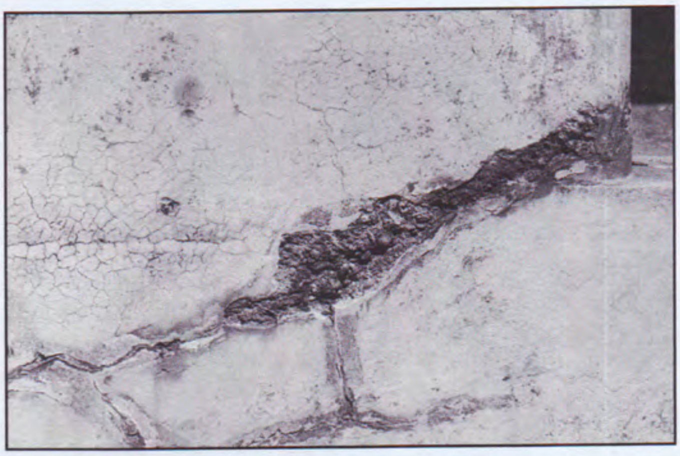
Concrete behaves much differently. Although cracks can mar concrete from the same structural movement as in masonry works, it is prone to many more different types of cracks from a number of causes that do not exist in masonry construction. The American Concrete Institute has identified a host of crack formations and has published a report to help identify them. The "Guide for Making a Condition Survey of Concrete in Service," ACI-201.1R-92, is included in the appendices. All cracks in a concrete fortification need to be assessed to determine their origin, the degree to which they affect the structure (whether they are of cosmetic concern or if their treatment needs to consider more significant aspects), and the priority for their repair, if any.

Typically, cracks are classed as active or dormant. Active cracks change over time. They widen, deepen, and increase in length as the fortifications move in response to internal stresses. Dormant cracks do not move, and in concrete they are often the result of shrinkage during the curing process. Some cracks may be classed as active if they change seasonally in response to temperature fluctuations, however

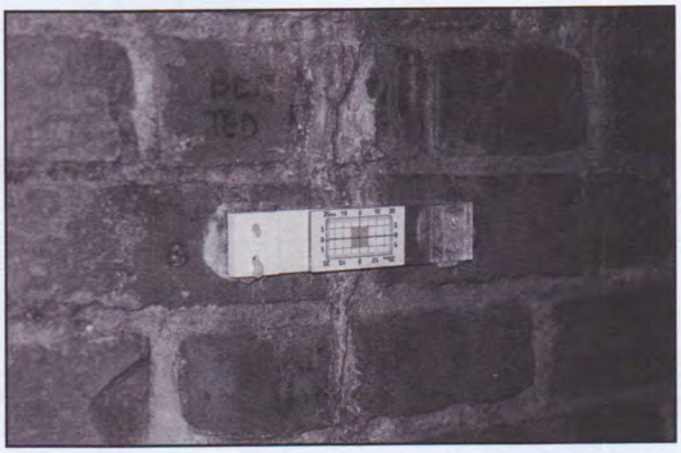
[23] ACR224-1R, Chapter 2.3.



A vertical crack in this heavy masonry wall may indicate significant change, and bears monitoring. Advanced Redoubt, Fort Barrancas, Florida.



Microfractures, broken parging, and exposed interior mass are typical crack conditions in early concrete fortifications. Battery Trevor, Fort Casey, Washington.



A crack gauge is a useful tool that can help determine extent, rate, and periodicity of movement. Fort Barrancas, Florida.

they do not have the habit of growth that is the true distinguishing feature of active cracks. Shrinkage and surface cracks or crazing should not raise the same level of concern as active cracks, but they should be regarded as a potential source for the entry of water into the interior mass.

The existence of an active crack does not necessarily mean that failure is imminent, a case in point being the Castillo de San Marcos. The general dimensions of the cracks in the scarp wall were recognized in 1839, and measured accurately in 1868. They were noted again in 1886 when several of the largest were filled with cement mortar; five months later the cracks had reappeared. When the property came under the care of the National Park Service, crack monitoring and repair continued. The net result of almost 175 years of concern over the same cracks and enhanced by increasingly sophisticated methods of testing and diagnosis, was the conclusion that the continued activity was due to the saturation of the fill behind the scarp wall. Hydrostatic pressure was forcing the walls outward. There are two lessons here. One is the need for monitoring and the accumulation of knowledge as precursors to action. The other is understanding that stress in a structure can accumulate over time, and intercession is necessary to prevent a continuing deterioration as well as catastrophic collapse.[24]

Solutions for Cracks

Do Nothing. Tight cracks that do not change dimension seasonally or over time may pose little threat. However, any crack carries with it the potential to admit water or dirt to areas that were intended to remain dry and clean. If left untreated, significant cracks will continue to grow and allow moisture greater access to the interior, creating conditions that will advance deterioration as long as the crack is left to develop further.

[24] *Castillo de San Marcos Design Analysis*, 12-18, 22.

Mechanical. Mechanical repairs are those that involve drilling or cutting, often inserting some type of pinning device, the addition of an adhesive filler, and finishing the repair with a grout that mimics the appearance of the surrounding surface. The adhesive filler and grout may be combined in a single material.

Epoxies are often proposed as the product of choice in crack repair, and they have many desirable qualities including strength, resistance to common solvents, limited shrinkage, and the ability to be formulated in a wide variety of physical properties such as resilience and viscosity. There are some cautions. Epoxy is expensive, and if there are many cracks to be repaired, as is often the case in concrete fortifications, it is worthwhile to consider a wider range of techniques than to rely on epoxy alone. In addition, its strength can be a problem. If the formulation is stronger than the surrounding material, it will successfully bind the crack, but any movement in the area of the repair will lead to the formation of new cracks nearby. If the cause of the cracking cannot be determined and resolved, it is best to rout and seal the crack with a non-epoxy filler.[25]

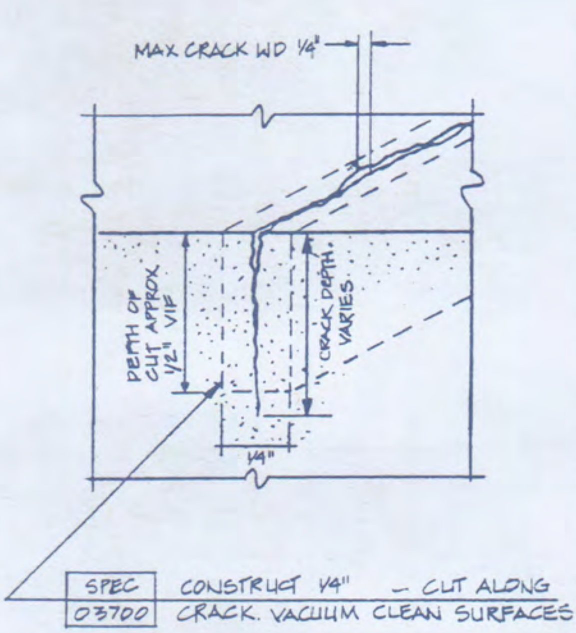
Any crack carries with it the potential to admit water or dirt to areas that were intended to remain dry and clean.

Epoxies are also sensitive to moisture (although there are moisture-tolerant formulations), and dirt and water in the crack can reduce the effectiveness of the repair. Also, a quality epoxy injection process requires a high degree of skill to accomplish, and a strippable protective film in the area of application to prevent the epoxy from altering the surface appearance.

Routing and sealing is an appropriate treatment method where strength is not an issue, and can be used effectively on pattern cracking and isolated cracks. It is most commonly used on concrete. The crack is chased with a hand or power chisel, the void is cleaned and allowed to dry, and then a sealant is placed in the groove. Modern sealants are available in many bases, including urethanes, polysulfides, and polymer mortars, and will perform better than the cement grouts used historically as a sealant in many fortifications. A bond breaker can be placed prior to the application of the sealant to help maintain the seal and to guard against rupture as a result of seasonal movement. The surface of the sealant itself can be coated with aggregate to simulate the appearance of cement grout or concrete if desired. Routing and sealing is particularly appropriate for horizontal areas where there is standing water. Overbanding or strip coating of sealed cracks, often seen in bridge and highway repair, is not suitable for historic fortifications.

Two additional methods of crack repair deserve mention. Portland cement grout is effective in stopping water leaks when injected along the length of a crack, although it will not bond across the crack. It also requires the installation of injection ports at regular intervals that will alter the appearance of the repaired area. Drypacking produces a repair that has little shrinkage and is durable, strong, and watertight when applied to dormant cracks. The process entails cutting a channel about one inch wide and one inch deep, enlarged at the base to form a key. A low-water content mortar is placed by hand into the channel and driven in place with

[25] John Griswold and Sari Ubicheck, "Loss Compensation Methods for Stone," *Journal of the American Institute for Conservation*, 1998, 101.



A practical and effective technique of crack repair calls for routing out the crack and then placing a sealant or grout. Battery Gregg, Fort Mott, New Jersey.

a hammer and hardwood drift. Because these techniques can produce a notable change in the appearance of concrete, they should be considered for use in areas that will be painted over or otherwise obscured.[26]

A repaired crack must have the same physical properties as the material around it so that they react in the same way to water exchange across the repair and changes in the environment. If the fill is less porous than the surrounding material, water and salts can collect in the original fabric, and there promote additional deterioration. Under these circumstances, freezing weather will produce further damage, particularly if the repair is harder than the surrounding material. If an exact match of physical properties cannot be made (and often it can't), err on the side of a repair material that is a degree weaker than the substrate so that the new work will not lead to further degradation in the original.[27]

Replacement in Kind. It is possible to remove a cracked brick or stone, repair it with pins and epoxy adhesive, and return it to its original location. Another option is the complete replacement of the damaged element with a new one that matches the original in color, texture, and dimensions. It is especially appropriate if the masonry unit is in a location of structural importance such as quoins, copings, and voussoirs.

Replacement may be a more ready option in fortifications than in other building types since the stones are seldom worked with a design or sculptured face. Such stones are better repaired rather than replaced because their significance in expressing an historical craft is greater than the significance of a simple dressed building stone.

For a more complete discussion of replacement in kind, see *Detachment, Breakage, Chipping, and Spalls.*

Crazing

A random pattern or web of small cracks in the surface of glazed bricks is called crazing. The condition indicates that the strength of the glaze has been exceeded by the expansion of the substrate. A similar appearance in the surface of concrete results from excessive expansion and contraction in green concrete, a surplus of water during cure, or over-floating the concrete which brings cement to the surface, causing in turn the mixture to become too rich.

[26] The summary of crack repair is based on ACI Committee Report 224.1R, *Causes, Evaluation, and Repair of Cracks.*

[27] "Loss Compensation Methods for Stone," 91.

It is largely a superficial condition and is not considered an important defect in fortifications. Fired glazes of any kind are an infrequent component in defensive structures. Where they do appear, it is in the form of glazed brick or tile placed as an interior wall treatment and not in an exposed or exterior location. Damaged glazes can be unsightly, but they are not likely to lead to further deterioration. Similarly, crazed concrete is usually stable and is not a significant source of water penetration unless water pools over the crazed area.

Solutions for Crazing

There is no effective treatment for crazing on glazed material short of unit replacement. Crazing in concrete may be treated with waterproofing as described under *Wet Interiors*.

Deflection

Sagging or tilting is called deflection. It is not common, and when it does occur, it is usually in the form of the upset of a single element, such as a floor slab or a column. Both concrete and masonry are brittle materials, and their elastic limits are reached quickly. When that happens, concrete cracks. Individual stones and bricks can also crack under similar stress, but it is more usual to see the stress relieved in a masonry wall as an open line that follows the mortar joints.

Sagging is a particular form of deflection. In this instance, it appears that brittleness of the material has been overcome by plasticity, and the material has drooped in response to a lack of support. The most likely place for sagging to occur is in the thin-section platform extensions of concrete gun batteries. While no examples were examined closely in the preparation of the Handbook, it is likely that sagging is the result of multiple micro-fractures induced by the slow and continuous loss of structural support over a long period of time.[28]

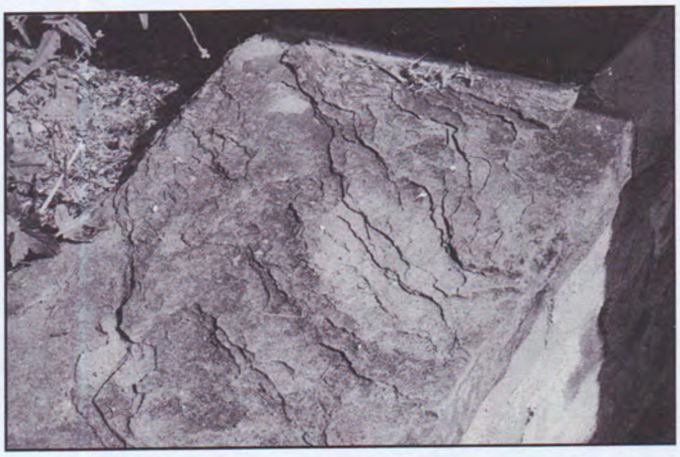
Sagging in a thin section platform extension. Fort Stevens, Oregon.

Solutions for Deflection

First, safety of personnel and the public must be assured by prohibiting access to the area in question. The structure must be stabilized by adequate shoring. Depending on the size and weight of the structural member, obtaining adequate shoring may require the services of a structural engineer or professional shoring and rigging contractor, who often has a structural engineering background, or one on staff. A prudent approach would be to obtain professional services for any questions regarding structural integrity or compromise in a structure.

[28] Thin slabs of marble and granite bow and sag, however since neither marble nor thin slabs of granite are used in fortification construction, the causes are not addressed in this text.

Demolition and reconstruction should be selected only after other solutions have been considered and rejected.



The contoured appearance of this stone is characteristic of delamination. Fort Worden, Washington.

Delamination and Exfoliation

Delamination is the separation of layers of stone parallel to the bedding planes; exfoliation is the peeling or scaling of stone surfaces. These conditions are similar in appearance and contain no significant differences from the point of view of repair. Both are characteristic of sedimentary building stone, and result from the natural separation in such stones along the contact surfaces of their integral layers. Zones of weakness, caused by silt or clay deposits, are often the point of beginning, with moisture accelerating the separation through natural weathering or freeze/thaw cycles. Brick and concrete are not subject to this separation because layers of material do not exist in them.

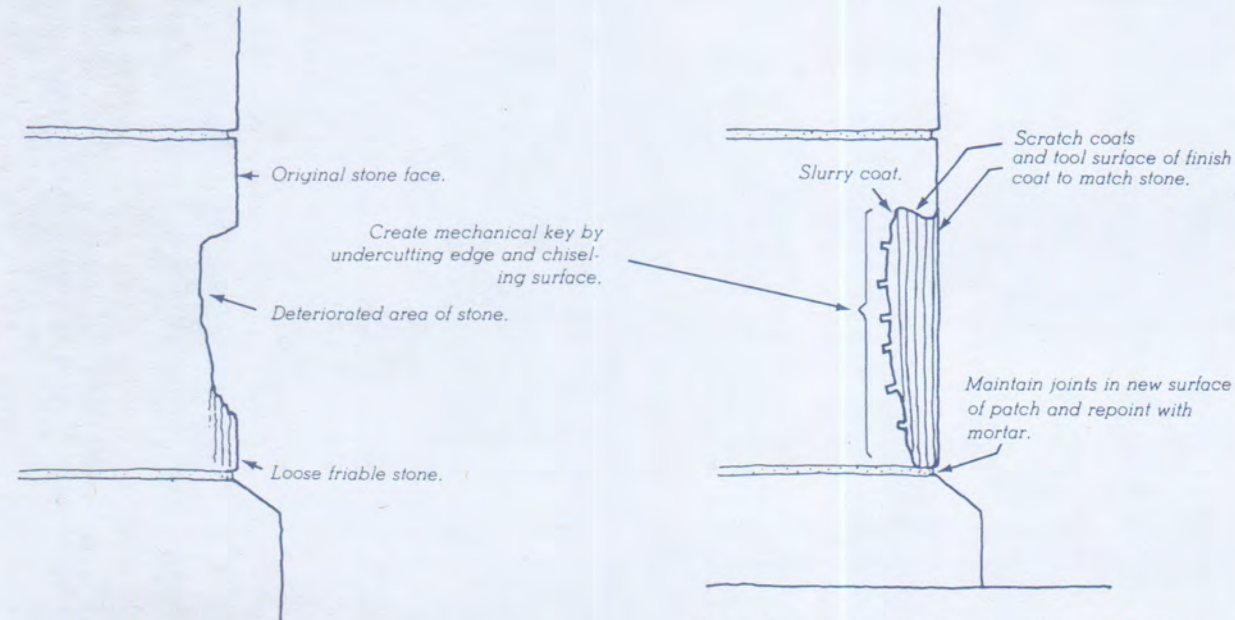
Solutions for Delamination and Exfoliation

Do Nothing. The stone will continue to flake away, and ultimately it will no longer exist as a distinct entity. Depending on the rate of loss and the present condition of the stone, that might mean anything from several years to several centuries.

Composite Patching. This is the building up of lost stone to its original contour through the use of a cementitious patching compound that matches the physical properties of the original stone. The patch is a substitute material, and substitute materials always need to be approached with caution since their inappropriate use can lead to increased loss of historic fabric. Patching is not a good approach for delamination and exfoliation because these conditions often cover areas that are large, and composite patching tends to work best on small areas. It also presumes that the substrate is in sound conditions, which almost certainly would not be the case in a stone whose remaining bond strength between layers is beyond our ability to predict without destroying the stone.

Consolidation. Perhaps the better choice, consolidation is the application of a penetrating chemical binder that compensates for the loss or weakening of natural bonds within the stone. However, there is little consistent information about consolidation products or methods whose performance has been measured over a long period of time.

Consolidants are applied as a liquid, but to work they have to penetrate deeply and deposit or produce a solid binder in the pores of the stone. The chemical properties of the consolidant and the physical structure of the stone all play a part in the efficacy of the treatment. Over the years a number of consolidants have been tested and used.



Shape cementitious patching material to match original profile of stone. Maintain joints in new patched surface and repoint with mortar. Illustration: Christina Henry.

The success of a composite patch depends upon a good physical and chemical match with the existing stone as well as a strong mechanical connection between the two.

Waxes are an ancient method and have been in use for more than 2,000 years. Although paraffin waxes are durable and can hold captive soluble salts, their low melting point and tendency to collect dirt make them unsuitable for any fortification application. Inorganic materials such as alkali silicates, silicoflourides, and various hydroxides (the most common being calcium hydroxide, or limewater) have also found their way into consolidant preparations. They have not yielded the desired results because of limited penetration, the introduction of soluble salts, or the creation of crusts that crumble and expose the untreated stone beneath.[29]

Other formulations are more promising. Alkoxysilanes can penetrate well, increase the strength of the stone, and have little effect on the passage of water vapor. The disadvantage is high cost. Synthetic organic polymer systems, including epoxies, offer some advantages, but are limited by lack of penetration, the formation of a brittle exterior layer, and deterioration in the environment.

The gist of all this is that the effective consolidant is elusive. There are several commercial manufacturers whose products have been in use over the past 20 years, including Brethane and Keim paints, but there is no certainty about their ability to halt delamination and exfoliation. As always, testing before application is important.

[29] James B. Clifton and Geoffrey J. C. Frohnsdorff, "Stone Consolidating Materials: A Status Report," in *Conservation of Historic Stone Buildings and Monuments*, N. S. Baer, ed., (Washington: National Academy Press, 1982).

Mechanical Repair. These measures require drilling, pinning, and gluing together the delaminating layers. No examples were found of mechanical repair being employed for exfoliation, probably because the many layers exposed in a typical delamination would require individual attention.

Redressing. Deteriorated material can be removed and cut back to sound stone. The process is a suspension of accepted conservation practice with its emphasis on the retention of historic fabric, but it may be appropriate when the original face of the stone has been lost. However, stone should not be redressed merely to improve appearance. A redressed stone should have the same weathering characteristics as the original, and accelerated weathering should not be a result.[30]

Detachment, Breakage, Chipping, and Spalls

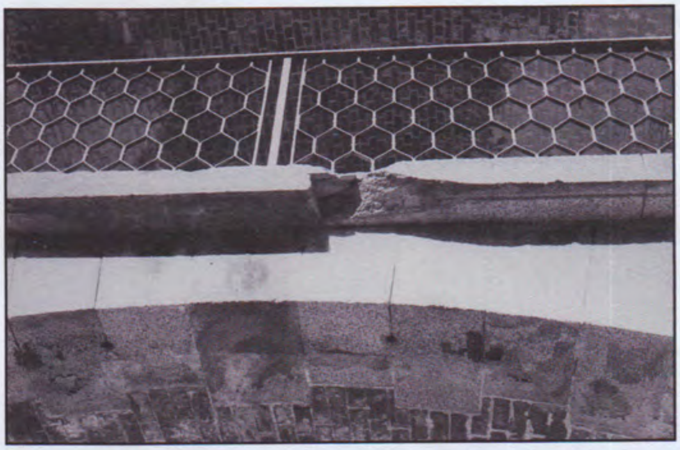
All of these terms mean one thing: some portion of the historic fabric has gone missing, or in the case of detachment, is about to. The condition is obvious, and sometimes so is the repair: if we have the missing piece, in many instances we can reattach it.

Broken concrete at Battery Mendell, Fort Barry, California. The likely cause is the expansive force of the corroded reinforcing steel visible in the photo.

The causes of this type of loss are many. A heavy blow can chip away a small divot or spall off an irregular block weighing hundreds of pounds. We already know that freezing weather promotes and exploits cracks, and the formation of ice inside a material can often lead to surface loss. Extreme heat from fire has an even more dramatic effect, although it is less common. Mortar can fail, and when that happens there is little to keep a masonry unit from becoming lost from its place. Also evident at some locations is breakage associated with attempts at demolition. Everywhere there are examples of corrosion forcing away spalls and chips as well as producing detachments of considerable size. As distracting as these conditions are, the first task is to treat the ultimate cause of the failure so that the treatments we apply to address the visible problem can have greater assurance of success.

Unlike other forms of deterioration, detachment, breakage, chipping, and spalls may not be the indicators of greater problems elsewhere in the structure. Unless the loss of material has exposed interior reinforcing or vulnerable fills, or is part of an other-wise diagnosed structural issue, these unsightly blemishes may be no more than that and may not necessarily require repair. That is particularly true if the damaged area is stable and not spreading. The decision not to repair may also be related to the historic nature of the damage itself: if a fortification shows

[30] John Ashurst and Nicola Ashurst, *Stone Masonry*. English Heritage Technical Handbook, Volume I, (New York: John Wiley and Sons, 1988), 1.6.



Broken granite slab at Fort Point, California. Its outline suggests that it is an impact spall caused by a heavy object.

scars of its use in combat, consideration needs to be given to the interpretive value of retaining intact those areas that were damaged by bombardment in the past.

In considering the solutions that follow, remember that it is important to retain as much of the original material as possible. It is tempting to consider large-scale replacement when the surface of a concrete fortification displays an extensive collection of cracks, chips, and spalls. It is surely less expensive to remove all of the facing concrete and replace it with a more durable modern layer, firmly attached to the historic substrate. However, the result will be a comprehensive loss of historic material, and our good intentions will have reduced the authenticity of the resource. Recall also that there is no guideline that tells us when a masonry unit should be replaced rather than repaired. Generally speaking, it is more reasonable to replace the units in a large area of deterioration rather than it is to repair them, and more appropriate to repair the units when they are confined to small area of deterioration.[31]

While our interest here is directed at individual masonry units or well-defined areas in a concrete structure, entire architectural and structural components can be gone, either as the result of a catastrophic event or the robbing of the fortification for its building materials. In that case, the treatment for the loss of material crosses into the area of ruin stabilization.

In the United States, most ruin stabilization has been directed toward adobe structures in the Southwest, and understandably little can be learned from those programs that could be applicable to masonry or concrete fortifications. Fort Frederica, Georgia, is one of the few examples of military architecture being managed as a ruin, although there are other treatment examples of ruins at sites of institutional (Eastern State Penitentiary, Pennsylvania), religious (St. Raphael's Roman Catholic Church, Ontario, Canada) and industrial (Virginius Island, Virginia) significance.

Ruins require special attention to ensure that their authenticity survives without the introduction of significant amounts of new material. Minimal treatment also helps retain the fabric of the historic structure so that it is available for study and the application of future conservation treatments that may be more useful that those currently available. The tendency to see ruins as romantic or picturesque–or the desire to intentionally neglect fortifications to produce the same effect–can make their repair a matter of debate, and in such instances, interpretation of the treatment can help broaden the understanding of stabilization.

[31] Helmut Webere and Klaus Zinsmeister, "Stone Repair and Replacement," *Conservation of Natural Stone: Guidelines to Consolidation*, (Ehningen: Expert-Verlag, 1991), 96.

Stabilization commonly addresses the needs of exposed core materials. Little can be done to stabilize structural cores that are on sites that are subject to active erosion (see photo of Fort Livingston on page 3.15) but prospects are much brighter for resources located on more stable ground (see photo of Fort Livingston on page 3.22). As with intact fortifications, plant materials need to be kept away from ruins and not allowed to take root.

'Rough racking' is the term used to describe the basic consolidation of the core; done properly, the core will continue to support the wall while its exposed appearance is minimally altered. Rough racking requires the same amount of attention as face masonry to maintain the distinction between the two. It is a goal of core stabilization to retain the broken outline of the ruin rather than to give it a more regular and finished appearance. Often the core is composed of materials that were not intended to be exposed to the effects of the climate (the loosely cemented fills of many Third System works is an example), and steps need to be taken to improve the weathering resistance of the ruin.

No survey was made in conjunction with the Handbook to identify the number of fortifications that might benefit from ruin stabilization. The general sense is that the number is small. Because it is a specialty, ruin stabilization is not covered in any detail here, and those who are interested in more information should examine European preservation sources that can help establish a strong background in the practice.[32]

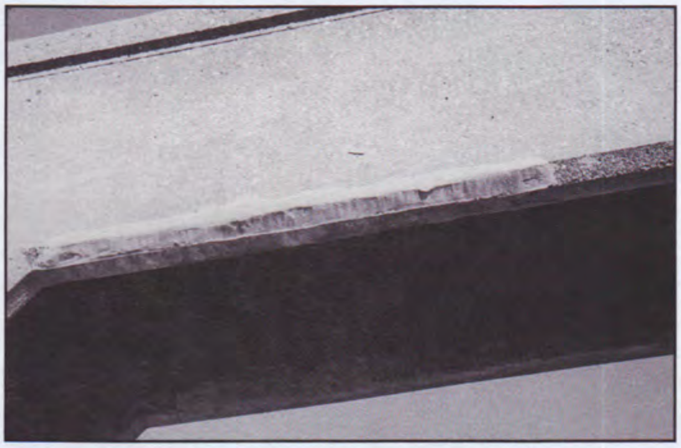
Solutions for Detachment, Breakage, Chipping, and Spalls

Do Nothing. As suggested above, if the area of loss of the material is stable and does not expose the interior of the structure to additional deterioration, it is always an option to leave the damage as it is. If the choice is made to do nothing, then the choice must also incorporate regular monitoring of the site and the commitment to take appropriate action should evidence of deterioration appear.

Replacing and Regrouting. The most direct solution, as the name suggests, is the return of the original masonry unit or concrete spall to the site of its loss. The technique assumes that the element to be returned is itself in good condition and of the same dimensions as it had when it was part of the structure. For masonry units, carefully clean out the cavity and place a bed of mortar matching the composition of that in the existing work on the cavity floor. Insert the stone or brick and carefully place mortar in the remaining joints, finishing off with a contour that matches the original strike.

A concrete spall can also be set back in place, although the preparation of the separated surfaces has to provide for a good bond for the epoxy repair mortar that will be used to provide adhesion. Because pins must also be part of the repair, the spall must be large enough to accept holes for the pins without penetrating to the exterior. If the borders of the spall match stone lines or construction joints, then

[32] Ashurst and Ashurst, previously cited, is an excellent source.



Successful repairs are compatible with the workmanship of the original fabric. The straight hard edges of poured concrete are difficult to duplicate by hand troweling. Fort Casey, Washington.

the edges of the spall need to match those margins. If the spall is not bordered by joint lines and has a feather edge (which is often the case) then the borders of the spall must be prepared in a manner similar to that described for replacement in kind as described below.

Replacement in Kind. If the missing masonry unit cannot be found, or if the original survives but its condition or dimensions have diminished, then replacement in kind is appropriate. The new stone or brick should match the original closely in type, size, color, and profile. The cavity should be cleaned out and the replacement unit installed with the surrounding joints finished to match the original.

Replacement in kind is the most common type of repair for concrete. Damaged concrete is cut away from the repair site, and the edges are cut back and dressed to ensure a good mechanical connection all around the perimeter of the repair. Because cutting back is most easily accomplished in a straight line, repairs in concrete usually take the form of angular patches that may not duplicate the original margins of the damaged area. For an overview of two instances of concrete repair, see the accompanying case studies on Battery Mendell, Fort Barry, California, and Fort Takapuna, Auckland, New Zealand. For additional details, see the description of the work carried out at Fort Mott, New Jersey, in the examples section that follows.

This is a good place to stop for a moment and consider the impact of these and related methods of addressing the loss of historic material. Good preservation practice calls for repairs to be compatible with the original work yet capable of being distinguished from it. Replacement in kind demonstrates how difficult it can be to put that principle in place. One of the typical character-defining features is the uniformity of appearance that is the result of consistent building practices and material selection at the time of construction. Using replacement in kind, we should be able to faithfully duplicate the original work so that at the conclusion of the treatment the repair work will be consistent with the uniformity of appearance. We have upheld an important character-defining feature, but it is a valid criticism to say that we have done so by being dishonest. If the new work cannot be distinguished from real historic fabric, then the result is also to devalue the genuineness of the historic structure as a whole.

There are techniques that can help make replacement units stand out from the original masonry. Employing a different finish on a new stone, for example, makes it possible to differentiate it among the many original stones in a masonry wall. Similarly, using a replacement brick with a smoother or rougher face, or recessing the repair slightly below the face of the original work, announces to the viewer that the masonry is not of the historic period. Another common method is to date the replacement unit with the year that it was installed.

The degree to which repair or replacements should be made visible is variable, and depends a good deal on the nature of the historic resource and the physical extent of the work being contemplated. As an added note, many fortifications in public ownership serve an interpretive purpose, and certainly the continuing efforts to maintain historic defenses should also be the subject of interpretation. It is an argument that supports the idea that repairs should be visible and not made to disappear into the historic fabric. The modest debate depicted here also points up the need to document what has been accomplished so that there is an additional source that can be used in the future to ensure our continuing ability to distinguish the original from the replacement.

The restoration of this brickwork has been done in a manner that distinguishes the area of the repair while remaining compatible with the surrounding original masonry. Fort Barrancas, Florida.

Dutchman. A dutchman is also a replacement in kind, but one that fits in a new piece of stone to repair a chipped or spalled area in a larger stone. The dutchman is cut from like stone and fastened in place with epoxy and pins. It is easily detected at close range, but tends to disappear at a distance and weathers in much the same manner as the base stone, provided that the dutchman itself is prepared from similar stone. It is an expensive technique, and one that requires skill and expertise in order for it to be done well. It is also a very durable repair with an average life of 50 to 60 years.[33] The same approach can be used to replace the entire face of a stone by cutting back the deteriorated material by at least three inches to permit the installation of a veneer of new stone. As with a stone patch, the new facing has to match the physical properties of the original and is secured with epoxy and pins.

No examples were found in the preparation of the *Handbook* of a dutchman repair being used on granite. It is a technique most commonly employed for limestone and sandstone, and since these stones have only limited use in fortifications, it is likely that a dutchman repair will be seldom called for in most defensive structures. Looking at other types of masonry, it is possible to repair a spalled brick with a dutchman, but again no examples were found, probably because the small surface area presented by an exposed brick face and the high probability of damage and loss when creating the cavity to receive the repair piece.

[33] Estimated for limestone. Derek H. Trelsatd, "Repair: Limestone Cladding," *Building Renovation*, (September-October, 1992), as reprinted in RESTORE 2001, 168.

Case Study: Spalling Concrete, Subsidence, and Safety Railing

Battery Mendell, Fort Barry

Golden Gate National Recreation Area, Marin County, California

— Stephen Haller, Golden Gate National Recreation Area, National Park Service

This case study examines repair and restoration of serious concrete spalling at Battery Mendell, in Fort Barry, Golden Gate National Recreation Area, California. While focusing on the history of the battery, and the craftsmanship and methodology used to carry out the repairs, it also offers some broader observations of the evolution of preservation project planning for this national park's extensive Endicott period fortification network.

Construction began at Battery Mendell in 1901 and was completed in 1904–the first of the outer line of harbor defenses to the north of the Golden Gate. The battery was named after Col. George Mendell, Corps of Engineers, who oversaw construction of 1870s and Endicott period fortifications in the San Francisco area. It was armed with two 12-inch breech loading rifles, model 1895, on disappearing carriages, model 1897, which bore on the north ship channel into San Francisco Bay (Fig. 1).

Figure 1. Firing practice at Battery Mendell, circa 1920. Note the projectile in flight.

Figure 2. Construction of Battery Mendell, ca. 1902. Note the tramway erected to bring concrete plant to the cliff top site from a batching plant at the north end of the beach. Note the farm at the left center background–leased by a family of long-time dairymen of Portuguese decent.

Spectacularly set at the very edge of a high cliff that drops sheer to the Pacific surf below, the location that offered such a fine field of fire for the coast artillerymen provided challenges to the engineers who built the battery (Fig. 2). A report to the district engineer lamented, "[w]here batteries sites in this harbor are on elevated positions, they are generally located on ridges where foundation material is usually rock and shales tending to rock. An exception to this rule was found at this 12-inch disappearing gun battery. . .the surface dipped back from the face of the cliff, below, the rock was about parallel with the surface, but 40 feet and more below. The soil overlying the rock was for the most part light yellow clay, while some portion(s) of it were sandy clay. When excavated and placed in a spoil bank it settled 20 per cent. . .A foundation bed of that character could not be depended upon to carry the loading designed for the work. . .The entire area therefore was excavat-

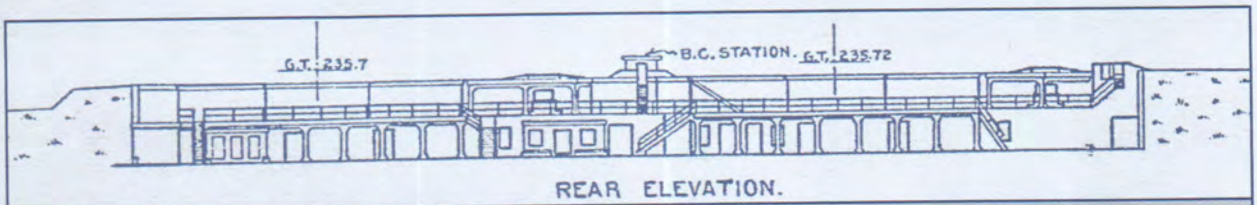


Figure 3. Battery Mendell, rear elevation.

ed to the grade of the bottom of the gun platforms, or about 3 feet 6 inches below the service room floors, and refilled with Portland cement concrete."

The vertical distance from parapet to service room floors is less than 25 feet, so the battery rests on this imperfect clay substrate (Fig. 3). "No iron or steel work was added to lessen the quality of the concrete, for the reason there were no old rails on hand or could any be obtained on the market cheaply at the time." Although "no appreciable settlement has since detected anywhere in the emplacement as the excavation was started and progressed" it appears that time, weight, and geology have since caught up with Battery Mendell.

Figure 4. Deterioration such as spalling concrete and rusted railing is evident in this 1973 photograph taken shortly after Golden Gate National Recreation Area was established.

About 1910, loading platforms were widened by eleven feet, and ammunition hoist tables with splinter proof overhead protection were added. Safety railing was installed in 1915. These functional improvements were supported structurally by a series of cast reinforced concrete pillars, which are the particular focus of this case study. Because of its remote site and northwesterly field of fire, it saw extensive use as a training battery regulars, reservists, and ROTCs. After the guns were dismounted in 1943, Battery Mendell served as ammunition storage and radar site for the antiaircraft artillery set up overlooking Bird Rock during the Korean War, but then entered a long period of relative neglect and consequent deterioration (Fig. 4). The minimal caretaking given by the Army to the empty battery was hardly supplemented by the National Park Service, which fell heir to the historic military properties at the Marin Headlands in 1972. The spectacular site was admired more for its viewshed than for its field of fire.

Figure 5. Severe spalling of vertical pillar supporting overhead protection at ammunition hoist, 2000.

Increasing public use of this scenic park site, especially by elementary and junior high school students taking environmental education programs at the nearby Point Bonita YMCA and Headlands Institute, impelled maintenance managers at the Golden Gate National Recreation Area to institute a broad program of reinstalling historically appropriate safety railing in the many places

Figure 6. The deteriorated column was removed with careful saw cuts as well as power and hand hammers, leaving as much original rebar as possible.

Figure 7. Replacement and original reinforcing rods are coated and tied together prior to pouring rapid setting concrete.

where it was missing. At Battery Mendell, severe spalling at all five pillars on the upper level made it impossible to even mount replacement railing until repairs were made (Fig. 5). The imperative for safety provided the reason—and the funding—for restoration of the concrete.

In the summer of 2000, DBI Construction of Sacramento, California, contracted to make repairs, under supervision of maintenance craftsmen on park staff. As the deteriorated pillars supporting the ammunition hoist canopies were cut and jack-hammered away, examination revealed a relatively coarse mixture with a high sand to rock ratio, and twisted iron rebar placed close to the surface (Fig. 6). Perhaps improperly washed beach sand may have contributed to the effects of the moist salt air to intensify the spalling. Molds were constructed, new one-inch rebar was tied in place to overlap the old, and Five Star Structural Concrete with Rapid Set Cement was poured in place (Fig. 7). All metal was coated with Burgess Rust Destroyer, to inhibit corrosion. Great care was taken so that the new concrete closely resembled the old in texture and color. A thin coat of Rapid Set Non Shrink Multipurpose Grout covered the grain left by the wood forms, emulating—with compatible contemporary material—but not quite duplicating the sandy-grained parge coat originally added as the work was poured (Fig. 8). Upon the completion of repairs to the pillars on the upper level, railings were installed in historically appropriate locations, using industrial grade galvanized steel coated with a rust inhibiting primer.

Concurrent with the safety-driven need to replace missing railing at heavily visited gun batteries, the park began to implement the recommendations of its recently published *Seacoast Fortifications Preservation Manual* to perform a survey of its entire network of historic fortifications, numbering fifty sites, and identify preservation needs and priorities. Not surprisingly, Battery Mendell rated the highest priority for continued preservation work. Twelve of the thirteen pillars on the lower level, supporting the gun platform extensions were immediately targeted for further repair, because of severe spalling and evidence of cracks in the gun platform extensions above. This work was carried out in the fall of 2001, based upon lessons learned during the earlier phase of safety rail replacement. While making the repairs it became evident that some of the pillars have shifted up to 1/2-inch due to settling. The clay substrate left in place when the battery was constructed continues to haunt us. Indeed, a wide crack has developed in the parapet of gun pit #2, while the blast apron has pulled away from the rest of the battery by several inches to the depth of as much as four feet (Fig. 9). Repairs will be made to seal the cracks, minimize water infiltration, and perhaps retard the settlement. In the long run, they will only delay the inevitable fate of the structure as the cliff it is perched upon looses the battle to the surf. Other work on Battery Mendell, such as eradication of social trails on the earthworks, vegetation management, and graffiti abatement will occur as time and other priorities permit. But the repairs that have been made will allow succeeding generations to appreciate and explore this historic and scenic site more safely.

Figure 8. The repaired support pillar convincingly recreates the complex chamfers and cornices of the original.

During the course of treatment for Battery Mendell, the preservation program for the entire fortification network at Golden Gate National Recreation Area has evolved. From a strong basis of craftsmanship applied to address the most immediate need for repair, park managers apply a framework of treatment methods to various batteries based on priorities driven by physical condition, historic integrity, and visitor and park needs. In a sense that the old army at the battery would have understood, the recent treatment of Battery Mendell built upon a strong tactical base and developed its operational level capability to improve its preservation.

Figure 9. Looking north to BC station from the front of emplacement two, showing separation and subsidence of blast apron from the concrete mass of the remainder of the battery.

The author is indebted to Charles F. Wofford, John A. Martini, E. Matt Feliciano, and Barbara Judy for their information and invaluable assistance in the preparation of this piece. All photographs are from the collection of the Golden Gate National Recreation Area and its Park Archives and Records Center.

Case Study: Spalling Concrete

Four-inch Examination Batteries

North Head and Fort Takapuna, Auckland, New Zealand

— Dave Veart

Although the focus of the Handbook *is the preservation of fortifications in North America, the following article demonstrates that preservation problems and treatments differ little in other parts of the world.*

This case study describes two methods used to deal with the problem of severe spalling of concrete at the examination batteries at two sites managed by the Department of Conservation in Auckland. The Department of Conservation is the government agency in New Zealand that manages many of the country's protected places, National Parks, historic public buildings, and sites of cultural and spiritual significance. In total the Department manages almost one third of New Zealand's land area. Among the historic public places are a large number of the old fortifications once associated with the country's coast defences.

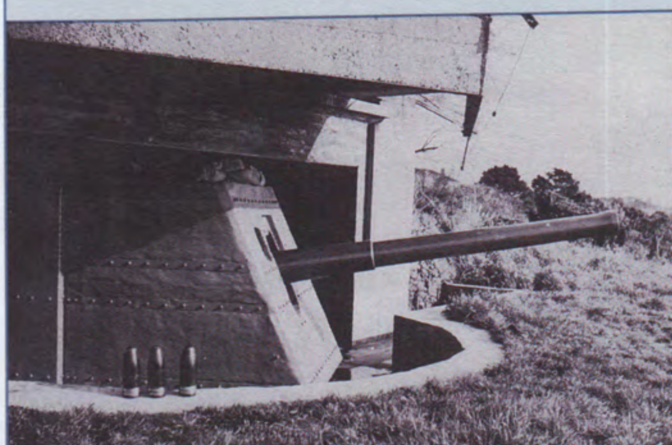


Figure 1. Four-inch gun and emplacement, Fort Takapuna, ca. 1943

Figure 2. Spalling concrete, four-inch emplacement, North Head.

The forts at North Head and Fort Takapuna stand on adjacent headlands at the entrance to Auckland Harbour. Both have been coastal forts since the 1880s, and new works were built during World War II. These included a number of emplacements to house guns for 'Examination Batteries' for the port (Fig. 1).

The examination anchorage during the war was directly to the north of both forts. This was the area where all ships entering port had to wait to be 'examined' to see if they were who they claimed to be; the examination batteries were there to ensure that the ships did stop. The guns used in these batteries are a good indication of the lack of suitable weapons in the country at the time and the emergency measures that needed to be taken. The four-inch guns at both batteries had originally been the secondary armament on the World War I battle cruiser HMS New Zealand. After the ship had been scrapped by the Royal Navy in the 1920s, the guns came to New Zealand where they had been used as saluting batteries. The urgency of the period after the entry of Japan meant that all available guns were pressed into service, including these veterans. The guns were emplaced in roofed concrete structures called 'Colchester' shelters, themselves a product of urgency and shortage of materials. The structures were built partly on the site and partly from prefabricated panels. Shortages of cement at the time has meant that these structures are now amongst the most heavily decayed of the coastal batteries with severe spalling over much of their surface. Deterioration is especially bad in the prefabricated parts of the structures. The concrete over the steel is of minimal depth and has lead to severe spalling as the steel reinforcing has rusted (Fig. 2).

Figure 3. Steel supports for emplacement roof, North Head.

In 1995, a number of people were killed in the collapse of a viewing platform built by the Department of Conservation. Following the accident, a major assessment of all structures on Departmental land was carried out, including historic structures. The four-inch emplacements at North Head were deemed to be dangerous and there were calls for their demolition, estimated to be $NZ10,000. There was insufficient funding available for a complete repair of the emplacements. At this stage a second engineer was called in who, in consultation with conservation architects and Departmental historic resources staff, came up with the alternative of building a steel frame to support the roofs. The cost was under $NZ1,000 (Fig. 3). At the same time, a company specialising in the installation of waterproof membranes offered to reseal the roofs of both emplacements at no charge. The membrane has stopped the passage of water through the old concrete roofs and appears to have slowed the spalling (Fig. 4). More extensive repairs will still be necessary when funding is available.

Figure 4. Applying waterproof membrane to emplacement roofs, North Head.

In 1999, the Department took over the management of a former Defence Department site at Fort Takapuna. The four-inch examination battery at this site was in a similar condition to that at North Head, although there was sufficient funding here to carry out repairs properly. Where the concrete had already broken away, the exposed steel was grit or water blasted (Fig. 5) and the product Nitocote CM210 was applied. Where the concrete had cracked but not spalled, the loose and drummy concrete was removed, the steel grit blasted and then primed with Nitoprime Zincrich (Fig. 6). The concrete was then treated with Nitobond HAR bonding agent and Renderoc HB 25 repair mortar used to repair the damaged areas (Fig. 7). Nitobond AR curing membrane was then applied and white Nitocote CM210 put onto the repaired areas.

Figure 5. Cleaning steel, Fort Takapuna.

In retrospect we have probably 'over restored' these emplacements. Neither the contractors nor the Department of Conservation had any previous experience in working on structures such as these. Until the concrete started to be broken out, we had no idea that such a large amount of material would be lost. In some parts of the emplacements little apart from the reinforcing steel remained. The poor construction methods used on these emplacements are part of their history, and reflect the urgency with which they were built and the shortages of materials at the time. There is a third four-inch emplacement at Fort Takapuna that we plan to work on in the future. We will use a more conservative approach, perhaps relying on steel supports similar to those considered a temporary measure at North Head.

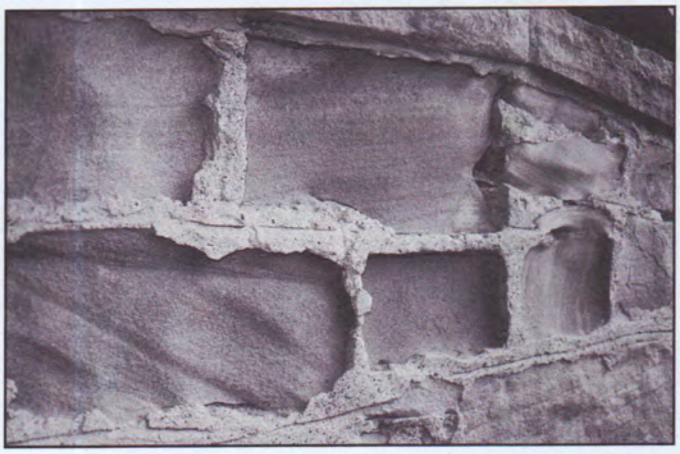
Obtaining historical data is an important part of planning for repair and maintenance strategies. There are, however, times when the information flows back the other way, when the repair work exposes elements of the history of the site that were previously unknown or incompletely understood. For example, we suspected that the Colchester shelters were built at a time when materials were in short supply, part of the cause of the poor condition of these structures. On removing the loose concrete from the examples at Fort Takapuna, it became apparent that not only was the concrete even thinner than expected over the reinforcing (less than 5mm in places) but the reinforcing was made of random lengths and thicknesses of material, an additional indication of the shortage of materials.

Figure 6. Reinforcing steel primed prior to plastering, Fort Takapuna.

Figure 7. New plaster in place on main lintel, Fort Takapuna.

Erosion

Some stone, especially sedimentary stones, are susceptible to erosion, the natural and gradual wearing away of material by wind and rain. The result is a depressed surface whose original detail has been lost. It is not a common phenomenon in fortifications because of the limited use of such stones, and no true examples of erosion in concrete were identified in the preparation of the *Handbook*.



Eroded sandstone blocks at Fort Worden, Washington. The causes of the erosion are uncertain, but the poor quality of the stone itself is a likely factor.

Solutions for Erosion

Do Nothing. Soft materials will continue to erode if their environment remains the same. Stones will erode to the point that they are no longer structurally adequate to support their own weight or that of the masonry of which they are a part. Their remnants will fall out of place, leaving a void and a weakened structure. It is a slow process, but it is also certain.

Composite Repair. Erosion can be treated by some of the methods previously described, such as the use of a veneer replacement stone. A more common technique is composite repair. It is the use of a plastic material that is cement based and formulated to match the appearance of the stone being repaired. Composite repair materials consist of a binder and aggregate, with additives to increase adhesion. It is also possible to color the material, but since cement dyes fade over time, a better color alternative is to use finely ground elements of the original stone as part of the aggregate. Fillers can also be used to extend the mixture, making the repairs less costly. Large repairs will need to be supported with stainless steel or fiberglass pins.

The choice of binder makes a difference. Cement is a common organic binder, and it offers strength, stability, and durability. It is also readily available. It also has a tendency to shrink and may introduce soluble salts and moisture into the substrate. Organic binders such as epoxy and polyester resin are useful in imitating several types of stone that are not found in fortifications, but they are often found as components in adhesives that are best suited for reattaching stone. While a composite repair material can be mixed on site to a specific formula, in many applications a commercially prepared repair mortar is just as satisfactory and easier to use. Availability of these products varies, and includes such manufacturers as Ledan, Mapei, Keim, Jahn Mortars, and Edison Coatings.

Pitting

Pitting is the occurrence of small cavities on bricks and stone. While it can result from harsh and abrasive cleaning, it is more often the result of reactions with the environment or imperfections in the material.

Pitted brick at Fort Point, California.

Solutions for Pitting

Short of *replacement in kind* (see *Solutions for Detachment, Breakage, Chipping, and Spalls*), there is no effective large-scale repair for pitting. Repair may not be necessary if the material is stable.

Mortar Deterioration

Masonry fortifications suffer from the same conditions experienced by other types of masonry structures, including the deterioration and loss of mortar from between the masonry units. The solution for mortar deterioration is repointing, a topic that is well covered in preservation literature, and a method that differs in no way when applied to fortifications. The same cautions also apply: remove deteriorated mortar carefully to avoid damaging the masonry units or altering the joint size, and be sure that the repair mortar matches the original in strength, color, texture, and profile.

Efflorescence and Subflorescence

Efflorescence is a white, powdery deposit of soluble salts that can appear on the exterior surface of concrete and masonry. Subflorescence is a similar deposit of salts just beneath the surface. Of the two, subflorescence is often considered the most serious because the crystallization of the salts can damage the surface through exfoliation or spalling. In truth, both are deleterious and indicators of other problems in the structure.

The appearance of crystalized salts is referred to as efflorescence. Battery Cavallo, Fort Baker, California.

Soluble salts have many sources. They can occur naturally in building stone, in the sand used in concrete or mortar, and in all soils; they can also be carried by sea spray. Water dissolves the salts and moves them by capillary action through the pores of a material. When the solution reaches the surface, the water evaporates and leaves behind deposits of calcium hydroxide, chlorides and sulfates of calcium, and calcium carbonate. Calcium hydroxide is the most frequently encountered source of efflorescence, and like all efflorescence, it can be easily washed off when it first appears. However, calcium hydroxide converts to calcium carbonate when exposed to atmospheric carbon dioxide, and calcium carbonate forms a tough deposit that is difficult to remove. It appears as a gel-like build up on the vertical surfaces of many fortifications.

Evidence of efflorescence varies with the season. It is much less in evidence in warm, dry weather, and more likely to appear in the cool, damp days and nights of Fall. Efflorescence and subflorescence depend on water. The salts themselves do no harm until they are in solution and migrate to the surface. Effective control depends on the diversion of water from the surface of the structure and the prevention of rainwater (which is slightly acidic) from entering the masonry wall or concrete mass.[33]

Solutions for Efflorescence and Subflorescence

Do Nothing. Salts will continue to come to the surface, or gather behind the surface where they threaten concrete and masonry alike with exfoliation and spalls.

Water Wash. This technique, described in *Solutions for Dirt Removal* above, is sometimes effective. If the techniques under that section are not successful, several dilute acid solutions provide for more aggressive cleaning of efflorescence on concrete:

1 part hydrochloric acid in 9 to 19 parts water;

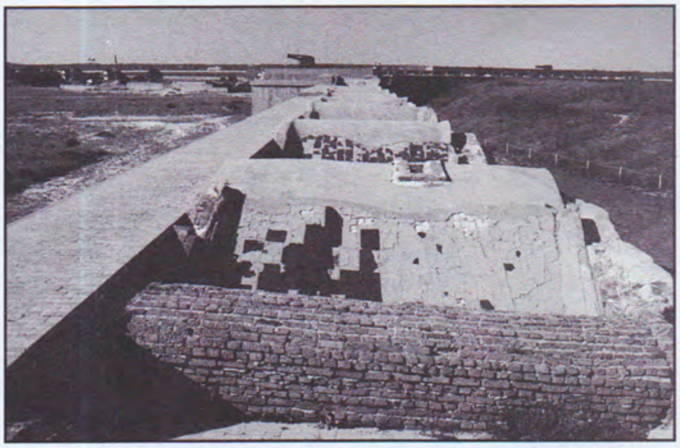
1 part phosphoric acid in 9 parts water;

1 part phosphoric acid and one part acetic acid in 19 parts water.

Thoroughly wet the area to be treated with water before applying any of the solutions, and try it first at an inconspicuous location before moving to more visible sections. Remove all traces of the solution by flooding with water to ensure that there is no remaining acid that might attack the surface. It may require annual treatments over a period of several years before the efflorescence ceases to appear. If the accumulation of efflorescence is localized, the removal can be accelerated by a poultice of paper pulp and water; let dry, remove, and repeat several times to draw the soluble salts out of the material.[34]

Blocked or Damaged Drains

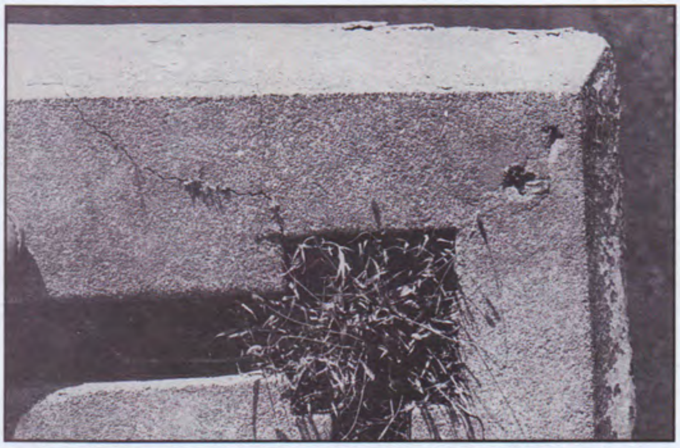
All drainage systems are designed and installed to collect, divert, and disperse rainfall. These systems, which include both surface and subsurface drainage, were considered in the original designs as are shown on drawings and described in engineering reports of the time. Protective coatings of various materials were applied to the upper surface of casemate arches in masonry fortifications to divert moisture from the earth fill above and channel the water through cast iron pipes away from the foundations. Noted previously are the fresh water catchment systems incorporated into the design



Brick vaults running in the valleys between adjoining casemates collected water in many Third System fortifications. Removal of the terreplein has exposed the vaults at Fort Pickens, Florida.

[33] Dukes, 430; Hurd, 791; "Removing some common stains from concrete," *Concrete Repair Digest*, (March, 1993), 6; David Hadden, "Cleaning Restoration of the Baha'i House of Worship," *Concrete International*, (September, 1992), 45; T. Ritchie, "Efflorescence," Canadian Building Digest, UDC 693.2:62.019.138, Division of Building Research, National Research Council, Canada, in RESTORE 2001, Section C.

[34] Hurd, 796; "Removing stains," 6.



Vegetation easily takes root in blocked and silted drains. Overflowing drains can promote leaching, encourage the growth of moss, and lead to freeze/thaw spalling in colder climates. Battery Mendell, Fort Barry, California.

of many Third System defenses. In these works, a six-inch iron drain from the terreplein passes vertically within the core of the structural piers and into the cisterns. These and similar drains require regular maintenance to prevent them from filling with debris. If the drain ceases to function, it is likely that water will saturate the surrounding masonry, gradually weakening its structural capacity. Water will then remain within and against the building, eventually causing damage. At the very least, water will overflow the drains, creating wet conditions on vertical and horizontal surfaces and encouraging the growth of moss and other plants.

Historic drainage systems are often deteriorated or clogged, yet it is critically important to maintain them and keep them operational. Existing drainage systems may be identified by examining original drawings and maintenance records as well as by investigation in the field. Metal detectors may be useful in locating subsurface cast iron piping, and ground-penetrating radar can be effective in finding clay drain tile. In both techniques, selective excavation may be needed to determine actual locations, depths, and slopes.

While there are instances of exterior rain leaders in fortifications, most drainage is internal to the structure in masonry and concrete fortifications alike.[35] These drains are seldom blocked except at their daylight ends, where they are at risk from damage and heavy plant growth. It is common for waste lines from latrines to connect with the drainage system; maintaining the system for drainage only should not pose a difficulty since no functional latrines were identified in the preparation of the *Handbook*.

In fortifications of the 1890s and early 1900s, many of these internal drains are surprisingly narrow, or fitted with grates whose small openings are easily blocked. To restore such a drain to operating condition, remove the grate (drain grates are seldom bolted in place, and most simply rest in the top flange of a tile pipe), and clean the grate of compacted mud and debris. Flush out the drain with water under medium pressure (<100 psi) or use a snake to displace the accumulated matter. Most drains once opened will function very well. Some drains have been filled with small rocks, the result of unsympathetic actions by occasional visitors. Because of the narrow diameter of most vertical drain tile, it is difficult to remove the rocks without damaging the tile. The removal of the accessible stones and lighter debris at the upper end of the drain may be all that it is possible to accomplish. However, large diameter rocks dropped casually into a drain are not

[35] An apparent exception are the projecting scuppers or channels at the Castillo de San Marcos, which extend two feet from the scarp wall exterior. These features were added ca. 1890; the original drainage detail is not known. *Castillo de San Marcos Design Analysis*, 10.

enough to stop a flow of water, and keeping the accessible end free of silt may be all that is necessary to restore and maintain function.

Excessive or Aggressive Plant Growth

Exterior surfaces can support the conditions needed to encourage plant life if they retain water, collect dirt, or remain moist. Cracks in masonry and concrete often provide an excellent habitat, as do debris-filled gutters. Plant life, ranging from trees and vines to small surface lichens and moss, is always an indicator of conditions that are good for greenery but not necessarily good for buildings. It may take decades for the plant to harm the structure, but any sign of plant growth indicates that the organism is living and feeding off something within the concrete or masonry, be it minerals or moisture. Vegetation management and related control of intrusive vegetation should be an integral component of preservation efforts and general grounds maintenance.

Solutions for Plant Growth

Do Nothing. Roots growing into cracks will force them open, increasing their breadth and length alike. Bigger cracks mean more water penetration, and that means leaving the material at risk for increased damage through freeze/thaw cycles and other water-based deterioration. Plants that grow in gutters and on paving, for example, can redirect water flows away from their designed course, increase the amount of standing water, or encourage the erosion of adjacent soils. Smaller plant growth like lichens and moss also retain water, keeping the surface damp.

Pulling the Weeds. Removing vegetation from gutters, construction joints, and masonry walls is a good maintenance practice and one that was called for when the fortifications were active. Not only does masonry and concrete benefit from the removal of vegetation, the practice also reestablishes the original contours of the structure.

Plants can root in the joints of brick or stone masonry, and there may be a reluctance to remove them for fear of accelerating damage to the mortar. However, the penetration of roots and the increased admission of water into the substrate are of far greater concern than the possible loss of mortar that is already deteriorated. Pull out the plants, roots and all, and plan to repoint the joints as part of the overall project. Not to do so is false economy.

Uncontrolled plant growth can lead to the rapid deterioration of wood-frame structures that are also part of many fortifications. Fire Control Dormitory, Fort Canby, Washington.

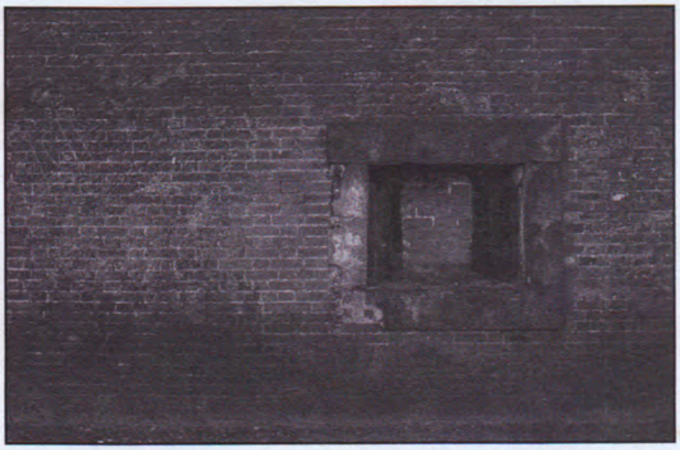
Power Equipment. Trees and brush immediately adjacent to structures will probably have to be removed with chain saws, brush hogs, and trimming saws. These larger plant materials pose threats through the powerful physical forces that can be exerted by their root growth, which can crack or upset parapets and retaining walls. Their steady increase in size contributes to the accumulation of leaf litter and other debris, which itself provides a starting place for secondary plant communities. The debris is also a natural poultice that will ensure dampness of the masonry throughout the year at the same time that it slows the evaporation of water from the interior.

Pruning away the roots of trees that are near a fortification is not recommended. It destabilizes the structural support for the tree and may lead to its loss in an uncontrolled manner with accompanying damage to the historic resources.

For more information about vegetation management in the vicinity of fortifications, see Section One.

Rising Damp

The movement of groundwater upward into a structure is called rising damp. It is often caused by improper drainage where excess groundwater is drawn up and into the stone and forced to the interior and exterior wall surfaces, bringing with it salts and other minerals that cause efflorescence. Rising damp is indicated by a horizontal water stain or "tidemark" and can discolor or deteriorate interior wall finishes as well as damage exterior masonry and concrete.



The dark area at the point of ground contact indicates rising damp. As the name suggests, the condition moves moisture upward as a result of capillary attraction. Fort Point, California.

Solutions for Rising Damp

Do Nothing. Water will continue to move upward, ensuring damp interiors and walls, creating and then maintaining the conditions necessary for weakening mortars, rotting wood, and corroding metals.

Installation of a Dampproof Course. Historically, many buildings incorporated a dampproof course into the perimeter walls of the structure, although they are not common in fortifications. This horizontal layer of waterproof material, located just above where the ground meets the building's walls, traditionally consisted of slate, tile, or other impervious materials, that prevented the capillary rise of groundwater into the masonry base of the building. Since these materials do not deteriorate rapidly, traditional dampproof courses remain the most permanent and successful solution to rising damp. Adding a dampproof course to an historic structure is extremely difficult and should be approached only with caution and thorough evaluation. To be successful, a dampproof course must incorporate a continuous layer of waterproofing material, such as sheeting of polyethylene, bitumen, or metal, usually located just above the ground and below the floor joists. This requires the removal of material, either by cutting a horizontal path or dismantling a brick or stone course, to allow installation of the waterproofing. Deteriorated mortar or unstable walls may prevent the removal of wall material, as may extremely thick, irregularly spaced stone walls, and hence such a technique would be difficult to undertake in a fortification. However, if installed correctly, this approach will most successfully interdict the rise of moisture.

A pressure-injected chemical dampproof course has been developed as an alternative to the cutting and removal of historic fabric. Holes are drilled into the masonry at regular intervals, into which is injected a synthetic waterproofing material such as a silicone-resin based water repellant or an aluminum stearate polymeric water repellant. The chemicals flow through the interior voids to form a continuous membrane. The insertion of a chemical dampproof course has become more widespread with the development of chemical products that have been tried and tested over the past 20 years.

There is no certainty that improving the drainage will have the desired effect on the incidence of rising damp.

Improving Existing Drainage. Simply regrading the area around the structure so that water drains away from the foundation walls may help prevent rising damp. A reevaluation and possible redesign of the drainage system may also reduce ambient groundwater sufficiently to prevent rising damp. The installation of footing drains will help remove rainwater and standing water from around the structure. Removing plant growth and debris from drains and gutters while maintaining the existing drainage system may also help. These solutions are less intrusive than the installation of a dampproof course, but there is no certainty that improving the drainage will have the desired effect on the incidence of rising damp.

We were unable to determine a typical design detail for footing drains of Third System and earlier fortification types. It may be that none were called for, given the water collection system frequently built into the terrepleins of such defenses. Concrete fortifications usually included a concrete footing drain coupled with a system of interior drains. The collected water was drained off to a sump, routed to a wetland or lower elevation, or if the site permitted, run out to a beach or over a bluff.

Masonry and Concrete Examples

1. Concrete Crack and Spall Repairs

In 1996, the State of New Jersey began to rehabilitate Battery Gregg, a medium-sized concrete structure dating from the 1890s at Fort Mott State Park. The thorough program of research and analysis leading up to the project, and the careful execution of the job by the contractors, provides an excellent demonstration of how good preparation is an essential partner for a satisfactory result.

The following excerpt from a portion of the Fort Mott technical report is reproduced here as a good description of the typical appearance of a concrete fortification of the 1890s as well as a comprehensive and understandable summary of the observed conditions.

The visual assessment of the concrete at Battery Gregg verified the presence of a mortar facing on the exposed surfaces. This surface is distinguished by its lack of coarse aggregate. The facing layer is typically two to three inches thick. The outer portion of the facing is darker in color than the underlying mortar. The underlying mortar has the appearance of the cement matrix of the mass concrete beyond; the interface between the facing and the body concrete is irregular.

Where the surface mortar has spalled, the body concrete beyond is visible. The body concrete is also visible where the top of the earthen embankment has receded from the concrete parapet caps. This latter concrete is unfaced and was cast against the earth. Where concrete lacks a mortar facing, the cement matrix is disintegrating.

The following conditions were noted during the visual assessment:

- *Horizontal cracks in vertical surfaces;*
- *Vertical cracks in vertical surfaces;*
- *Delamination and spalling of the surfaces;*
- *Cracks and spalls at embedded metals and metal anchors;*
- *Disintegration of body concrete where the surface has failed;*
- *Vegetative growth;*
- *Failure at previous patches;*
- *Cracks in horizontal surfaces;*
- *Damp surfaces;*
- *Exudation and incrustation.*

The mortar-facing surfaces of Battery Gregg are riddled with cracks of varying width and orientation. Horizontal cracks dominate the vertical surfaces. These cracks are 6-inch to 16-inch on center and are occasionally linked by vertical cracks. These cracks vary in width from 1/32-inch to 1/8-inch. In some locations, the concrete surrounding the cracks has spalled. Cracks of 1/8-inch to 1/4-inch appear in the horizontal concrete of the gun emplacements and on the sloping surfaces of the access passage walls.

The spalls at Battery Gregg are typically one foot square and approximately 1-1/2-inch at their deepest. The spalls usually consist of the full depth of the surface mortar. In addition to the mortar, as much as an inch of the body concrete beyond may be loosely bonded to the spalled facing. Spalls are typically associated with the horizontal cracks present in the access passage walls.[36]

Subsequent to the visual assessment, physical and chemical tests were carried out on the concrete. The test results were combined with the earlier field observations to develop the specifications for the work, as excerpted below.

Concrete Restoration

. . .

2.1 Concrete Patches

A. *Basic mortar components as follows:*
   1. *Portland cement: ASTM C150, type I, low alkali, white color, non staining. . .*
   2. *Aggregate/Sand for mortar: ASTM C144, (sieved to pass #16 screen). . .*
   3. *Hydrated Lime for mortar: ASTM C207, type "S". . .*
   4. *Coloring pigment: pure ground mineral oxides, non-fading and alkali proof . . .*
   5. *Water: potable water free from injurious amounts of acids, alkalis, oil, and organic matter.*

B. *Select and match the sand and pigment components of mortar using the Mortar Analysis Reports provided by the A/E*

C. *Proportions: Provide initial mix proportions as indicated below. Adjust the proportions in the field as directed by the A/E.*
   1. *Mortar match:*
      a. *One part portland cement; to*
      b. *One-half part hydrated lime; to*
      c. *One-sixteenth part Raw Umber;*
      d. *One-thirty second part Raw Sienna;*
      e. *Four and one-half-sand measured damp and loose.*

2.2 Forms

. . .

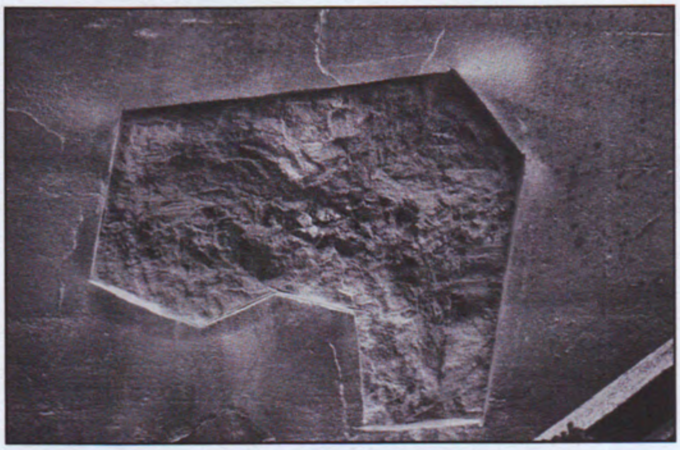
2.3 Reinforcement

A. *Bars and wire:*
   1. *Bars: AISI Type 304 stainless steel, 1/4-inch diameter;*
   2. *Welded wire fabric: AISI Type 304 stainless steel, 8 gauge, 1/8-inch wire diameter, 3-inch by 3-inch mesh, welded or woven.*

B. *Fabricate in accordance with the Drawings.*

C. *Do not use reinforcement with the following defects:*
   1. *Misfabricated;*
   2. *Unnecessary bends or kinks;*
   3. *Reduced cross-section*

[36] *Technical Report for Concrete Stabilization*, Watson and Henry Associates for the State of New Jersey, DBC #P702, (November, 1994), 46.



An area of damaged concrete has been cut back to sound materials prior to patching. Battery Gregg, Fort Mott, New Jersey.

. . .

3.3 Preparation for Repairs to Existing Concrete

A. *Remove deteriorated concrete and incompatible patches until sound concrete is established, taking care not to damage reinforcement or embedments:*

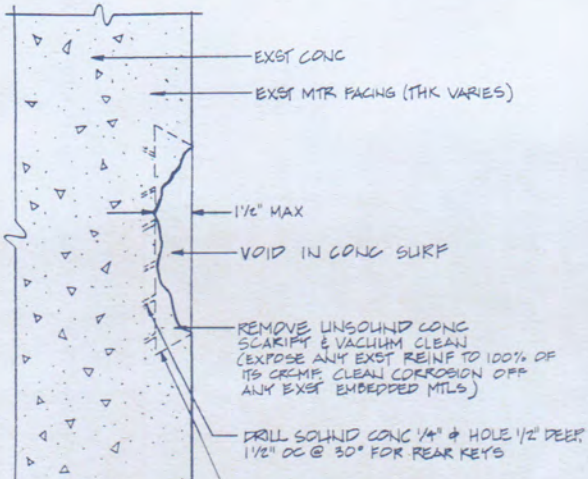
1. *If reinforcements or embedments are encountered, continue to remove unsound and sound concrete to undercut reinforcement by 1/2-inch minimum;*
2. *Undercut adjoining sound material at 30 degrees to form key for patch on all sides.*

B. *Mechanically clean the exposed reinforcement until free of rust, grease, oil, and other bond-inhibiting material.*

1. *Sandblasting will not be permitted.*

C. *Mechanically clean the surface of the exposed concrete face until free of rust, grease, oil, and other bond-inhibiting material. Expose an aggregate fractured surface using a scabbler to obtain a minimum surface profile of +/- 1/16-inch.*

1. *Sandblasting will not be permitted.*



3.4 Patches Less Than 1-1/2 Inches Deep

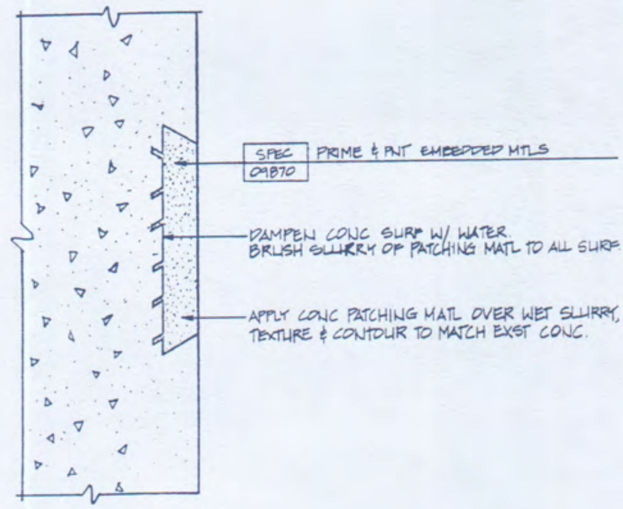
A. *Perforate sound material at back:*
   1. *Drill 1/4-inch diameter by 1/2-inch deep holes on 1-1/2-inch centers, to form key for patch;*
   2. *Angle holes at 30 degrees from horizontal on vertical faces.*

B. *Apply anticorrosion protective coating to the prepared existing reinforcing steel or embedded metals:*
   1. *Comply [with] manufacturer's instructions, including minimum thickness, and overlap neatly onto concrete.*

C. *Saturate the concrete until surface saturated dry, free of standing water.*

D. *Apply concrete patching material, packing the material tight in the prepared void, filling all back key spaces and side key spaces.*

E. *Texture and contour the final application to match the original concrete.*



3.5 Patches 1-1/2 to 4 Inches Deep

A. *Perforate sound material at back:*
   1. *Drill 3/8-inch D by 1-inch deep holes on 3-inch centers, to form back key for patch;*
   2. *Angle holes at 30 degrees from horizontal on vertical surfaces.*

B. *Construct patch reinforcement:*
   1. *Install bar stubs in epoxy resin adhesive in back key holes.*
   2. *Weave wire or welded wire fabric to bar stubs;*
   3. *Provide 1-inch minimum cover to 2-inch maximum cover from reinforcement to finished surface;*
   4. *Position, support and secure reinforcement to provide the required concrete coverage and to prevent displacement by concrete repair operations.*

C. *Apply anticorrosion protective coasting to the prepared existing reinforcing steel or embedded steel, in accordance with the manufacturer's instructions, including minimum thickness, and overlap neatly onto concrete.*

D. *Saturate the concrete with water until surface saturate dry, free of standing water.*

E. *Apply concrete patching material, packing the material tight in the prepared void, filling all spaces around the reinforcement and in all key spaces.*

F. *Texture and contour the final application to match the original concrete*

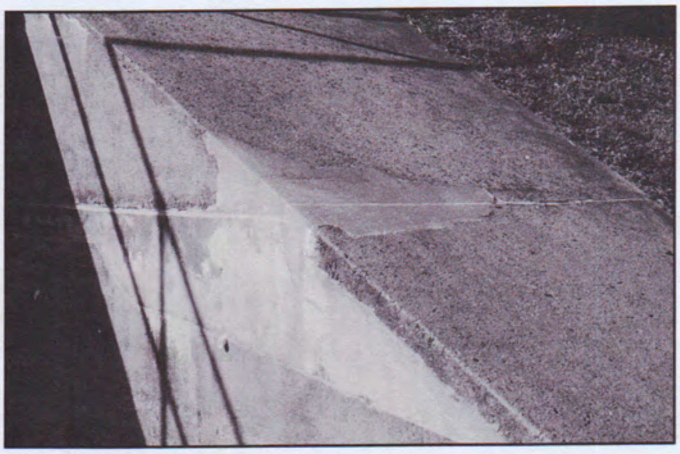
3.6 Curing and Protection

A. *Protect concrete patches and reconstruction from premature drying and extreme temperatures.*

B. *Protect curing concrete patches and reconstructions from mechanical injury by construction.*

C. *Cure the concrete patch for 14 days.*

After new concrete was placed in the patch area, it was covered with burlap to encourage a better cure. Battery Gregg.



This view of a concrete repair at Battery Gregg was taken about five years after the work was completed. The patch is intact and appears to be well-bonded to the substrate.

2. Repointing

Repointing deteriorating masonry joints involves the removal of the existing mortar to a depth of 1/2 to 1 inch, matching the original mortar mixture, and reapplying, by hand, new mortar into the joints. Using power tools, such as a disk grinder, to remove the original mortar is not recommended, since it is too easy to damage the existing masonry. A power tool can also result in a more even appearance to the masonry that may be inconsistent with the character of the historic fabric.

Open joints indicate that this brick wall is overdue for repointing. Battery Cavallo, Fort Baker, California.

The new mortar mixture should match the original mortar in color, texture, and "softness." It is important that the mortar have less compressive strength than the surrounding masonry to allow for expansion and contraction between masonry units. Mortar harder than the surrounding masonry will not permit sufficient movement, and can cause cracking or spalling of brick or sandstone. Achieving the proper mortar mixture is based upon research and testing that in turn leads to a replacement mortar that is compatible with the historic mortar in color, texture, and chemical composition. In reapplying the mortar, care must be taken to match the new joints to the original profile. This usually requires a skilled mason experienced in duplicating historic masonry mortar joints. Successful repointing of masonry joints can extend the life of the masonry wall and visually enhance the structure.

If the repointing mortar does not match the appearance of the existing mortar, the repair will be too noticeable. Battery Cavallo.

Example: Fort Monroe, Hampton, VA

> *The primary task of this project was the raking and repointing of mortar joints. Failed mortar joints of both the coarse ashlar stonework and the brickwork associated with the embrasure openings were raked back to sound mortar using hand tools. The selected mortars were used to conduct a selective repointing campaign of all masonry between the intersection of the moat floor and the scarp wall and the coping stones. Prior to raking and repointing areas below the high tide mark, the area was cleaned with a power washer. This work was conducted during small windows of time when tides were at there lowest. . .A minimal amount of brickwork associated with the embrasures along the wet flank required both repair and replacement. This was accomplished using "in-kind" bricks and the selected mortar.*

Excerpted from "Preliminary Design, Stone Preservation and Repair, Buildings 133, 134, 138, and 161," National Park Service, September 30, 1980. The examples from this source typically deal with structures associated with fortifications rather than fortifications themselves. They are, however, illustrative of techniques that are appropriate for most historic resources.

3. Composite (or Plastic) Patching

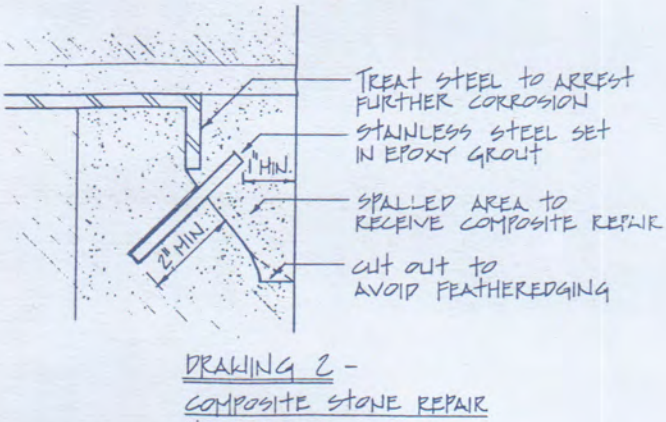
This technique consists of patching a missing area of masonry with a cementious patching compound, formulated for the specific masonry type, color and finish of the stone. Sand or crushed stone are common aggregates used in the mixture, which, like mortar, must always be softer than the surrounding masonry. Artificial coloring may be used to obtain a matching patch color, however dyes may fade under ultraviolet light and may also weaken the chemical composition of the patch. A successful composite patch will match the existing masonry in color and surface texture, will permanently adhere to the surrounding masonry, and will not cause harm to the original masonry. A successful patch is the product of research and testing.

Patches of small areas, approximately 1-3 inches deep, are the most successful, and when accomplished by a skilled worker, may appear indistinguishable from the surrounding masonry. Large patched areas may require the addition of stainless steel or polyester pins to support the weight and ensure bonding to the original masonry. Extensive patching carries with it the possible aggregation of the differences in expansion rates between the patch material and the original masonry, which could eventually lead to the destruction of the patch or the loss of original masonry in contact with the patch. Large patches are also more noticeable and may result in visible differences in the overall appearance of the wall.

Example: Fort Monroe, Hampton, VA

Composite or "plastic" stone repair is an effective and economical treatment when used for the repair of small areas. This treatment is recommended for the repair of non-structural cracks, previous repairs and small areas of spalled stone. The technique basically involves the use of a plastic composite mixture of stone aggregate, natural and/or polymer binders and colorants applied to non-corrosive reinforcement support. Individual patches would be color and texture-coordinated with the adjacent masonry...any existing masonry should be appropriately treated prior to application and a proper moisture barrier installed.

Excerpted from "Preliminary Design, Stone Preservation and Repair, Buildings 133, 134, 138, and 161," National Park Service, September 30, 1980.



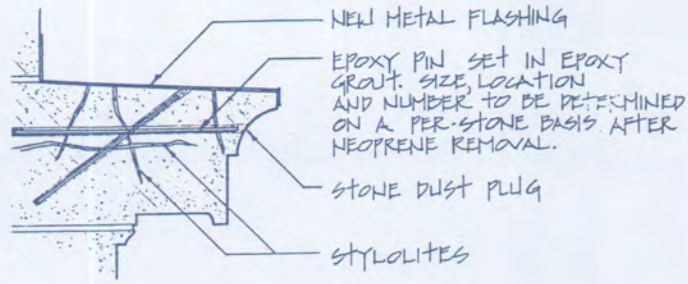
DRAWING 2 -
COMPOSITE STONE REPAIR
HALF SCALE

4. Pinning or Stitching

Pinning or stitching is the practice of drilling, cutting, pinning, gluing, or grouting to fasten together pieces of fractured masonry or concrete. Each detached piece requires its own solution, and in the case of spalls, the detached piece must be thick enough to accept pins and substantial enough to adhere to an adhesive or grout. Important points include the use of non-corrosive (stainless steel) or ceramic pins, compatible grout or epoxy, proper drilling and cutting of original masonry, and protection of the surrounding original material. This example describes the repair of small or decorative features and building components; see Example 7 below for structural pinning.

Example: Fort Monroe, Hampton, VA

Pinning or stitching is the recommended treatment for the repair of Building 138's cornice where weathered stylolites represent a condition of potential stone failure; due to its location, this presents a serious safety hazard...Areas of potential stone failure should be identified by a qualified geologist or stone conservator and specific repairs formulated such as a reinforcement system utilizing non-ferrous pins set in an adhesive grouting.



DRAWING 3 -
PINNING OR STITCHING CORNICE
SCALE: 1" = 1'-0"

Excerpted from "Preliminary Design, Stone Preservation and Repair, Buildings 133, 134, 138, and 161," National Park Service, September 30, 1980.

5. Replacement in Kind

If the masonry is significantly deteriorated, the best solution may be complete replacement of the compromised unit with a new unit, matching in type, color, and dimensions. To ensure a good match, it will be necessary to identify the type of stone or brick, and to determine possible replacement sources. If the unit being replaced is highly detailed or ornamental, it may be necessary to secure a stone carver capable of reproducing the original design. As it is taken from the ground, stone contains a certain amount of moisture called quarry sap that will evaporate causing minor shrinkage that the carver will take into account when he dresses the replacement stone. If it is impossible to match the original stone or brick type, or impossible to duplicate the texture or surface detail, replacement with cast stone may be the better solution. All replacement materials should be marked with the date to identify them as replacements.

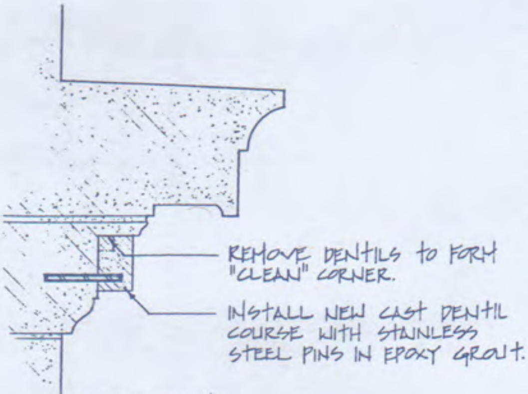
These two new bricks replaced damaged units. Avoid distressing new material to give it the appearance of age. Fort Point, California.

Example: Fort Monroe, Hampton, VA

Stone replacement is recommended only in those areas where the existing stone has reached an advanced state of deterioration from steel corrosion, weathering of stylolites or extreme surface degradation. This replacement would affect only isolated areas of the cornice, parapet coping and base; matching Indiana limestone would be employed. . .In the few areas of replacing the base stone, a veneer stone with non-corrosive pins and adhesive resin mortar is recommended.

Excerpted from "Preliminary Design, Stone Preservation and Repair, Buildings 133, 134, 138, and 161," National Park Service, September 30, 1980.

6. Replacement with Cast Stone



DRAWING 1 – BUILDING 134 DENTIL REPLACEMENT
SCALE: 1" = 1'-0"

Cast stone products use an epoxy or cement-based compound cast in the shape of the original unit. Cast stone was widely used on buildings during the late 19th century and gained great popularity through the early 20th century. It is of value today in the replacement of highly ornamental carved stone that has a level of detail that could not be easily reproduced, or as a replacement for stone or brick that is no longer available. Rather than using masonry with a different color or composition, sometimes cast stone can provide a better match. Cast stone work is often more costly, since a mold is taken from the original masonry and used to cast the new "stone" unit.

Example: Fort Monroe, Hampton, VA

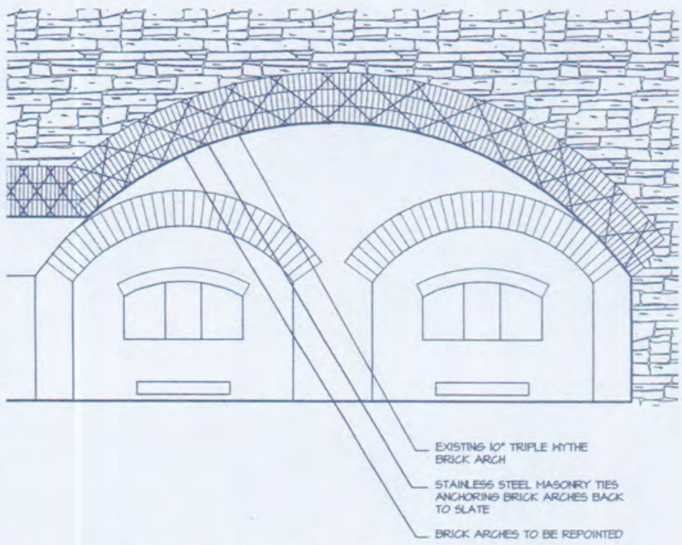
One exception to the use of stone as the replacement material is the dentil course on Building 134. As this is a fairly protected area and it is recommended that all of the dentil blocks be replaced, a cast stone, stone dust-coated fiberglass, or glass-reinforced concrete replacement is recommended, again using non-corrosive pins and adhesive resins.

Excerpted from "Preliminary Design, Stone Preservation and Repair, Buildings 133, 134, 138, and 161," National Park Service, September 30, 1980.

7. Structural Stabilization

Pinning Damaged Masonry. Pinning masonry in place is both a construction technique as well as a method that can be readily utilized for repairs. Historically lead, iron, or hard wood was used as pin material. Stone in ancient structures was pinned by lead or wrought iron bars, and wood was used to tie together the stone chains that supported the structural loads in Brunelleschi's famous dome in Florence, Italy. Stronger, safer, and more durable corrosion resistant materials in use today are stainless steel, titanium, and fiberglass. The choice of material is dependent upon the loads to be carried and the budget.

Structural work should always be designed by a structural engineer or by a tradesman with much experience in structural masonry repairs. Typically the masonry components being pinned together must each be stabilized into a coherent mass. One must be capable of carrying the weight of the other, or both together must be in equilibrium. A hole is made in each of the components and the pin is inserted. The pin is grouted in place by cementitious or epoxy material. The pin, made of material that is most strong in tension, helps tie the masonry components together. The pin must be of sufficient size to carry the load imposed, and the connection must be equally strong. This may be difficult or next to impossible to achieve if the masonry is friable and has lost its integrity. In such case, replacement may be necessary.



Schematic pinning diagram to stabilize arch. Fort Adams, Rhode Island.

Example: Fort Adams, Newport, RI

An immediate plan for the stabilization of the Northeast Demibastion is necessary to prevent structural collapse. Water infiltration over decades has partially collapsed interior arches in the Southeast Demibastion, and the goal of structural stabilization is to prevent further collapse. Stainless steel or composite steel/masonry ties will be inserted into pre-drilled holes in the brick arches, and tie the weakened brick to the underlying masonry structure.

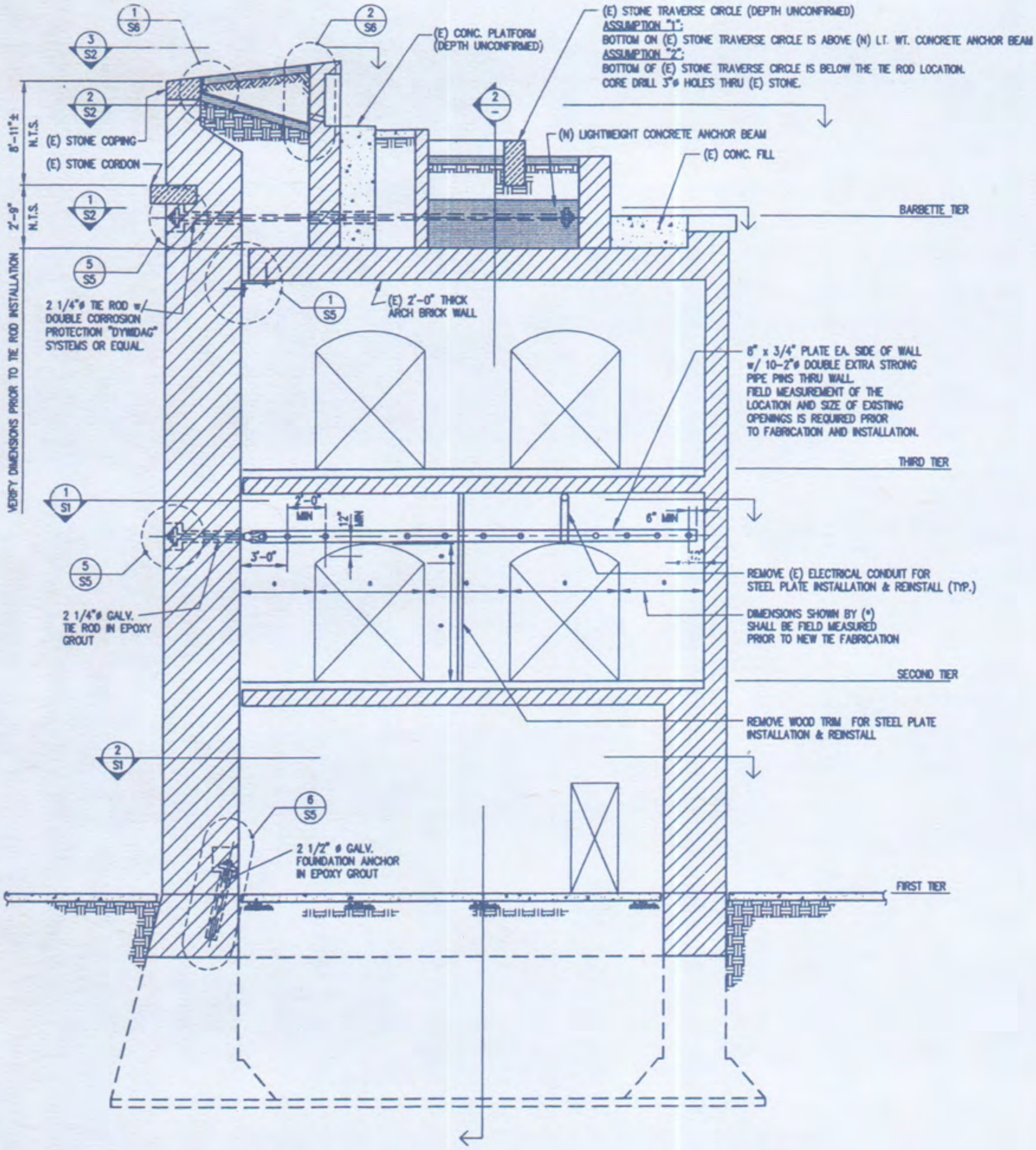
Excerpted from "Rehabilitation Plan: Fort Adams, RI," Fort Adams Trust/ Newport Collaborative Architects, Inc., 2001.

Façade Retention. Steel tie rods have wide application in construction of all types. The strength of steel in tension is applicable for the repair of masonry structures as well as instances where a structural intervention is required. Tie rods have been used widely in historic preservation, including the arches and vaults of numerous structures in Europe and the walls of brick and stone buildings throughout the United States.

Tie rods come in many sizes and can be used to stabilize facades, arches, vaults, or walls of fortifications. They can also reinforce an existing structure to prevent damage from earthquakes or other potential natural threats such as flooding, tornadoes, or hurricanes. Careful attention must be given to how the tie rod attaches to the fortification, and changes in load conditions on the historic features that result from the new structural configuration.

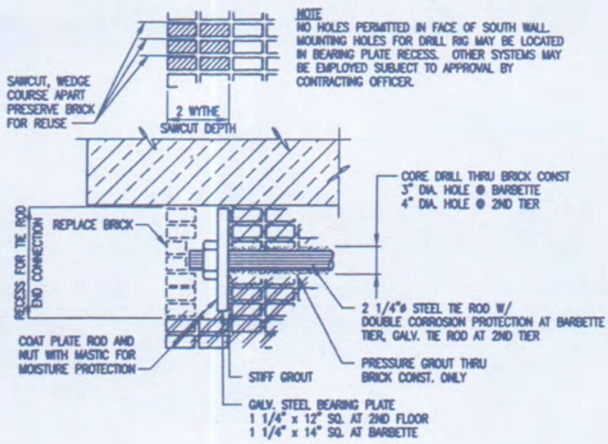
Example: Fort Point, the Presidio, San Francisco, CA

Details for Fort Point specify the use of metal tie rods running through the length of the building to retain the sagging load-bearing masonry façade and to reduce the possibility of failure during seismic activity. The rods are corrosion protected,



Above: Sectional elevation of Fort Point showing placement of tie rods.

Right: Tie rod anchor end recessed and covered with outer wythe of brick.

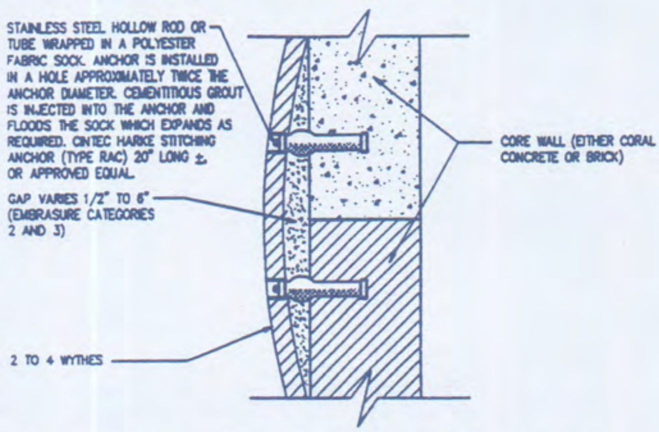


and the exterior bearing plate and fastener are recessed into the masonry. Similar connections are also called for between the foundation and exterior wall, and between the upper floor slab and the exterior wall. These connections tie the façade to the floors, which also helps prevent collapse during an earthquake.

Grout Injected Anchoring System. Grout-injected anchoring systems offer an alternative to tie rods in many applications. One such system, the Cintec anchor, uses a mesh fabric sleeve surrounding a steel tube that is inserted into a predrilled hole in the masonry. Ultra-fine grout is injected under pressure into the flexible sleeve, causing the anchor to expand almost twice its original size while molding itself to the shape of the space it passes through. This creates a physical bond difficult to pull out, as well as a chemical bond between the anchor and the substrate. The anchor hole is then patched on the exterior, eliminating the need for traditional washers or metal plates on the building's exterior. These anchors can be used to stabilize entire masonry walls, repair heavily cracked masonry, and tie external wythes to internal wythes in load bearing masonry walls.

Example: Fort Jefferson, Dry Tortugas, FL

The masonry scarp walls at Fort Jefferson experienced an outward bulging and separation of the face brick. Corrosion jacking of iron embrasures and iron ties (a similar condition was noted at Fort Adams) within the wall was considered to be the primary cause of the movement, resulting in a structurally unsound condition and posing potential life-safety hazards. The repair was based upon a grout injected anchoring system that tied the deformed wall sections back to the stable masonry core. The anchors were placed on a 3x3-foot grid, and inserted into pre-drilled holes that were approximately twice the diameter of the rod. The facebrick was removed at the areas of the anchor ties for installation. After the installation, the anchor heads were covered by replacing the facebrick, resulting in a repair that was largely unnoticeable.



Anchors help secure bulges up to six inches deep at Fort Jefferson. The anchors do not correct the bulge, but stabilize an area of potential failure.

New Structural Beams. Structural beams transfer loads. Horizontal beams that are fixed at each end carry loads of the structure (dead loads) and loads imposed by people or machinery (live loads). Columns are vertical beams and perform structurally in the same way. When structural elements have deteriorated, beams can be used to transfer loads from weakened to stronger structural elements.

Example: Fort Point, San Francisco, CA

Details on page 89 show the installation of a new, lightweight concrete anchor beam above the existing casemate vaults. This reinforced beam will structurally support the brick vaults by tying the brick and concrete together with stainless steel dowels set in epoxy grout. This process involves removing a portion of the earth and concrete slab from the terreplein above to allow construction of the concrete beams. A new concrete slab with expansion joints will be poured after construction is complete.

8. Repairing or Replacing Drainage Systems

Intact and functioning means to remove water are critical for the long-term preservation of fortifications. One of the challenges is to assess the condition of drainage systems that often are buried deep within walls or other structures.

Intact and functioning means to remove water are critical for the long-term preservation of fortifications.

Historic systems may be made of brick, clay tile, or iron pipe. Standards for historic preservation apply to decisions affecting these structures as well. If they cannot be repaired, replacement is possible, but only in a manner that does not impact important historic or archaeological features.

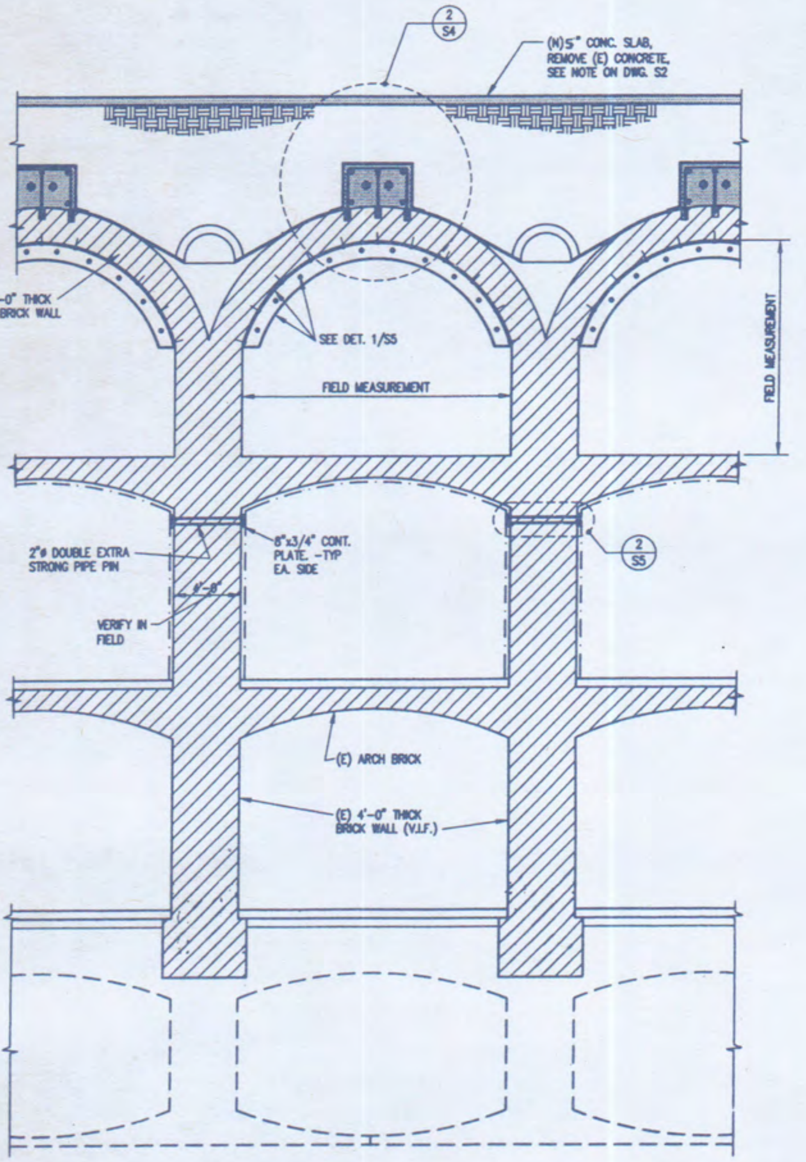
Example: Fort McHenry, Baltimore, MD

During the summer of 1999, work began on the postern tunnel that houses the main drainpipe used to drain water from the fort. Original specifications outlined a plan to excavate sections of ground above this pipe, cut open sections of the cast-iron drain and insert a rubber liner one section at a time. As an alternative, over 420 feet of liner for the pipe (made of rubber and polyethylene) was joined together into one long piece. Then, the entire length was taken out onto a barge on the Patapsco River. Using the bucket of a backhoe, the liner was forced into the cast-iron pipe all the way from the opening at the edge of the river up to the inside of the fort. This alternative avoided unnecessary disturbance of archaeological resources and resulted in considerable savings of time, money and resources. The diameter of the cast-iron pipe was 28 inches and the slip-liner had a diameter of slightly less than 24 inches.

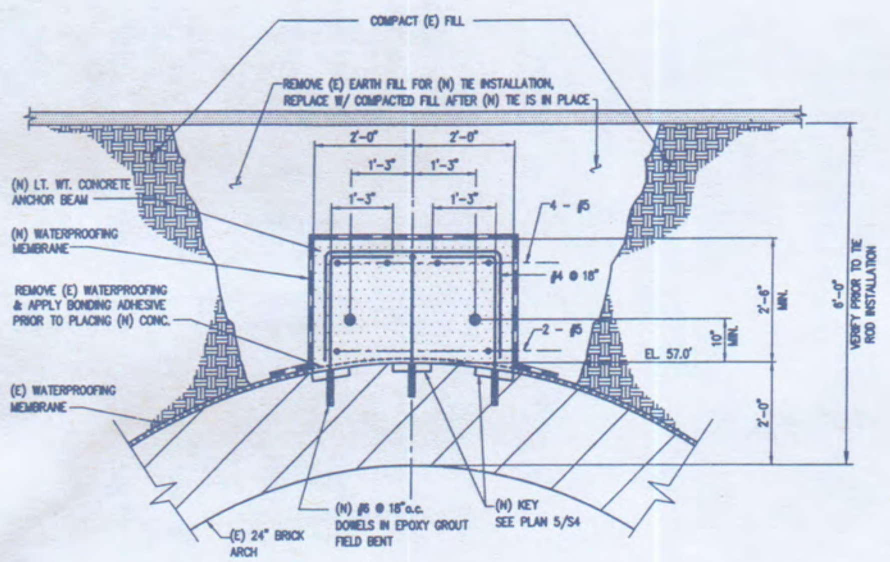
Example: City Walls, Old San Juan, Puerto Rico

The construction of the city walls of Old San Juan began in the early 17th century. The walls, composed of mamposteria (a concrete-like mix of lime, limestone, and crushed bricks) are up to 35 feet high and from 12 to 25 feet thick. In some locations, brick storm sewers run beneath the fortification walls and empty out to the ocean. Near the Santo Domingo Bastion, part of the two-foot high tunnel had collapsed, leaving chunks of masonry that created eddies or blocked the free flow of water. With every heavy rainstorm, water rushed through the tunnels further eroding the brickwork and fill within the city walls.

Eventually, lacking support below, the masonry top of the wall collapsed. A repair was implemented by installing steel beams to support a new slab on top of the wall, however the breach in the tunnel remained. As subgrade turbulence continued, the ground and firing steps next to the wall began sinking, as the soils below continued to be washed away. The final preservation solution was to excavate the area, rebuild the breach in the historic brick tunnel, and repoint all of the mortar



Masonry vault stabilization using new structural beams at Fort Point.



Detail of new concrete anchor beam above vault.

Above the area of the collapsed drainage tunnel, the terreplein has sunk and the stones of the firing steps along the parapet are beginning to drop away. City Walls, San Juan, Puerto Rico.

joints to prevent further collapse. The soil was backfilled to restore the ground level next to the wall and adjacent firing steps.

9. Waterproofing Roof Systems

A wide variety of roof conditions exist on historic fortifications. Each situation requires understanding the historic design and the existing circumstances so that sensitive solutions to waterproofing problems can be made. Some roofs were designed to cover casemates that were intended to be open to the air, or interior rooms intended to be enclosed to the weather and heated or cooled. The roofs over the 17th to 18th century casemates at El Morro in San Juan are examples of the former, and the roof over the 20th century Joint Operations Command Center at San Cristobal and the Radio Control Station at El Morro are examples of the latter. They all were designed to function as roofs with careful attention to waterproofing and drainage.

Other features that act as roofs today were not originally intended to perform that function. The apparent roofs over the casemates at Fort Sumter, for example, were originally covered by rubble to provide a level stone floor for the second tier of casemates above. This second tier was destroyed during the Civil War and subsequent preservation was designed to preserve the fort in its ruined state. Concrete coatings were applied to these areas, and they were also given a slope to encourage water run-off.

Close-up view of a new stucco application and an elastomeric membrane at Fort Sumter, South Carolina.

Example: Fort Sumter, Charleston, SC

The roofs over the right flank casemates are made of brick and rubble, and coated with a historic concrete. The concrete, which varies in thickness from 1/2-inch to several inches, was installed during the preservation of the fort after the Civil War. This area was originally designed with a second tier of casemates above. The early concrete, being relatively soft and permeable, had eroded and cracked extensively because of a lack of expansion joints. Previous maintenance and moisture control efforts included the application of aluminized tar coating. This coating had failed and deteriorated with only traces left on the concrete surface. Water was seeping through the cracked and eroded surface into the casemates below. The project documented the aluminized coating and replaced it with a fluid applied latex membrane. Before coating, the concrete was cleaned, severely eroded areas were patched, and larger cracks were repaired. The final coat of latex emulsion was covered with sand to match the adjacent mortars. Other work included repairs to existing stucco parapet walls and brick repointing. Water repellant silane was applied to the stucco for additional moisture protection. This coating is being re-evaluated due to the recent appearance of moisture in the stucco wall.

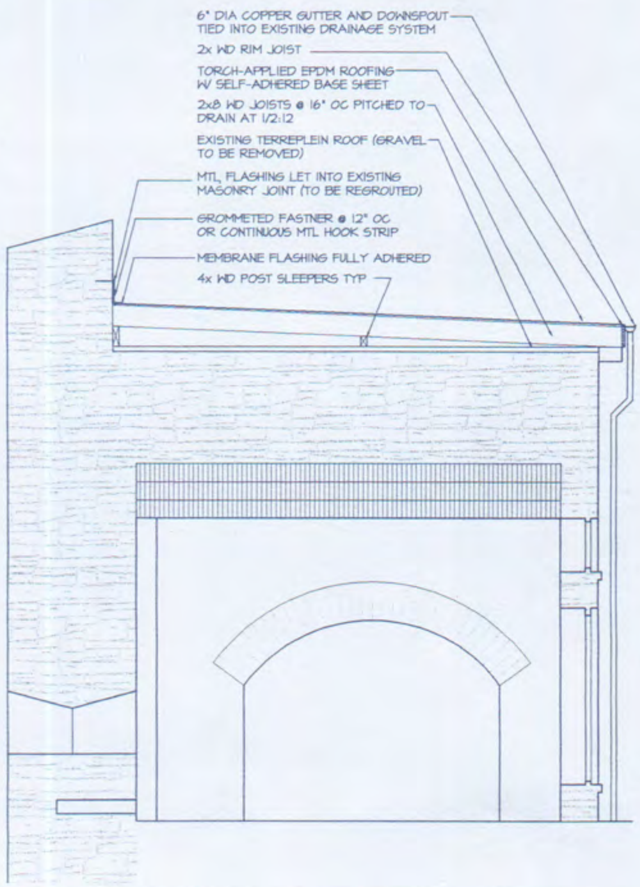
Example: Fort San Cristobal, San Juan, PR

The open-air casemates overlooking the Atlantic Ocean at Fort San Cristobal were designed to shelter both men and arms. The roofs were originally made of wooden vegas supporting a layered basketweave brick structure, and stucco topping in the typical Spanish colonial method of construction. These types of roofs can be found throughout the former Spanish territories in the continental United States. These roofs were designed to cover spaces open to the air while shedding water. The roofs at San Cristobal were replace by reinforced concrete by the United States Army in the early 20th century. Clay tiles and concrete sloped to drains now provide a successful water proofing system over the spaces below. However, irreplaceable historic fabric was lost in the process. A better solution would have been to apply and maintain waterproof coatings as many owners of colonial houses still do in Old San Juan today.

Example: Fort Adams, Newport, RI

> *The roofs in the project area are in poor condition. They were initially designed to absorb and channel water through the structure into cisterns in case of siege. Over time much of this water management system has failed, causing large-scale damage. The structural masonry arches are saturated and damaged, and the interior finishes are deteriorating where leaks allow water entry. These areas should be protected by constructing a new roofing system.*

From *Rehabilitation Plan, Fort Adams, Newport, RI.* Prepared by the Fort Adams Trust, February 2001.



A stick-built fly roof over the terreplein at Fort Adams provides an interim solution for water penetration.

10. Sacrificial Coating (Stucco)

This treatment is recommended to protect or restore fortifications that have been documented to have been originally coated with stucco. The material was most often used to protect softer stones or masonry from deterioration, and it could be tooled to create false mortar joints that gave the appearance of a massive stone structure. Historical stuccos were made from lime putty mortars mixed with sand, and were renewed periodically. Mineral pigments may have been added to give a desired color that was not available in the local lime and sand.

Fortifications can be found throughout the Caribbean with stucco coatings, and in the mainland United States, stucco may have been used to protect tabby fortifications in the Southeast. Because the coatings were likely applied with varying levels of quality in both materials and application, few examples survive. Restoring the lime mortar coating would require conclusive evidence and documentation of its existence and appearance. The re-application of stucco has the potential to be one of the most effective and often critically important means for long-term preservation of these softer structures that are increasingly threatened by acid rain and the natural deterioration of materials.

However, thoroughness and prudence call for adequate testing and planning before implementing the work to ensure that any current or unknown problems are not exacerbated by extensive changes to the equilibrium of the structure. The coating will add weight that has been absent from the structure for a long time. Changes in loading can affect stability and should be analyzed by structural engineers. Another possibility is that a water infiltration problem may have caused porous fill material to become saturated. Installing a coating at an inopportune time during a moisture cycle may trap a high level of moisture; any residual salts may damage the new stucco.

Example: City Walls, Old San Juan, PR

Research indicated that the rough walls were originally coated with stucco made from locally produced lime mortars. The purpose was to cover and protect the relatively soft mamposteria limestone walls from sea water and wind erosion, and possibly to give the appearance of a much stronger solid stone coursed masonry since portions of the fortifications have evidence of darker "mortar" lines rendered on the old stucco.

Critical lack of maintenance has led to advanced deterioration of the city walls in San Juan. The binder is all but gone, and only the weight of the stones hold them in place.

Efforts were begun to obtain funds and to develop a stucco mix to restore the sacrificial coating. Several mixes were produced and tested on a readily accessible part of a ravelin of Fort San Cristobal for color and appearance. International conferences were held to discuss historic fortifications and to present the plans and the test panels of the stucco project. However, the mortar analysis and laboratory work recommended in the original planning document was overlooked. The recommended quality controls and scientific methods were not being used.

In the meantime, differing preservation values surfaced, culminating in local opposition to the re-stuccoing project because of a perceived loss of the "age value." There was concern that the old and rustic appearance of the walls would be destroyed. In addition, the stucco work that had begun on the exposed and windy ocean side of the walls effloresced and cracked within weeks of completion.

A team of international experts was called to review all of the existing and historic documentation available. In general, they identified priority concerns regarding structural stability and drainage, material loss, vegetation, previous repairs, and areas to receive protective renders. Major specific recommendations included the inspection and repair of all drainage systems, crack monitoring, inspection and testing for voids in rubble masonry, inspection of terraces and repairs of water infiltrations, mechanical removal of higher vegetation, removal of selected hard cement repair mortars, the application of stucco to all water-shedding surface and vertical areas presenting a significant loss and active decay of masonry, and the replacement of metal reinforcing in sentry boxes with non-metallic material.

Plenty of planning is essential for large public preservation projects. The seemingly straightforward project to restucco the walls of San Juan was highly controversial and fraught with delays.

The team also reiterated the need for further studies including laboratory testing of mortar mixes, analysis of the existing fabric, test and trials of repair materials, documentation of the trials, completion of existing documentation, and subject-matter specific education of the public, decision-makers, and crafts-people. The report emphasized the value of a commitment to regular monitoring and maintenance and on-going research including comparative studies with other similar structures.[37]

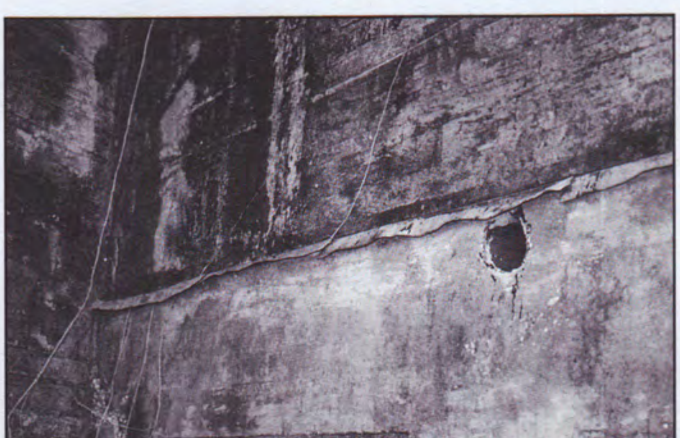
[37] "Recommendations of the Expert Committee Regarding the San Juan Fortifications", San Juan, Puerto Rico, 7-11 June 1999. A. Elena Charola, Fernando M.A. Henriques, Luis Torres Montes, Jeanne Marie Teutonico, Luz Angela, Usache.

Section Three: Metals

Ferrous metals—cast iron, wrought iron, and steel—are the most common metals in fortification construction. As in other building types, the use of metals increased over time. Defenses of the late 18th and early 19th centuries depended upon wrought or forge-worked iron primarily for fasteners and door hardware (hinges, handles, and escutcheons). The range of uses in the Third System brought in decorative cast-iron grilles, stairways, and railings, but relied on wrought iron for embrasure shutters and throats, pintle hardware, and bars. By the end of the 19th century, mild steel had replaced cast and wrought iron for many purposes. The concrete fortifications of this period contained mild steel in the form of ceiling beams, reinforcing rods, doors, and structural shapes, not to mention the growing use of steel in the many mechanical devices contained in the interiors. The ultimate use of steel occurred in World War II with the development of the shielded barbette carriage for 6-inch guns. Here the wrap-around shield of thick armor embraced the gun and its crew, displacing the centuries-old protective functions that formerly belonged to casemates and parapets of masonry and concrete.

Plate steel, forged iron, galvanized iron, and structural steel shapes are all in evidence in this predominantly concrete fortification. Battery Richmond, Fort Wadsworth, New York.

Iron and steel share some physical properties in common, but there are important differences. Wrought iron is tough and malleable, it can be worked easily on a forge or in a rolling mill, and it is strong in both compression and tension, qualities that made it an excellent choice for the manufacture of beams and girders. It was preferred over cast iron in most structural applications. Cast iron is brittle. However, cast iron when molten can take on a variety of complex and decorative shapes, and for those reasons it became a very popular material for the erection of elaborate building facades. It has little resistance to tension loads and breaks easily under impact. Mild steel replaced wrought iron because it was less expensive to produce, had higher strength, and more uniform consistency. Both cast and wrought iron are resistant to corrosion, mild steel is not.



A sheet of non-ferrous metal acts as an impervious membrane between two concrete pours at Battery Pensacola, Fort Pickens, Florida.

The most common non-ferrous metal was bronze; its lubricating properties made it desirable for hinge hardware. Sheets of copper and lead were sometimes lofted into masonry casemate ceilings to divert dripping water, and were also incorporated or retrofitted into concrete construction for the same purpose. As in non-military applications, copper also served well as a gutter or gutter liner. Lead was also often used as packing for rail standards.

Metals in fortifications deteriorate for the same reasons that they do in other locations: challenging environments and insufficient maintenance. Corrosion is the single greatest agent of metal deterioration, and if left unchecked, it can reduce ruggedly-built components in a surprisingly short period of time. The significant amount of exposed metalwork in many large fortifications places staggering demands on the small maintenance staff that is typical of most historic properties. To these difficulties must be added the complete loss of some items due to unfortunate but legitimate salvage as well as less condoned metal-robbing that took place at many fortifications after they were abandoned.

Typical Problems and Treatments

Corrosion

The salt-laden atmosphere of coastal locations, localized acidic rainfall, and generally damp conditions favor the advance of corrosion, which can also be accelerated during periods of high humidity and high temperatures. Corrosion begins with the formation of a film of moisture that actively promotes the deterioration of ferrous metals by serving as an electrolyte. The product of the electrolytic action is a layer of iron oxides visible as rust. If left unchecked, the process of oxidation will continue until the metal is destroyed. In addition to atmospheric corrosion, galvanic corrosion takes place when dissimilar metals are placed in contact with each other; iron and steel can degrade when associated with various copper and nickel alloys.

A wet climate and salt-laden fogs are ideal conditions for the rapid loss of ferrous metals, as suggested by this corroded door at Battery Harvey Allen, Fort Canby, Washington.

Ferrous metals are not equally susceptible. Cast iron because of its high carbon content is more resistant to corrosion than wrought iron or steel. Wrought iron rusts more quickly than cast iron, but because of its slag content, it is more resistant to progressive corrosion. Mild steel as found in most early concrete fortifications is easily attacked by salts, particularly if its carbonation layer is broken (more on that later), and can be so heavily corroded to the point that the material no longer survives. Galvanized iron pipe railings appear in many

When corroded, metal expands to approximately ten times its original volume. The force is sufficient to break and detach surrounding concrete or masonry. Battery Tolles, Fort Worden, Washington.

applications, and often remain in good condition with little maintenance. However, where the galvanizing is incomplete or damaged, such as at threaded ends, rust and corrosion can take hold and reduce the material. If pipe railings are installed so that their uprights fit into sockets in stone or concrete, they are subject to corrosion at the base of the socket, particularly if the lead or sulfur packing is not intact.

Carbonation and Corrosion

It is likely that steel became impacted by carbonation within a short time.

Chlorides in concrete attack and corrode ferrous metal. Unhappily, the use of calcium chloride as an accelerator, the increase of concrete in marine environments, and the introduction of steel as a reinforcing material all occurred at the end of the 19th century just in time to coincide with new fortification construction.

On the positive side, a fine layer of iron oxide and alkaline cement paste protects steel or iron embedded in concrete. The metal will not corrode as long as the layer is unbroken. However, its integrity is threatened by the natural conversion of calcium hydroxide to calcium carbonate, which reduces the steel-friendly alkaline environment. The conversion is called carbonation. If the zone of carbonation reaches the protective oxide layers over the steel, the layer becomes unstable and corrosion begins. If chlorides are present–and they almost always are in early concrete fortifications–the corrosion is much more rapid and causes much greater damage.

The carbonation of concrete takes place very slowly and advances equally slowly from the exterior surface inward. Steel is protected from carbonation-related corrosion if the depth of the concrete is at least two inches over the metal, the concrete is dry (<50% relative humidity), not permeable, and free of defects. These conditions do not obtain in fortifications and other construction until after 1910, when builders, engineers, and scientists gave much greater attention to the causes of corrosion. Because early reinforcing materials in fortifications were placed with little cover or were partially exposed, it is likely that steel became impacted by carbonation within a short time and subsequent chloride attack began with great vigor.

There are simple tests for carbonation, but in the conservation of metals as used in fortifications, chlorides are a more common and more aggressive source of corrosion. Drying the concrete by the application of penetrating sealers may increase the potential for carbonation, but drier concrete will reduce the amount of chlorides in solution, and is thus a preservation strategy worth pursuing.[38]

[38] Grant T. Halvorsen, "Concrete Cover," *Concrete Construction*, (June 1993), 427; William G. Hime, "Chloride-Caused Corrosion of Steel in Concrete: A New Historical Perspective," *Concrete International*, (May 1994), 57-58; Rick Montani, "Concrete's Forgotten Enemy," *Concrete Repair Digest*, (December 1995/January 1996), 331-332.

Solutions for Corrosion

The best solution for corrosion is to avoid the conditions in which it prospers. That means keeping the material clean and dry, with plentiful air circulation, and in an area of low humidity. These are conditions that rarely pertain in fortifications where humidity is often high throughout the year and interiors are often closed. Humidity above 65% promotes the formation of rust, and the bright orange droplets that can appear on iron at humidity levels above 70% indicates active and advanced corrosion.[39]

If corrosion is not already present, industrial corrosion inhibitors can help protect the metal with a durable film that can be removed at a future date when other treatments may be considered desirable. These products typically contain paraffin or other waxes, which accounts for their resistance to weathering. The coating is soft, and is not intended for walking surfaces or items that will be handled. Water displacement products, such as WD-40, were not developed for long-term protection, and they should not be relied upon or expected to deliver good performance in fortification environments. While there are useful products that can prevent metal deterioration, corrosion is well established in most fortifications, and the question must be what to do about it rather than how to avoid it.

Always test products, especially rust converters. Here, several products are undergoing long-term trials (including one that has left a white residue on the surface) Battery Grattan, Fort Flagler, Washington.

Consolidation. Rust and corrosion can be made chemically inert by the application of proprietary products generally classed as rust converters. These products combine with iron oxides in the corroded metal, converting them to iron tannate, which is a more stable chemical compound. An organic polymer is also present to enhance performance as a primer, and some formulations include oxalic or phosphoric acid to speed the chemical reaction. Rust converters need to be painted with a top coat when dry, since without a protective film, they will break down with time and the corrosion process will begin again.

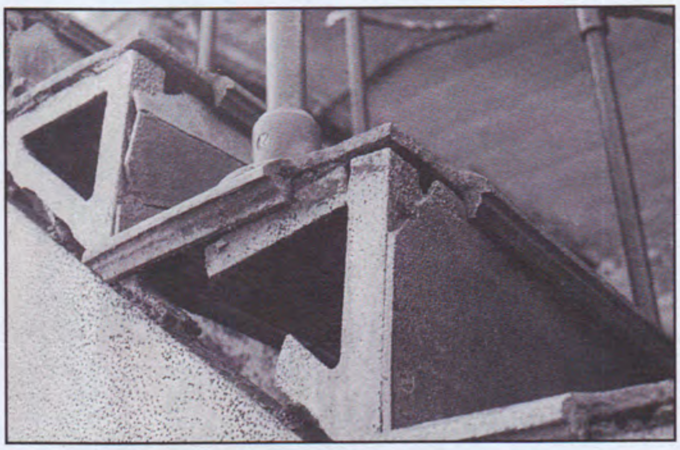
Rust converters could be used successfully in many fortification applications, but the nature of some sites and the condition of some materials may limit their effectiveness. To ensure good adhesion, soluble salts must be flushed away from the surface to be treated, and as identified elsewhere, soluble salts are common in most fortifications. There also must be no oil or grease on the corroded surface. The temperature of the metal should be between 50 and 90 degrees F. That range should not be difficult to obtain seasonally, however most heavy corrosion is in the interior of fortifications, where in the northern latitudes the temperature may not be much

[39] Margot Gayle, David Look, AIA, and John G. Waite, AIA, *Metals in America's Historic Buildings*, (Washington, D. C.: Department of the Interior, National Park Service, 1992), 131; "The Care and Preservation of Historical Iron," Henry Ford Museum and Greenfield Village; webpage; available from http://www.hfmgv.org/research/cis/iron; accessed September 18, 2002.

above the lower end of the scale. Converters are also slow to cure when the ambient humidity is above 75%.[40]

The treatment creates a chemical reaction only; it does not in any way restore the surface. The blue/black appearance of the cured converter and its subsequent painting with a top coat may be objectionable to some because the appearance could be interpreted as a treatment that stopped short of restoration or that significant deterioration was simply painted over. The rough texture of corroded surfaces may be brought to a more uniform appearance by automotive body putty, sanded down prior to the application of the final color coat. Be careful not to sand through the converted layer since it must remain intact to be effective. Finally, rust converters are difficult to apply overhead and they may not bind flakes of heavy corrosion.

Patching. Metals sometimes can be repaired in the same way as masonry by patching in new materials to replace a deteriorated section. The technique is especially appropriate for mild steel, since it is easily cut, welded, and finished. Wrought iron also has these same qualities, although wrought iron in fortification use seldom exhibits a pattern of deterioration for which patching would be the right fix. Because modern steel shapes differ in dimension than those used in the past, patches will be apparent upon close examination, which in itself will help distinguish new work from the historic fabric.



Repairing broken cast iron is difficult, especially if pieces are missing. Fixes include recasting a replacement section or fabricating a new section from appropriate substitute materials. Battery Harker, Fort Mott, New Jersey.

Cast iron breaks easily because of its brittleness, but even when broken elements can be pieced together, repair is difficult. Welding cast iron is a challenge. The job usually involves removing the damaged materials to a workshop where they can be preheated to avoid the creation of thermal stresses inherent with the welding process, and then welded with one of the alloys that are made specifically for the repair of cast iron.

Cold metal stitching is a more successful method. It is most often applied to cracks in cast iron, but it can also be used to attach patches. In this method, the crack is drilled out and replaced with threaded nickel steel pins called locks. The locks have the same coefficient of expansion as iron and bind across the crack. The repaired surface can be ground down to match the surrounding material and repainted to provide an almost invisible attachment.

[40] Susan L. Maltby, "Rust Converters," *Old House Journal*, November/December, 1998; journal on-line; available from http://www.alan.net/prgshoptips/rustconv.html; accessed September 20, 2002.

Mechanical Failure

Metal components can fail if the loads placed upon them exceed their structural capacity. Overloading can take place because of an increase in static or dynamic loads, or by thermal stresses, however the most common cause of overloading in fortifications is the loss of section in load-bearing members. In this case, the failure is the result of corrosion steadily reducing the original design strength of a steel or iron shape so that it can no longer support the original static load. The root cause is almost always lack of maintenance, although the failure of an adjacent load bearing member (or its removal) can also produce buckling or other deformation.

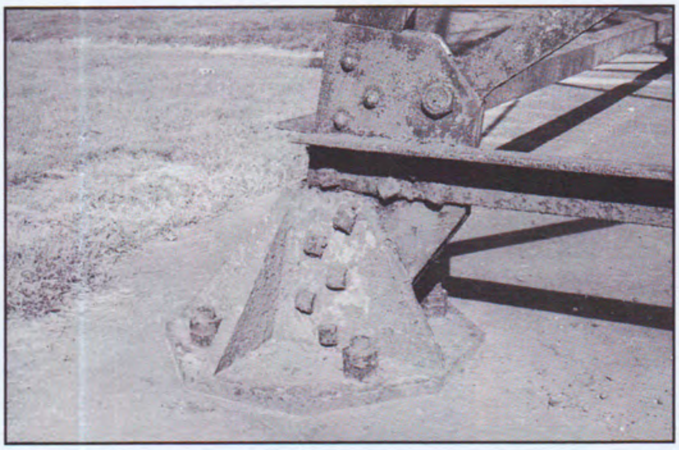
Several causes contributed to the failure of this platform at Battery Cullum at Fort Pickens. Included among them are loss of a supporting column, corrosion-induced loss of section in the beam, and questionable original design detail.

Solutions for Mechanical Failure

Iron and steel that have been distorted cannot be returned to its original strength; it must be replaced by new material of the same appearance, section, and performance as the original. If distortion is not evident, deteriorated shapes sometimes can be strengthened by adding plates to the web or the flange in an unobtrusive manner. The success of the repair is in large part dependent on preventing water from occupying any space between the original material and the reinforcing plate, and both contact surfaces must be prepared with a waterproof membrane.

Connection Failure

Bolts and rivets are the most common type of metal connectors in fortifications, with pins and screws putting in an occasional appearance. Connection failure occurs if the cross section of the connector is no longer sufficient to resist the loads or stresses placed upon it. Loss of cross section is usually due to atmospheric or galvanic corrosion. The best solution for preventing connection failure is a program of regular inspection and maintenance, and the use of replacement connectors (usually stainless steel) to counter the effects of galvanic corrosion.



This cast-iron shoe is the connection for an assortment of stiffener angles at the base of a fire control tower at Fort Mott. It displays a variety of connectors. Loss of section of any components will compromise the structural integrity of the tower.

Solutions for Connection Failure

Connections in fortification practice are either cast iron or built up from steel shapes. While cast iron usually retains its integrity, built-up connections are subject to water penetration and corrosion, and may have to be replaced if they are deteriorated. If the holes in the connectors have become enlarged, but the connector itself is still sound, over-size diameter connectors can be used to re-establish the original strength. The holes in connector components are usually not threaded, and thus retapping should not be necessary.

There is no remedial treatment for deteriorated connectors. Defective connectors must be removed and replaced with new connectors that are compatible with the features of the historic connectors and the metallurgy of the connection components.

Case Study: Steel Doors, Repair, and Rivet Detail

Battery Worth, Fort Casey State Park, Washington

—Heidi Seidelhuber, President,
Seidelhuber Iron and Bronze Works, Inc.

When the Washington State Parks and Recreation Commission wanted to gain knowledge about the safe and appropriate repair of steel doors, it contracted with the same three firms that had successfully restored the well-known pergola in Seattle's Pioneer Square. Anthony Construction, Long Painting, and Seidelhuber Iron were selected because of their proven ability to work sensitively with historic materials. Anthony Construction removed and transported two doors from Fort Casey to Long Painting, where they were grit blasted. Seidelhuber Iron next began the repair, and when that work was complete, Long Painting applied the paint system. Anthony Construction returned the doors to Fort Casey and reinstalled them in their original locations.

The doors of Battery Worth at Fort Casey were built to a common pattern: a plate of mild steel about 3/16 inch in thickness was hot riveted to steel stiffener angles that continued around the perimeter of the plate as well as extending from corner to corner. On the opposite side, two hand-forged strap hinges and a forge-welded sliding latch were also riveted to the plate. The hinge straps had a distinctive taper that could only be duplicated by forging, and they were also interesting from another aspect. Once the heavy paint layers had been removed, we could see that each hinge had been stamped with a number that corresponded to the same number on the plate. That meant that each hinge had been fashioned for one particular door, and that the doors had not been assembled from mass-produced components.

Brackets had been welded to the doors at some time in the past to hold them in an

Figure 1. To remove each door, a block of wood was placed beneath the lower hinge. It was then levered upward until the hinge pins were free of their sockets.

Figure 2. The door was lowered down to rest on wooden sleepers that had been positioned to receive it. The lighter color on the back of the door is the surviving layer of red lead.

Figure 3. Using heat to loosen a frozen nut. Safety equipment was necessary because of the potential of lead paint hazard.

open position, and the brackets were attached to the concrete with threaded fasteners secured by welded nuts. The welds were broken and the nuts removed. In one instance, the nut was firmly rusted in place, and heat was used to loosen it (Fig. 1). Anthony Construction removed the doors by applying penetrating oil to the hinge pin and working the door slightly until it had some free motion. The door was levered upward until the pin was clear of its socket (Fig. 2), and then it was lowered to the ground by four workers; we estimated that the door, which was seven and one-half feet high, weighed about 225 pounds. Although the back of the door had not been painted in decades, the red-lead primer was still intact and prevented the spread of the corrosion that had destroyed the bottom edge (Fig. 3).

At Long Painting, the doors were treated with Sandblast SSPC-SP-7 to remove the paint layers. When the doors arrived at Seidelhuber iron, we removed the bottom 10 inches of both doors to get to sound metal. We then welded in new plate and angles of similar dimension (Figs. 4 and 5). The heat generated by welding caused the doors to warp slightly, although the doors were significantly warped before the welding began. The warpage on the unrestored doors was caused in part by corrosion between the faying surfaces. This uneveness was enough to bind the door slides, and explains why they were not operational. The doors were straightened before the rivets were installed (Fig. 6).

Figure 4. New steel plate being welded to an original door to replace the corroded section that has been removed.

Since the tools and skills required for hot-rivet fabrication rarely exist in modern construction trades, we devised a way of recreating the look of hot rivets while using a mix of historic and contemporary techniques. The method should be within the scope of modern steel shops

Our first step was to pre-punch the stiffener angles with twice as many holes than were required. Every other hole was plug welded to hold the angles snugly in position for riveting (Fig. 7). Holes were then punched in the door plate so that we could insert the shaft of the mushroom-shaped rivet. Extra rivet heads were drilled to receive the rivet stems (Fig. 8), and the joint between the two was welded. Each new rivet was heated and dressed so that its shape matched the distinctive truncated cone shape of the original (Fig. 9).

Figure 5. The weld was ground flush with the existing steel plate.

As work progressed, we noticed a small hole in the front of the plate, the result of corrosion that had developed between the plate and the stiffener angle. The hole and the gap between the plate and the angle were filled with Devoe Deumat 142HB caulk.

Long Painting finished the doors with 3 mils of Devoe 302 epoxy zinc primer, 5 mils of Devoe 235 epoxy, and 1.5 to 2 mils of urethane topcoat. The final topcoat was to have been Devoe 4208 water-based topcoat, but urethane was selected because of its rapid cure time. The faying or contact surfaces between the sliding latch and the door plate were painted with Catha Coat 302 primer only since the full paint system would have prevented movement. Faying surfaces should be maintained with oil.

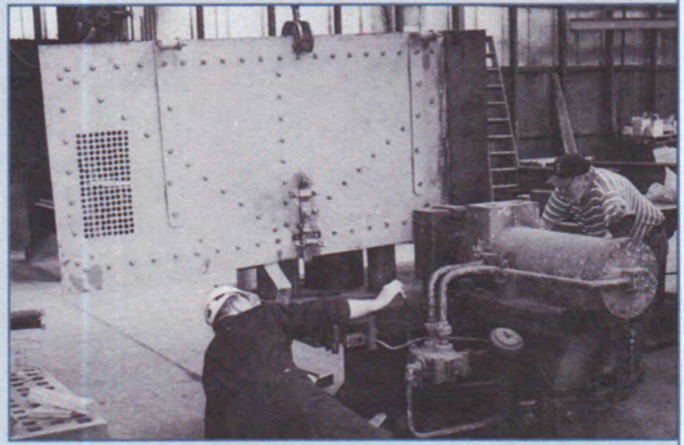


Figure 6. An hydraulic press was used to straighten each door so that new rivets could be fitted to the repair section.

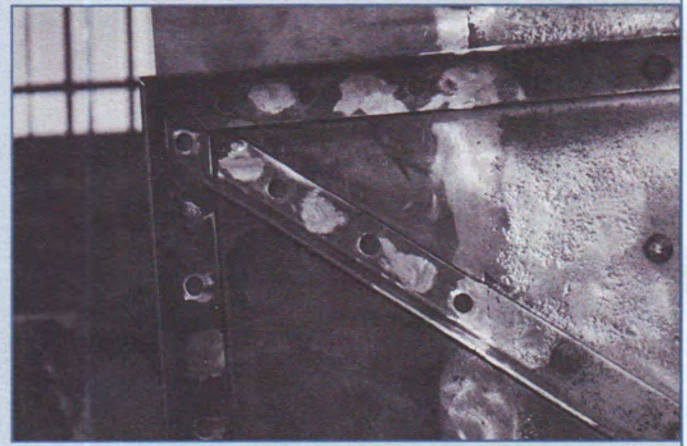
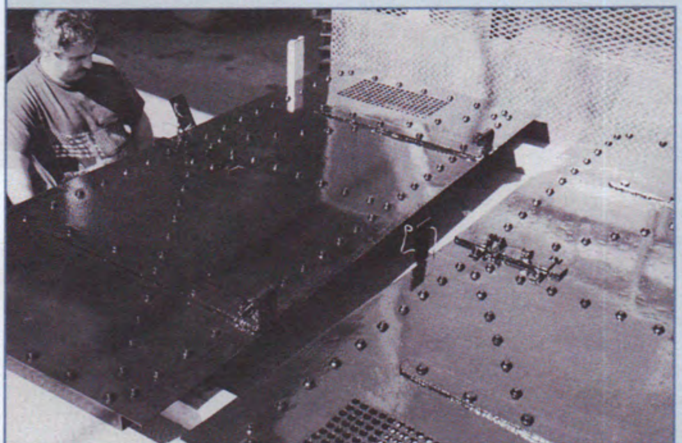


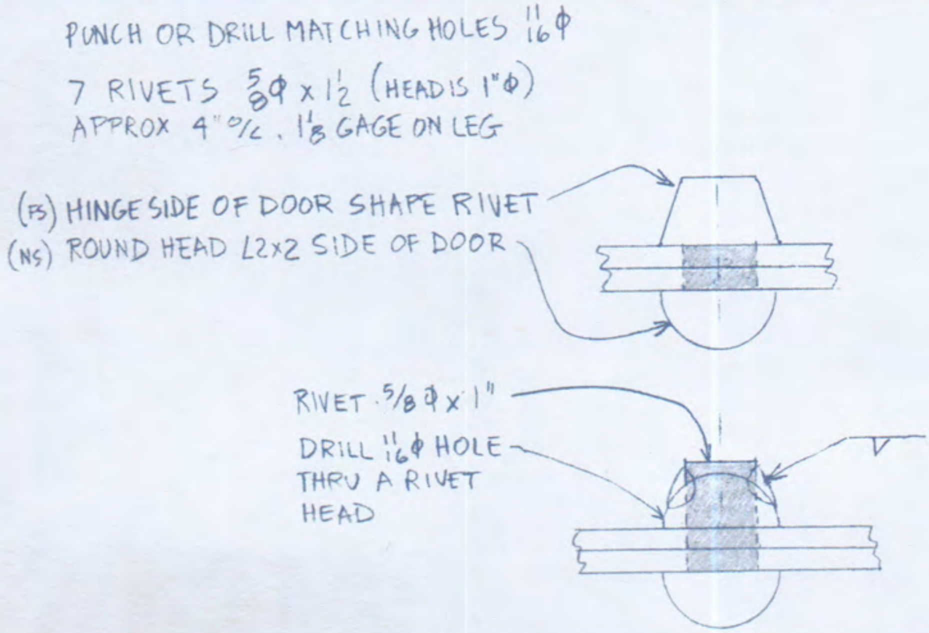
Figure 7. New plate and stiffener angles in place with original door to the right. Every other hole in the stiffener angle has been plug welded to ensure tight contact with the plate.

Figure 8. The process of duplicating the appearance of hot rivets began by drilling out the stem of one rivet (shown here on the right) so that it would fit over the stem of another rivet (left).

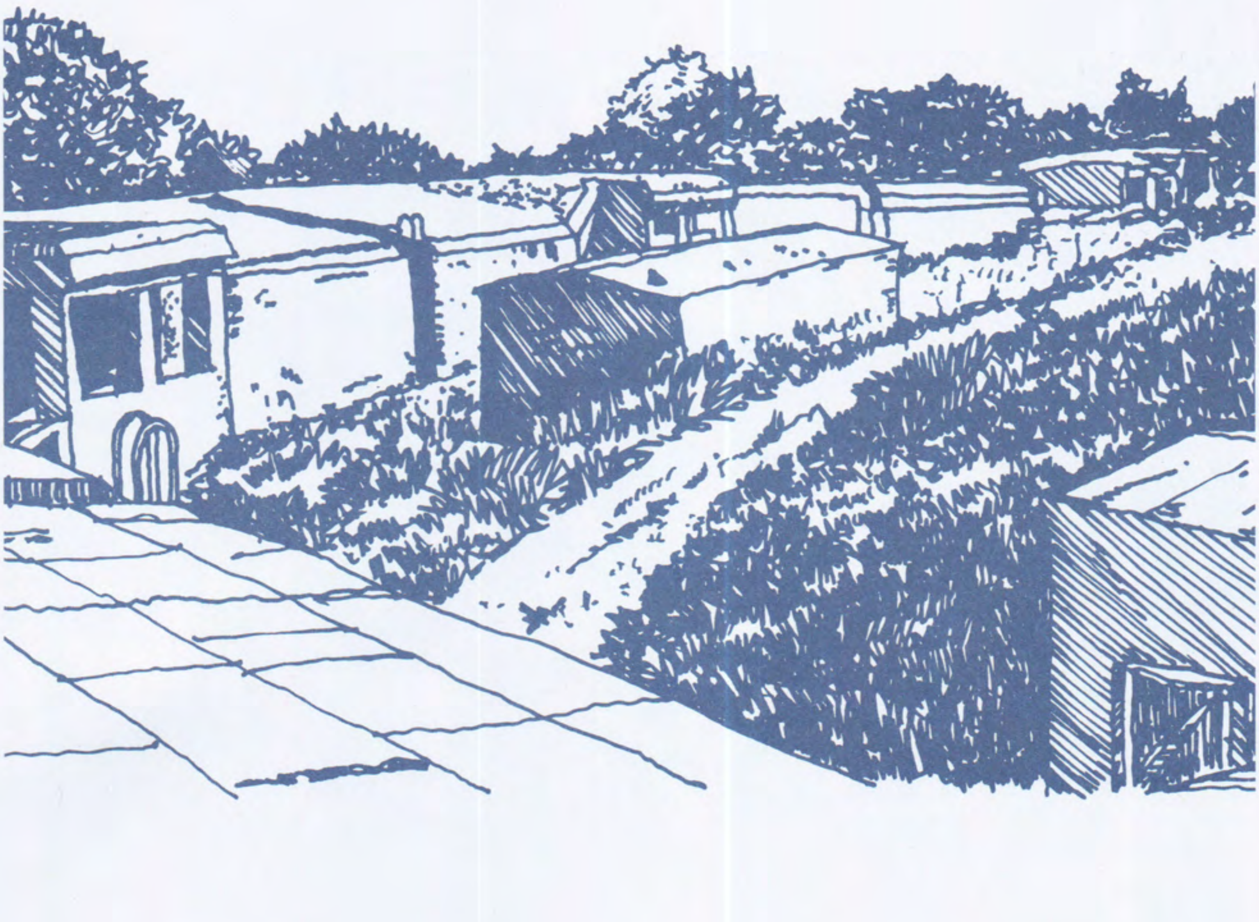
Figure 9. The two rivet elements were welded together and then shaped to the configuration of hot rivets.



The completed doors ready to be returned to Fort Casey and rehung in Battery Worth. Seidelhuber Iron photo.



Part Four: Managing the Resources



Toward Common Goals

The previous sections of the *Handbook* have approached fortifications in terms of their significance and their construction materials. This section brings much of that earlier information together with another important component: people. People as the managers, property owners, caretakers, visitors, or supporters of any historic resource are the fundamental element of success.

Washington state park manager Mike Zimmerman outlines measures to improve the appearance of the historic landscape at Fort Flagler.

Managers and property owners make decisions about the future of fortifications. Through the knowledgeable actions of caretakers and maintenance workers, character-defining features survive so that others can enjoy them. Visitors benefit when they have the opportunity to experience a fortification whose integrity is intact and whose interpretation is meaningful. Visitors turn into supporters when their experiences motivate them to become involved in the present well-being of the site, and often their activities can have positive results that are far reaching. Visitors and supporters influence managers, property owners, and other decision makers. This section emphasizes the need for effective connections between all of these people toward the common goal of preserving, using, and interpreting historic fortifications.

Those who work on-site themselves have considerable practical experience in the day-to-day business of operating a former fortification as an historic resource. The perspective of private property managers is often different than their public counterparts, but it is a difference based on subjects of emphasis rather than a point of view that is explicitly antithetical. Given the knowledge that this group represents, we have added the remarks of a particular manager as a preamble to each of the sections below. The author is Ken Hageman, who has been the manager of Fort Casey State Park in Washington for more than 25 years. That substantial period of time makes Ken the longest serving person at Fort Casey in all of its history, and his insights add a commentary that is of value in other locations.

Maintenance and Documentation

"The maintenance of these unique facilities is the responsibility of not only the park and supporting administration, but the public as well. The main responsibility, realistically, rests on the park manager and park staff. If they are willing to accomplish the planned maintenance requests and are willing to get started on projects that can increase the life expectancy of the facility, then improvements in preventive maintenance can be accomplished. The important thing is to just get started. Too often the immense workload and number of projects needing attention can be discouraging. . .never let the lack of funding be your excuse to not start a project–find the money."

No preservation action is more necessary and more ignored than preventive maintenance and its cyclical application. There are several reasons, among them a limited number of hands to carry out a large number of maintenance tasks and the assumption that concrete and masonry structures can do without a regular program of care. It doesn't have to be that way. Once an annual preventive maintenance schedule has been established for all or part of a fortification, many of the tasks can be done quickly; frequently they can be completed by volunteers.

No preservation action is more necessary or more ignored than preventive maintenance.

The first step is the creation of a Preventive Maintenance Schedule. It is a partner of the Historic Fortification Field Form – Features Condition that was introduced in Part Two, but it has a different function. The Features Condition Checklist is an inspection form. It is a method of identifying specific problems that, if left untreated, will contribute to the deterioration of the resource. The Preventive Maintenance Schedule establishes a routine that helps avoid the creation of problem conditions; think of it as a guide to a healthy lifestyle for historic fortifications. It emphasizes the importance of keeping building systems working, especially those that move water away.

As with the Historic Fortification Field Form, the Preventive Maintenance Schedule has to be sized to fit the resource. The area covered by the schedule has to be large enough to incorporate the key building systems, but not so large as to make implementation difficult. For a small masonry fortification, it will be enough to prepare Preventive Maintenance Schedules that are based on walls and bastions; the walls of larger fortifications can be subdivided into ranges of casemates. The battery is the natural subdivision for concrete fortifications, since it is usually comprised of no more than two or three emplacements. Maintenance schedules also need to be prepared for free-standing structures such as fire control buildings or searchlight shelters. A sample form on page 4.4 gives a suggestion about how the form could be organized.

There should be a Preventive Maintenance Schedule for every Historic Fortification Field Form. These documents are the foundation for an on-going property record. With the addition of Project Completion Reports, the repair record of any fortification becomes a part of the permanent library of actions that detail the life of the structure as an historic resource. Equally important is the availability of the documents and provision for their long-term care. Since our interest is in maintaining stewardship well into the future, all who work with the fortifications need to know where the documents are, how and when to use them, and be willing to add to them as new actions take place.

It is not likely that all of the documents will be created. The Historic Fortification Field Form or similar inventory aid should be completed for all historic properties, but only a few will be the subject of the remaining titles such as investigative research reports or plans and specifications. The number of documents can be confusing. To help keep things straight, there are two guides at the end of this section. The Document Summary briefly explains the use of common documents and where they are described in this text. The Preservation Process Diagram connects the documents to several key steps in the treatment of an historic fortification.

Maintenance carries with it some cautions, particularly in regard to the use of equipment. The discussion of vegetation management in Part Three noted the potential disadvantage of bringing mowers to a terreplein; it could impact the soil through possible compaction as well as erosion. The same is true for other motorized equipment. It can be a temptation to develop informal service roads to provide a quicker way to reach a work area, but the practice reduces the integrity of the historic landscape. If the road crosses an earth feature such as a parapet or slope, it can also promote the erosion of a significant feature. String trimmers can cut into brick and stone, and some types of concrete as well. The message here is to use only those maintenance tools and practices that will not damage any historically important aspect of the fortification.

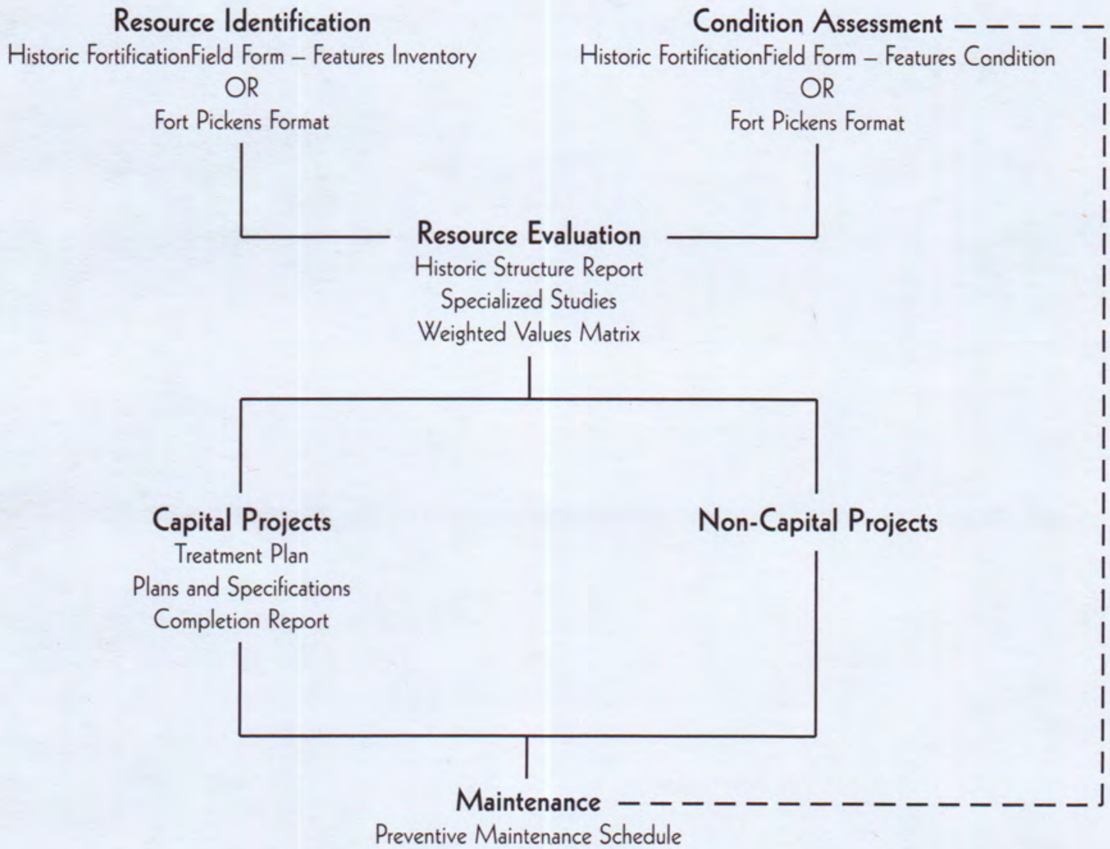
Historic Fortification
Preventive Maintenance Schedule

Location ____________________ **Resource name** ____________________

Schedule prepared by ____________________ **Date** ____________________

Element	Action	Date Completed	Time to Complete
Site			
	Trim back any encroaching plant growth		
	Clean gutters and remove obstructions		
	Test drains and confirm that they are free-flowing		
Exterior			
Horizontal surfaces	Clean away organic matter and debris		
Horizontal surfaces	Clean and flush drains and leaders		
Vertical surfaces	Remove plant matter, especially from cracks		
Vertical surfaces	Treat graffiti with previously approved method		
Steps and walkways	Clean away organic matter and debris		
Doors and shutters	Lubricate hardware		
Doors and shutters	Treat graffiti with previously approved method		
Wood or metal work	Treat surfaces with previously approved method		
Ventilators/openings	Clean away debris to maintain operation		
Interior			
Horizontal surfaces	Clean away organic matter and debris		
Horizontal surfaces	Clean and flush drains and leaders		
Vertical surfaces	Treat graffiti with previously approved method		
Steps and walkways	Clean away organic matter and debris		
Doors and shutters	Lubricate hardware		
Doors and shutters	Treat graffiti with previously approved method		
Wood or metal work	Treat surfaces with previously approved method		
Ventilators/openings	Clean away debris to maintain operation		
Conditions Noted but Not Corrected			

Preservation Process: Using Basic Documents



Document Summary

Document	Use	Discussed in Part
Historic Fortification Field Form – Features Inventory	Identifies character-defining features	Two
Fort Pickens Format*	Identifies character-defining features	Two
Historic Fortification Field Form – Features Condition	Identifies physical condition of features	Two
Fort Pickens Format*	Identifies physical condition of features	Two
Investigative Research Reports (historic structure reports, technical analysis, other research studies)	Summarizes history and physical development of resource or its historic fabric	Three
Weighted Values Matrix	Helps determine relative resource values	Three
Plans and Specifications	Describes the exact work to take place	–
Completion Report	Summarizes work accomplished under plans and specifications	–
Preventive Maintenance Schedule	Outlines basic maintenance steps	Four

* The Fort Pickens Format refers to the documentation methods developed by the National Park Service for use at Fort Pickens; the methods are described in Part Two.

Managing for Multiple Uses

"We are stewards of both cultural and natural resources, but how do we balance the management? We sometimes must ask what we are willing to give up to preserve or protect a resource. This is not an easy decision, but one for which we must take the responsibility. Here field staff often have the best knowledge of the existence of the resource if not always total expertise of the subject; it also has the best knowledge of use patterns, public comments, questions, and interests.

"Multiple use of these two resource types on a single site is certainly possible. What is needed is input from qualified staff for both natural and cultural resources, and the willingness to approach joint management.

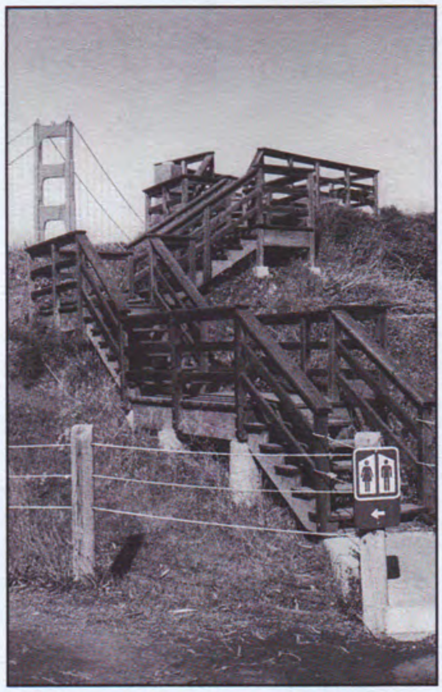
"While it is our responsibility to manage all the resources in our park, we must accomplish it through asking the right questions and asking for the right assistance. Let's not get in a situation where through ignorance we make the wrong decision, and find as someone once said, 'Let no one say, and say it to your shame, that all was beauty here before you came.'"

Although most fortifications in public ownership have been set aside in recognition of their historic qualities, it does not always follow that their use is restricted to those activities that center on the past. Many fortifications occupy large tracts of land. Since most permanent fortifications in North America were located on the seacoast or major waterways, the acreage now has enormous appeal for many types of recreation. Swimming, fishing, boating, camping, kite and model airplane flying, hiking, and biking are common activities in the vicinity of many fortifications. Are these recreational activities appropriate for an historic resource?

As is often the case, the answer is "it depends." What we are looking for is a harmony that allows the historic character of a fortification to guide activity within its setting. If fortifications are to be managed to emphasize their historic values, then much of what we consider recreation must take place somewhere else. Playing Frisbee on the terreplein or parade intrudes upon the historic character and diminishes the quality of the resource for as long as the game continues. For those moments, it becomes less valuable for those who want to gain a sense of the fortification as a structure that can tell us something about our past.

Trails should never cross historic earth features; it is an inappropriate use and encourages erosion. It is almost always a better choice to stay with original circulation patterns. Fort Casey.

Some administrators of historic properties, notably Parks Canada and the U. S. National Park Service, have guidelines for the types of activities that are appropriate in the vicinity of historic buildings, structures, and districts. Recreation other than participating in the resource as an historic property is directed elsewhere in favor of maintaining a sense of place that is a key value of the site. A commitment to stewardship establishes the prominence of character quality as a fundamental standard against which other uses must be tested.



While a stairway may be a better way to avoid eroding an historic slope, the design needs to be consistent in scale and materials with the resource. Fort Scott, California.

A sense of place or character quality is more difficult to define than the idea of character-defining features discussed in Part Two. In some ways, it may be easier to see when considering the impact of people on the natural environment; there is a contemporary sense that the unspoiled and intact landscapes of the natural world are themselves a standard to be maintained. That same idea has not made a complete transition to historic properties. Part of the reason has to do with the differing perception of historic and natural resources. Buildings and structures are intended to be used or visited by people, and the inevitable wear and tear that is expected in any building, historic or not, falls under the well-understood practice of maintenance. People are also visitors to the natural world, but they bring to it an enhanced sense of stewardship that heightens awareness of and sensitivity for visible changes that have a human source. The question of character quality for the natural environment runs along the lines of determining the degree of impact that an area can sustain before the resources themselves are adversely affected or the quality of the visitor experience is diminished.

There is no true counterpart for historic properties, particularly when it comes to the concept of diminishment of the visitor experience. Visitors to a successfully maintained and interpreted fortification are going to leave with a much different impression than if they had visited a similar site whose grounds had been adapted for gardens, walks, and picnic sites, and whose precincts are the home of parking lots and new structures that serve purposes not associated with the historic site. Part of the equation is that most visitors will not know the difference because of their limited exposure to fortifications as historic resources. If we had a definition for character quality that fit historic fortifications, there could be more guidance for use and reuse. As it is, our option is to rely on the definitions of character-defining features that are laid out in Part Two. Those definitions favor building elements over the recognition of character because building elements are much easier find, yet character is the basis for satisfactory visitor experience. Sense of place or historic character remains an elusive element, but all historic properties have it, and our ability to recognize it and manage it in a way that sustains it is part of the charge of treating fortifications with the same regard that we have for other resources.

Our efforts at preservation and interpretation benefit when visitor activity is in balance with the historic character of the resource. Visitor activity and resource management also need to consider the natural environment and its place within the cultural context of fortifications.

Military planners favored large reservations, although they were not always able to get them. When fortifications occupied only a portion of a military post that contained hundreds or perhaps thousands of acres, or when the reservation occupied a distinct parcel such as an island or well-defined headland, much of the property entered into something of a fixed state. Those that had no business with the military were excluded, and military construction tended to concentrate in small areas within the greater acreage. Development continued outside the reservations, and today the former defenses are often the only unaltered examples of the earlier landscape. As a result, they are also often home to rare, threatened, or endangered plant and animal species. Some of these locations are closed to casual visitors. For example, Fort Michie, at the eastern entrance to Long Island Sound, is now a wildlife refuge and research station, and entry is carefully regulated. For the most part, however, the protection of significant aspects of the natural environment takes place side-by-side with the efforts to protect aspects of the built environment, with the understanding that public access is frequently the reason that undergirds management decisions about the property.

A view of the water is an important element of all coastal fortifications. In the years that have passed since the end of their military value, both native and introduced plant materials have often prospered in their vicinity, and in some cases, prospered to the extent of eliminating the view entirely. Re-establishing the visual connection is fundamental to any interpretive program, as is emphasized in the following section on interpretation, and that can mean potential conflict between the preservation and interpretation of the historic property and the continued integrity of the plant material and habitat. It also can mean changes that enhance both interests, as demonstrated by the accompanying case study describing the propagation of the Golden paintbrush at Fort Casey, Washington. Included in the appendices is a research report that was undertaken to help understand the extent of historic tree cover and the degree of alteration of landforms at Fort Flagler. The report is an example of how historic materials can inform present-day decision making and how they can support conclusions that are enduring and defensible.

Tree and brush removal in front of Battery Calwell at Fort Flagler has helped restore its historic appearance.

Case Study: Co-Management of Cultural and Natural Resources

Fort Casey State Park
Whidbey Island, Washington
— Robert Fimbel, PhD, Stewardship Program Manager, Washington State Parks

Golden paintbrush (*Castilleja levisecta*), a federally threatened plant species, occurs at nine sites in Washington including Fort Casey State Park. This shade-intolerant, perennial herb establishes from seed and is estimated to live approximately five years. In the park, the paintbrush population appears to be in decline because of habitat loss and grazing by wildlife.

Golden paintbrush has grown in the main battery field of fire, which was constructed from fill before 1900.

Historically, the landscape in front of the main battery at Fort Casey was maintained in an open grassland condition by mowing or grazing. The military reduced maintenance of the area in World War II, and with the transfer of the facilities to State Parks in 1955, further reductions in mowing operations lead the invasion of many of the grassland areas by native rose (*Rosa nutkana*) and snowberry (*Symphoricarpos albus*) shrubs. This successional process degraded the quality of the Golden paintbrush habitat and reduced the integrity of the significant cultural landscape. At present, Golden paintbrush is restricted to the edge and face of the coastal bluffs, where grasslands are still the dominant vegetation community.

Rob Fimbel, Stewardship Program Manager for Washington State Parks, and other scientists establish a study area. The main battery is behind the brush in the distance.

To reverse the declining Golden paintbrush population trend at Fort Casey, biologists from Washington State Parks, the Washington Department of Natural Resources - Natural Heritage Program, and The Nature Conservancy worked with State Parks historic preservation specialists to identify vegetation treatments that enhance both the Golden paintbrush and the landscape in which it occurs. Using historic and recent aerial photographs, scientists have established the approximate extent of the grasslands during the fort's active period. Within this historic grassland landscape, efforts are currently underway to reverse the successional process by brushing back shrubs and small trees. Initial results are encouraging, suggesting that grasses and forbs quickly colonize the treated areas. Trial exclosures for rabbits and deer, the principle species to graze Golden paintbrush, have reduced the animals' grazing pressure in the wake of the shrub (cover) removal. In addition, trial controlled burns and mechanical duff removal treatments have been initiated, mimicking on a much smaller scale the grassland conditions created in the wake of wildfires that may have been more common in the early 20th century. These latter efforts seek to create desirable seedbed conditions for the establishment of Golden paintbrush. Scientists are presently assessing the contribution of these and other treatments to reverse the decline in Golden paintbrush at Fort Casey State Park.

Clearing 6.5 acres of brush away from the main battery helps reestablish the historic appearance of the main battery and raises hopes that the Golden paintbrush population can establish itself above the minimum viability threshold.

The treatments underway at Fort Casey appear to be a win-win situation for habitat conservation and cultural landscape preservation. In a few years, staff at Washington State Parks hope to have fully restored the historical grassland landscape in front of the main battery, and by doing so, recreate abundant habitat for the expansion of Golden paintbrush.

Interpretation

The following material has been prepared by John Martini, a former National Park Service employee who has extensive experience in the interpretation of fortifications. The terms used here, such as kiosk and wayside, topic and theme, may have a different meaning to those who are interpreting fortifications outside of the NPS. Terminology differences aside, his perspective in widely applicable.

Interpreting coastal defense structures is a challenging task for most parks, especially because the empty fortifications offer little clue as to their original use. To many visitors, the batteries' hulking concrete presence conveys some vague sense of the military past, but there is little to explain the history of the fortifications or to put them into historic context. Perhaps as a result, many visitors believe that the concrete "bunkers" were all built during World War II. The Army's late-1940s disarmament program was so thorough that only a handful of coast artillery weapons have survived, and modern attempts to interpret fortifications are immediately hamstrung by the lack of artillery pieces and the vast array of specialized equipment that once supported them. Without their armament and furnishings, the empty batteries and support buildings give little indication of their age, their original use, and sometimes even their defensive origin.

When the original setting is destroyed or altered, the reason for the existence of the defenses becomes even more obscure.

In many cases, the settings have also been compromised over the years. Vegetation has reclaimed many of the installations, especially along the Pacific Coast where entire batteries have been engulfed by forests. When this occurs, the installations are frequently separated visually from the sea areas they once protected, and the visitor loses all sense of the batteries' tactical positions. Later-era construction has resulted in some fortifications being modified to the point they are no longer recognizable as defense structures, and in a few seaside communities, entire batteries have been demolished to make way for residential construction. When the original setting is destroyed or altered, the reason for the existence of the defenses becomes even more obscure.

The challenge, then, is to find creative ways to interpret these resources for visitors through a variety of preservation efforts and educational media and services. The discussion here covers some of the methods used in interpreting coastal fortifications, giving special attention to working with a minimum of resources. Practical examples and illustrations are included (both successful and not so successful) to illustrate techniques used by other parks in attempting to tell the story of their defenses.

Helping Visitors Understand the Sites

Most parks don't have the luxury of inheriting well-preserved coastal fortifications complete with weapons, equipment, or even a track record of good maintenance. The opposite is true, and the abandoned fortifications have suffered from decades of neglect and outright abuse. Railings are missing, undergrowth obscures earthworks, trash litters the abandoned magazines, and electricity and running water are only distant memories. These decrepit conditions both communicate a poor image to the public and also detract from a real understanding of the fortifications and their history.

The first steps in interpreting coastal fortifications should focus on basic maintenance, preservation, and safety: remove debris and intrusive vegetation; clear clogged drains; scrape and paint rusted metal surfaces; eradicate graffiti; replace missing hand railings; close off hazardous interior spaces; and perform other basic housekeeping and safety projects. Not only are these actions wise preservation measures, they also begin to convey to visitors a sense of the original condition and appearance of the structures.

Interpretive opportunities should be considered early in this preservation process. When planning interpretive media for coastal fortifications, try to envision the site the way a casual visitor might first view the resource. Then try to anticipate their subsequent questions and needs for additional information.

One basic method of interpreting an historic structure is simply to point out what it is, and in the case of coastal fortifications this includes giving the batteries back their proper names. The Coast Artillery had a standing order that every battery have a name board affixed to it, and signs with the battery's name painted in large block letters were usually posted on the rear of such structures. These signs are easy to replicate today, and provide both a level of historic restoration as well as interpretive information. The military term 'gun battery' is well known to the public, and a visitor's chance encounter with a large sign reading "BATTERY GODFREY" conveys a quick overview of a building's purpose. If these signs inspire visitors to ask questions such as 'how old is it?' or 'why was it built?' then so much the better. Provoking additional questions is one of the goals of interpretation.

Specialized interpretive signs are frequently installed around fortifications that relate the story of the fortification in greater detail. These often include maps and photographs along with a historic narrative. These interpretive signs can take several forms, but the most commonly found form are wall-mounted panels, free-standing upright panels sometimes called kiosks, and waist-high angled panels known as waysides. Any type can easily be installed at historic fortifications, but care should be taken when positioning and installing these signs. Keep in mind that these are historic structures we are interpreting, and avoid damaging them at all costs.

With tourism from other nations becoming more common, it is often desirable to have interpretive materials available in several languages. Fort Rodd Hill.

When planning locations for exhibits, try to intrude as little as possible upon the historic landscape. In general, exhibit panels that are set into the ground or are attached to moveable bases are preferable to attaching signs to historic walls. If a wall surface is determined to be

Case Study: Interpretation
Fort Mott
Pennsville, New Jersey
— Alicia M. Bjornson, Resource Interpretive Specialist, New Jersey State Park Service

Education and historic preservation go hand in hand. The future generations that will be responsible for the stewardship of our cultural heritage need positive, exciting experiences that offer involvement and interest. Often school field trips provide this forum. When children have a great time, they will bring their families back to share their experience. Conversely, interested families suggest programs to teachers.

When I first began at Fort Mott, there was a single basic tour. Over the years, we have developed additional tours and programs: a Basic History Tour, Technology Tour, Artifacts Program, and Signal Flag Program. Some living history consultation was provided by a private contractor. The Signal Flag Program was initially developed to dovetail with near-by Fort Delaware's interpretive programming. However, timing, weather conditions, and staffing sometimes posed difficulties. The program was then done in-house. Tour groups were divided and moved to a line-of-sight position. A colleague, Andres Grant, worked on developing a system to facilitate the translation and sending of flag code.

To supplement these offerings, over 50 interpretive signs have been placed along the walking paths. The signs provide detailed illustrations and plans of the fort, weaponry, and soldiers. Included are important statistics about each of Fort Mott's artillery pieces, as well as biographical material related to the battery names.

Working partnerships are essential when discussing interpretation at the fort. The last decade has shown a clear increase in annual attendance as liaisons with partner organizations have matured. One example is the creation of a teacher's kit in collaboration with Fort Hancock, a National Park Service historic property also in

This rehabilitated hoist gives visitors a demonstration of how technology was used to lift heavy ammunition up to the guns.

Tours at Fort Mott

The **Technology Tour** takes visitors through the fort to highlight innovations: reinforced concrete and other construction technologies, electricity, guns and equipment, and the latrines (where the new-fangled flush toilets were located).

The latrines have even been their own program (**Two Heads are Better Than One**). Little kids and adults as well are fascinated by the bathrooms. Officers had a door on their toilets/urinals while the enlisted men had none—the enlisted toilets and urinals are all located in a small unpartitioned room.

Electricity in Forts is a program that explains early developments in electrical power, including the advantages and disadvantages of direct current versus alternating current. Visitors can see the locations of old lamps, light fixtures, and storage battery rooms, and even examine artifacts. They can compare their experiences today to those of a soldier stationed at the fort.

The **Artifacts Program** is an indoor program. This lesson works well with younger audiences or during inclement weather. The collection at the fort has pieces of the fort: metal, power cable, glass, tools, architectural elements, as well as found objects. Preservation is a large part of this dialogue. Why do we keep these items? What can you tell us about them? Some items here offer great hands-on opportunities. My favorite artifact is a 12-inch shell that was excavated during the renovation of the pier.

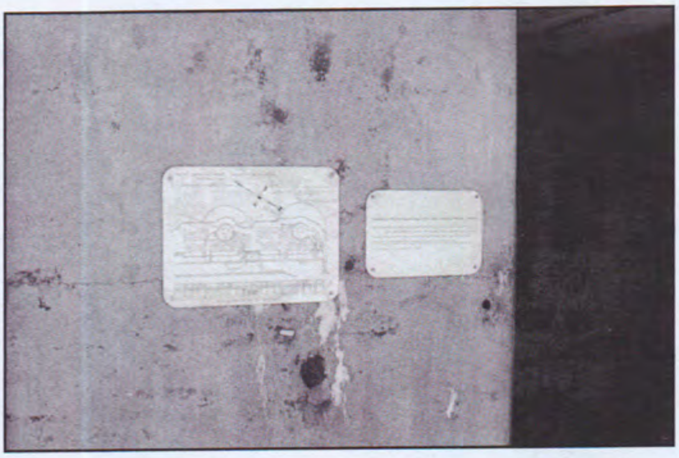
A teacher's kit contains objects, photographs, and written documents to help prepare students for a trip to Fort Hancock, another coastal fort in New Jersey.

New Jersey. The kit was an outgrowth of the federal "Parks As Classrooms" program. It supplements school curricula, and offers pre-visit, visit, and post-visit activities. In addition, as demands on the interpretive program have increased, the efforts of our volunteers in program development, interpretation, and support functions have been crucial to our growing success. Notable among these are the Friends of Fort Mott, an independent nonprofit organization that conducts events and raises funds in support of the park. The community outreach efforts that the Friends provide allow local citizens to actively participate in a park experience and to expand the park audience.

The New Jersey Coastal Heritage Trail (NJCHT) is a great example of a successful partnership. The Trail is a 275-mile automobile tour with a unified central theme. It highlights New Jersey's coastal defenses, commerce, agriculture, industry, navigation, and natural resources. The Division of Parks and Forestry (DPF), local sites (both publicly and privately operated and maintained), and federal agencies pooled their resources and efforts to implement the Trail. Fort Mott State Park, which is the southern "anchor" of the Trail, continues to benefit from the enterprise. The NJCHT Welcome Center began with joint support from the State Park Service and the National Park Service. The NPS expressed an interest in converting the vacant ordnance building to serve as the center. The agency worked with DPF staff to create exhibition space, video theater, information center, and office space. In 1993, the NJCHT Welcome Center was dedicated, and since then, it has grown to include a larger exhibit space, wheelchair-accessible ramp, and gift shop.

As visitation and services at a site increase, it is important to develop a solid interpretive plan to provide a template for interpretive and educational objectives. These can be useful and drive future capital improvements. Several years ago, the exterior of the post headquarters building was stabilized, and eventually the interior will be rehabilitated. Recently we completed the restoration of one of the two fire control towers at the fort, adding an unusual feature to our collection of interpretive assets. Transportation of visitors needs to be considered, since the fort is 104 acres in area. A video that will provide an introduction and orientation, as well as the history of the installation, is a future project. Rotating exhibits need to be developed to encourage return visits.

Stairways connect different levels of Fort Mott. At the head of the stairs is one of the many interpretive signs in the park.



Signs bolted directly to a wall at Fort Casey. A preferred alternative would have been to attach the signs to non-intrusive brackets or freestanding bases.

the best location for a panel, attach it by means of clamping it to some existing surface. At all costs, avoid damaging historic fabric by drilling into it, using powerful adhesives that could harm the surface, or welding to historic metalwork.

Try to locate the exhibits so they don't look out of context within an historic battery, such as in the dead center of an open loading platform. Setting the panels a few feet off to one side can be equally as effective. Don't worry; visitors will still find them. When installing concrete bases for wayside or kiosk displays, avoid digging into the sculpted earthworks that surround many of the batteries and support structures. These carefully designed landforms are important character-defining features, and just as significant as the concrete or masonry parapets and platforms of the batteries.

Here are some ideas to keep in mind when planning basic interpretive signage:

Are the fortifications clear of vegetation so that the views, vistas, and geographical setting are understandable? As mentioned previously, clearing accumulated undergrowth is a wise choice that also makes the fortifications more understandable to visitors. Heavy vegetation not only obscures a battery, but it can actually isolate it from its historic setting. Once these "fields of fire" are reestablished, the structure's tactical relation to coastline and other nearby fortifications can be interpreted to visitors. Also, a well-maintained structure tends to discourage such illegal activities as vandalism and graffiti.

Do the structures give any indication of their original use? If not, consider simply erecting interpretive signs identifying the batteries or replicating the original wooden name boards as described previously. If resources allow, install generic panels telling the overall story of the area's defenses together with additional panels describing the history of the individual fortifications.

Can visitors explore the structures safely? Visitors have a natural curiosity about the fortifications and, if at all possible, should be allowed to explore them. However, always consider safety before opening new areas for visitation. Safe access can usually be achieved through simple actions such as replacing missing railings, closing off unlit interior spaces, keeping walkways and stairs in good repair, and removing hazardous materials. If a structure is so dangerous that it must be fenced off completely, then post signs informing visitors of the reason for the closure.

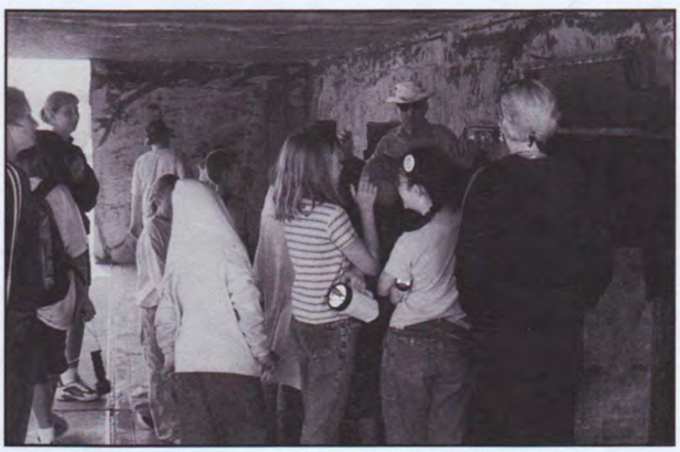
Is there an indication of where to go to learn more, such as a visitor center or museum? Visitors will often seek out additional information once their initial curiosity is satisfied. They may ask questions of the first staff member they encounter (maintenance workers usually get the brunt of these questions) or go hunting for additional interpretive exhibits. Even if your budget doesn't permit extensive on-site displays, at least make sure there are directional signs showing the way to the park's information or interpretive center.

Guided Tours and Programs

Guided tours and programs are probably the most flexible forms of interpretive media and the easiest to implement. All that is required to begin these services are an informed and capable interpreter, an historic resource, an audience, and an approved tour route. Many parks, in fact, offer personalized services as their first interpretive activities simply because they are so effective. In addition, if volunteers provide the service, the cost is very low.

As with any guided program, though, interpreters must be aware of their audience and know how to adapt their programs to varying circumstances. Although this is a basic tenet of interpretation, group leaders occasionally get so familiar with their material that they forget to adjust their programs to visitor needs. For example, a program originally developed for a group of military history enthusiasts would be totally over the heads of a class of fourth graders. Likewise, a physically exuberant discovery walk designed for Cub Scouts would be a disastrous outing for a group composed of the very elderly.

One common pitfall is to present too much information. On these tortuous programs, the leader spends long periods describing esoteric topics such as ammunition hoists or base-end position finding while failing to put the technical information into any sort of overall context. I call this technique the "rivet counter" school of interpretation, and while it may work on very rare occasions, it usually fails. If an interpreter possesses an advanced level of expertise and wants to share it with visitors, consider having them present it as a special lecture series or, better yet, write a technically oriented interpretive publication.



Trained interpreters should not only have an extensive knowledge of their subject matter, they should also be able to adjust their presentation to varying audiences, such as this school group at Fort Casey.

Different groups require different approaches. Here are some good guidelines when preparing interpretive talks:

Children's groups and school tours. Be prepared to be peppered with questions like these: "who were we fighting?", "what was in this room?", "what's that thing for?", and the ubiquitous "why can't we go in there?" On one memorable tour, a child asked me a question that went to the very heart of the coastal fortification story: "why were we afraid?"

Determine the group's level of understanding, and at the start of the program, present a simplified review of American and state history.

Explain the perceived need for fixed coastal defenses. Similes are useful, and I compare harbor defense forts to the security bars installed over residential windows; you hope you never have to use them, but that the 'bad guys' will see the bars/forts and not even try to get in. Don't concentrate on details in your program, but rather make your tour of the fortifications an exploration of discovery. Bring along visual aids such as photographs or drawings that will help furnish the vacant structures. Finally, all people but especially children relate to the human side of history. I find they like hearing about the soldiers' lives, what they wore, where they lived, and in the case of officers, what their families were like.

Adults and senior citizens. Unlike a school group, adults have joined your program because they want to be there, and they already have interest in your topic. Their knowledge of recent history—especially senior groups—is probably extensive. You can safely skim over some of the history that preceded the construction of the fortifications, but still remember to begin with broad themes and then progress to specific stories—the "macro to micro" technique. Chat with your group before you get started and you'll quickly learn their level of awareness, and probably ascertain any physical limitations that might affect the program.

Don't concentrate on details in your program, but rather make your tour of the fortifications an exploration of discovery.

Special interest groups. Coastal fortification sites are magnets for historical groups, and when leading a tour for such buffs you may well find yourself outclassed in technical knowledge. Bring along photos, illustrations, and any other materials that might be useful during the program. These groups come armed with a wealth of background gained from long familiarity, and will probably want to share their expertise with you and the rest of their group. In some cases, members may even try to take over the tour program. About the only way to head off this last type of visitor is to offer to let them talk to the rest of the group—after the regular program is finished.

Finally, never guess at answers, especially the ones that are arcane or obscure. When confronted with a question for which there is no ready answer, a good interpreter should always say, "I don't know" followed by, "but I'll try to find out for you." And then make sure the presenter knows where to turn to research the information.

Interpretive Displays

The next level of interpretive media at fortifications after identification signs and personal services is often interpretive displays. These can take the form of outdoor kiosks or wayside panels, or more substantial exhibitry installed within the structures themselves. However, many visitors will have little previous knowledge of coastal fortifications and their history. Just as with personal services, avoid the temptation to unload substantial amounts of technical information on the casual visitor who, in many cases, just wants to know why the Army built the defenses in the first place.

Interpretive displays should initially take the "macro view" and orient visitors to a site's overall history and themes, stressing that the particular fortification they are viewing was part of a much larger defensive system. Themes such as "Defense of the Columbia River" or "Guarding the Golden Gate" should be stressed in these overview exhibits. Only when a visitor has been exposed to the broad story should subsequent exhibits present more specific and technical details. Set out an organized palette of choices for visitors. This approach allows them to first understand the general outline of an area, and then to pursue additional queries as their interests and time allow.

This display panel at Fort Scott tells the story of Presidio's fortifications and the specific role of Battery Boutelle, visible in the background. The use of an historic photo is especially effective since it mătches the visitors' perspective exactly.

When designing interpretive displays, try to incorporate historic photographs that illustrate features no longer present such as the armament, ammunition, hoists, generators, and the gun crews. Whenever possible, use historic images that match the visitors' perspective. Such then-and-now views help make the sites come alive in the visitors' minds and provide an interactive experience by comparing and contrasting the current scene with the historic one. If no historic views of a particular location are available, consider adapting images of identical weapons or installations; coastal fortifications were nothing if not standardized. In some cases, original art or illustrations may be necessary to fully depict how an installation looked or to explain a particular piece of technology such as the operation of a disappearing carriage.

Waysides should also describe the complexity and diversity of the defenses. Contrary to first impressions, they were not limited to artillery pieces alone. The networks of defense included searchlight positions, mine fields, observation stations, plotting rooms, magazines, power plants, telephone switchboard casemates, and, in later years, observation balloons, patrol aircraft, and radar. Backing up these purely defensive structures and systems were the residential, administrative, and maintenance buildings of the post cantonment.

A wayside exhibit positioned in a manner that does not block views of the gun or emplacement at Battery Chamberlin, Fort Scott. The descriptive panel is helpful when the gun is covered to protect it from the elements.

Interior museum displays are probably the most effective media for conveying the broad scope of the coast artillery story. Here, in specially designed gallery spaces, visitors can view fragile or irreplaceable objects that cannot be displayed outside, along with expanded interpretive displays and original and replica equipment. Interior display galleries are also perfectly suited for educational and interactive exhibits such as models, dioramas, and audio-visual programs.

In recent years, some parks have actually been able to acquire rare examples of coast artillery weapons and equipment, and installed them in their empty fortifications. These forts become especially powerful interpretive sites, since visitors to them can appreciate the size, scale, and complexity of the nearly vanished coastal defense weapons. A few parks, recognizing the interpretive value of full-size weapons and equipment, have begun replicating artillery and equipment to help visitors better understand how the fortifications looked and operated.

The staff at Cabrillo National Monument rehabilitated this small generator building to serve as a display gallery. Artifacts, graphic panels, and videos complete the interior. Fort Rosecrans, California.

Here's a list of interpretive possibilities that can be incorporated at various sites:

Remote or minimally developed fortification areas: Clear vegetation; replace name boards; ensure visitor safety; offer guided programs; install generic waysides; desktop publish an interpretive handout; develop self-guided driving or hiking tours to other fortifications.

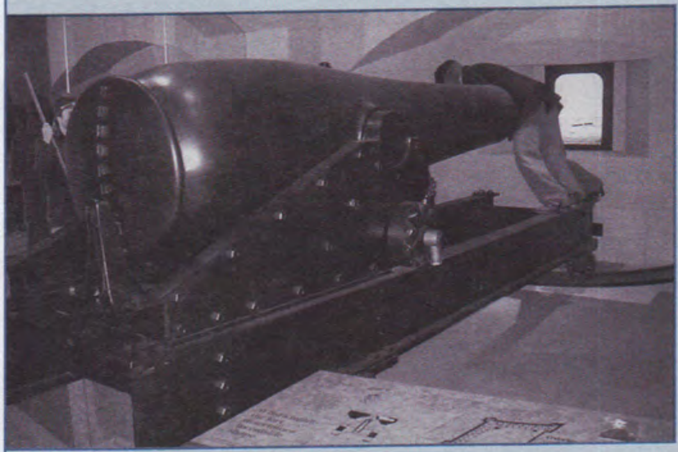
Fortifications in moderately developed areas: Install exhibits describing individual batteries and how they functioned; offer guided programs; use historic photos or original artwork to illustrate these stories; carry out additional restoration and provide access to areas not accessible at other sites.

Highly-developed or destination areas: Return the fortification to an approximation of its original appearance; restore utilities, especially electricity; adapt interior rooms for expanded exhibits or museum displays; furnish selected interior spaces with replica equipment and ammunition; develop audio-visual program; develop site-specific publications; replicate missing coast artillery weapons.

This projectile gallery at Fort DeRussy has been restored with replica 14-inch projectiles, overhead rails, lighting, and "crew." A waist-high fence, not visible here, separates viewers from the display.

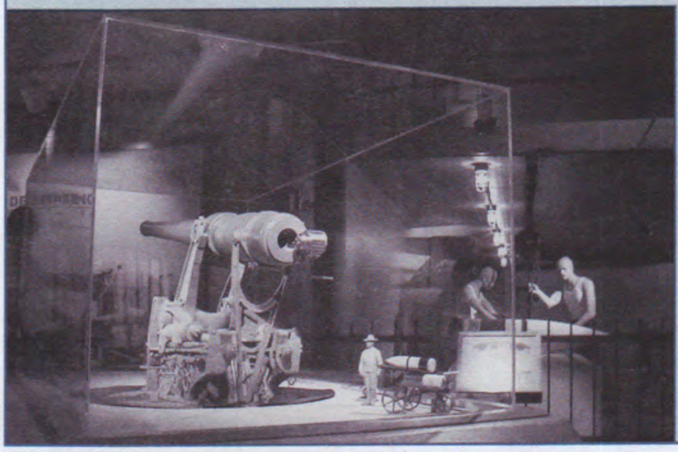
Interpreting the Missing Guns

Artillery pieces are one of the most fascinating elements for visitors at any fortification. Given that there were once hundreds (perhaps thousands) of them in place at any one time, it is odd that very few are left. While some examples do survive, most historic fortifications have to make do with a variety of substitutes.



Replicas. Full-scale reproductions are possible. This 10-inch Rodman cannon on a casemate carriage at Fort Wadsworth, New York, is an outstanding example of replica artillery. The gun itself is fiberglass and the "iron" carriage is wood and fiberglass. Interpretive panels and mannequins dressed in 1880s uniform complete the exhibit.

Combination. There are more cannon to be had than there are carriages. A six-inch gun lay dismounted for many years in the Upper Battery of Fort Rodd Hill, although no carriage was available to mount it. Parks Canada undertook the next best alternative. A structural steel framework now supports the original cannon in its firing position, giving visitors a sense of how the battery looked when it was armed.



Scale Models. Interpretation often relies on scale models to depict objects that are too large for traditional display or that are otherwise unavailable. The Fort DeRussy Army Museum in Hawaii was able to acquire Ordnance Department models of both a disappearing gun and a seacoast mortar for display. Models can recreate features such as artillery pieces, original topography, and architectural details.

Selecting the Right Themes

Following are some common themes that can be used in developing interpretive programs.

Defense of North America. The story of how the military defended America's coastline, and the technologies they employed, is repeated many times around the country. At seaport after river mouth, the military constructed several generations of fortifications to defend against perceived threats ranging from British coastal raids to the Cold War nightmare of thermo-nuclear attack. As time progressed, weapons and fortifications became standard throughout the country and its possessions. By the end of World War II, for example, the coastal batteries built in Alaska were virtually identical to those constructed around Boston Harbor.

No single fortification operated as a unique unit . . .one can compare fortification systems to a large machine.

Coastal fortifications and international policy. Until the 1880s, the U.S. Navy served as a sort of floating coastal defense system against foreign attack. When the United States began building its modernized coastal fortification in the 1890s, a primary goal was to free the U.S. Navy to look after American interests overseas. And it worked. At the start of the Spanish-American War, naval forces seized the Philippine Islands and helped consolidate possessions in Guam and Hawaii. It was not a coincidence that the Endicott era of coastal fortifications and the subsequent freeing of the navy coincided with America's expansionist and imperialist policies of the late 19th and early 20th Centuries.

Fortifications were interdependent. When interpreting coastal defense sites, it is easy to focus on one particular battery while overlooking its role in the greater defensive system. No single fortification operated as a unique unit. Each fort, gun battery, fire control station, switchboard room, and mine casemate was designed as part of a tightly integrated system of defense that stretched along dozens of miles of shoreline. As a simile, one can compare fortification systems to a large machine; an individual piece cannot be understood by itself, and has to be put into the context of the whole mechanism.

Lives of the troops. The coastal defense forts were more than just masonry and steel structures. Each coast artillery post was a community, and behind the batteries was a village of barracks, officers quarters, administration buildings, stables, storehouses, and all the other features of a small town. The soldiers who manned these defenses formed a unique branch of the United States Army, one with its own history, traditions, and prejudices. Officers formed the top layer of the Coast Artillery, and they usually had their wives and families with them. Just as the fortifications became uniform in design, so did life for men assigned to the harbor defenses. Aside from geographic differences and the comparative pleasures of serving at certain artillery posts, the lives of the soldiers were also very much the same. Barracks and furnishings were almost identical, training was continual and standardized, peacetime service routine, and class differences between officers and enlisted was strictly observed.

A panel at the Fort Rosecrans interpretive center portrays the end of coast defense as a system of fortifications.

Obsolescence. Every generation of fortifications in time became obsolete, and in turn was replaced by newer defenses. Concrete emplacements and breach loading rifles replaced brick walls and smoothbore cannon, and these in turn were replaced by even longer-range guns and anti-aircraft defenses. This story continued through the end of the Cold War when the last Nike surface-to-air missile sites were disarmed in the early 1970s. Even today, it can be argued, the military still carries out a 'coastal defense' role through such modern weapons as the Air Force's ICBM systems and the Navy's ballistic missile patrol submarines.

Visitors and Safety

"Fort Casey State Park is a destination for as many as 800,000 day users annually. Many are families with young children involved in environmental education and history as part of their schoolwork. They are recreating in an area that was never intended to be open to the public. Having this in mind, visitor protection is accomplished at the park through signing, closing of potentially dangerous areas, public education, law enforcement, interpretive programs, and maintenance.

"As an example, our law enforcement program is focussed on eliminating or discouraging those activities that are dangerous; it is a tool to promote resource and visitor protection. It is directed toward visitors ignoring danger signs, engaging in reckless endangerment, and malicious mischief. These activities include climbing on the guns, ignoring hand railings, climbing on roofs, erecting structures inside the rooms, rope climbing, and general horseplay. They all have the potential to interfere with the safety and recreational experience of other visitors."

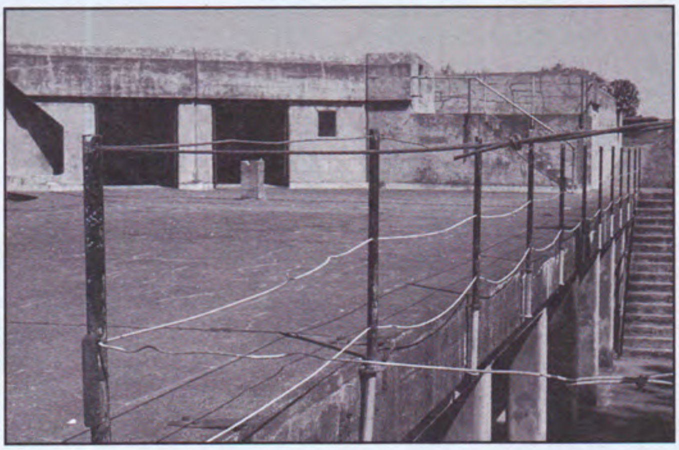
"Similarly, our interpretive programs contain information encouraging the visitor's awareness of their own safety and the responsibility of stewardship they own while visiting. I am always amazed at how well this message is received by younger children and how well they do in reminding parents and older siblings."

Fortifications were designed to be functional, and certainly no regard was given to their potential reuse as historic properties or to the possibility that anyone other than military engineers and artillerymen might be interested in access to them. Times change, and today people do want to see and touch these odd survivors from another century. However, visitors face a structure that they may not be prepared for. Walking on top of a fortification can be hazardous because of the height above the ground, and the walking surface itself may be on a slope or obstructed by tripping hazards that are part of the historic fabric. Not all heights are protected by railings, and where railings were provided originally, they may not remain in place. Interiors are often dark, and floor recesses, stairs, and other features appear where they are not expected. Rusted ironwork dangles from the ceiling. Stair risers feel too tall and the tread too narrow. Accidents are common in these surroundings, just as other kinds of environments have their own risks, and most managers report a steady incidence of injuries that run from bruises to broken bones.

In view of all this, the temptation is to close off all or part of the fortification so that there is no access. If there is no access, no one can get hurt. That thought is often indistinguishable from another desire: if there is no access, no one can litter, vandalize, or indulge in other behaviors that can aggravate the management of the resource. While this seems like the right thing to do, and there are many examples of access denial in historic fortifications, it usually falls short in execution on several counts.

Fortifications are popular destinations for families; caution and common sense helps visitors stay safe.

First among these is lack of effectiveness. Fencing is the most common method of excluding people from an entire structure, but most fencing constitutes a small barrier for those who feel the need to get inside. If the goal is to exclude people from the interior, it may be possible to use the existing doors. However, closing a door and locking or welding it shut usually leads to a ruined padlock, broken welds, or a damaged door.



This expedient railing repair is difficult to maintain, offers little protection, and is not in keeping with the historic design. Battery Kinzie, Fort Worden.

A second disadvantage is impact to the structure and its details. Covering an opening with steel plate or wooden timbers that are secured by bolts set into the surrounding historic fabric results in holes and fractures. Welding an iron or steel hasp can reduce the section of the material. That is especially true for metals that have been weakened by corrosion prior to welding.

A third consequence is that when we eliminate access to visitors, we almost always eliminate access for everyone else, including those who are responsible for caring for the structure. There must be some method of allowing entry to permit periodic inspection. Out of sight being out of mind is incompatible with good stewardship.

A final result is the unwelcome visual change that even temporary measures can produce. A fence line is intrusive in the landscape of most fortifications in North America, and a poorly fashioned closure for a doorway can detract from the workmanship of the original structure. Both of these effects convey the sense that the resource is not important and can be regarded in an off-hand, uncaring manner.

How much fencing is enough? Multiple fences obscure the historic resource. We need to determine if fences are to constitute an absolute barrier or if they are intended to warn people of a hazard. Fort Mott.

A fence surrounds a recessed floor at Battery Murphy, Fort Columbia. The decision to fence off the feature is a good one, although a shorter fence would be just as effective and less intrusive.

An operating slide secures this double-leaf door. The nut is welded to the bolt that passes through the padlock opening, but no part of the slide itself is welded. Periodic lubrication will ensure its continued functioning.

Following from the above, an appropriate method of controlling access has to meet three tests: it has to be effective, it must not result in damage to the historic structure, and it must allow for periodic inspection.

Fencing can be the right choice, but more as a means of hazard mitigation than a method of exclusion. Erecting a fence around a ground-level void or similarly dangerous feature is preferred over fencing off an entire resource. An alternative would be the reconstruction of the original closure, presuming that the void would have been fitted with a closure during the historic period. Avoid placing fence posts or other supports directly into the concrete or masonry of the fortification since such a practice damages the historic fabric. The argument has been made that these materials can be easily repaired, and therefore we need not be concerned about boring or gadding out holes. While repair is possible, there is little evidence to suggest that holes for fence posts (or anything else) would be addressed any more quickly than the naturally occurring deterioration that is evident at most historic fortifications, or with the requisite skill. The promise of future remedial action is never preferred over a sound decision in the present.

There is some value in fencing an entire resource pending treatment decisions. It will not prevent trespass, but it will reduce casual traffic. Ensure that the fence includes a mangate, and if the site permits, a vehicle entry point as well. Restricting access in this manner is not itself a resource treatment; inspections and regular maintenance are still necessary.

The best method of closing off an interior space is to use the original means provided. Double- and single-leaf doors or shutters of wood or metal kept weather and unwelcome visitors out of the defenses. Where they still remain and their closing mechanisms are intact and operable, they should be repaired as may be required and returned to service. Most closing mechanisms were fitted with eyes for padlocks, and a padlock is still a good choice as long as it is protected by a steel sleeve that fits over the lock to prevent the use of bolt cutters. The mechanism can also be secured with a nut and bolt. The nut can be tack-welded to the bolt (but not the historic fabric) or temporarily seized with compounds made for the purpose.

In whatever manner the door is secured, it must be capable of being opened for maintenance of the doors themselves as well as for inspection of the interior. Fixing a door, grill, or shutter in place in a way that will result in damage if the choice is later made to open it is an inappropriate practice. The inability to maintain all surfaces of the closure, particularly the points of contact with the surrounding masonry or concrete, will lead to corrosion or rot and the loss of the feature.

There are other choices if a door is not in place. Under the best circumstances, it will have been removed to a secure location where it has been stored until such time as it could be returned to use. If the original is not available, a replacement can be fabricated based on original design drawings or the details of existing historic doors elsewhere in the fortification. Since preservation is the most common treatment for historic fortifications, and since preservation precludes the reconstruction of missing elements, the decision is often to provide a substitute. The choice is frequently reinforced by considerations of economy.

The historic resource should never be scavenged for materials. Doors taken from other locations have been cut and welded together to close this opening at Battery Mishler, Fort Stevens.

A good substitute has several aspects that make it a success. Its installation is reversible; it does not require the use of new fasteners embedded in adjacent walls or ceilings; it is of materials that are visually compatible with the historic character of the structure; it is held free of jambs, sills, and lintels; and it allows for ample air circulation to the interior. It may or may not be operable, but there needs to be access to both sides for preventive maintenance so long as it is in place. One possible design, especially appropriate for remote locations, is included in the appendix as part of the Long-term Conservation Project for Coastal Defense Fortifications.

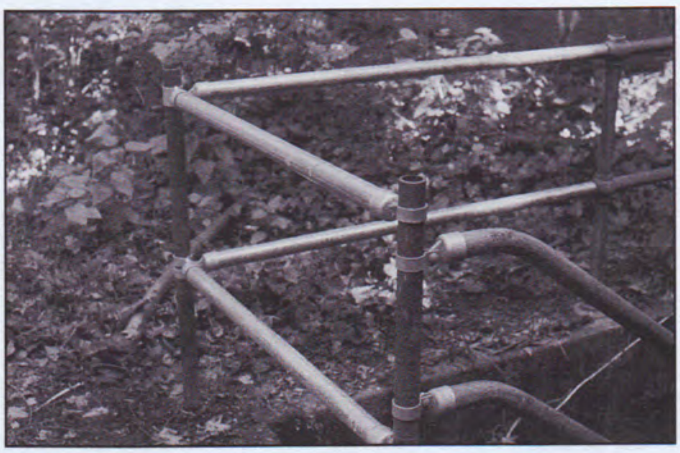
In some instances, entryways have been covered over with earth. Similarly, where doorways open from a stairwell, the stairwell has been filled to grade so that the doors are completely or partially buried. Some managers consider both actions as appropriate in the name of public safety; in reality, the reasons have more to do with limiting maintenance requirements or denying the opportunity for undesirable activities. Dirt has only two attractive qualities in these examples: it is cheap and easily available. It fails every other requirement.

An earth-filled stairway at Battery Vinton, Fort Ward, Washington.

If used to fill a stairwell or other cavity, dirt ensures that there will always be a source of moisture to contribute to rising damp, corrosion, rot, and the growth of unwanted vegetation. It will plug floor drains, which could result in water accumulation in the closed-off rooms if the rooms themselves were not furnished with drains. Eventually the doors will collapse from a lack of maintenance, and the earth fill will slump into the rooms, permitting the access that the material was supposed to prevent.

It may be that there are instances where fill is an appropriate treatment, but other options should be considered first. In the case of a stairwell, the safety concern could be resolved by replacing a missing railing. For an entryway, access could be controlled by a purpose-built closure. If fill still seems the best method after the examination of other approaches, a series of actions must take place. Floor drains are protected so that they will not clog with sediments. Character-defining features such as doors or other objects are removed, identified, and stored in a protected location; if the features cannot be removed, they are covered by a heavy layer of a product designed for sub-surface use. The fill material itself is designed and selected to be free of silt, resist compaction, and drain easily.

Heights cause many concerns. Railings often protected the rear of casemates and emplacements when they were located above ground level. The best protection for visitors is to maintain the historic railings where they are intact, repair them where they are damaged, and restore them where they are missing. There was large variation in railing design, and any selection of replacement railing should be based on thorough research to ensure the right choice. Borrowing a railing pattern (or even the railing itself) from an adjacent work may not be the wisest course. That caution is especially true when considering railing designs from different time periods and locations. Availability and preference had much to do with what railings were installed in any particular fortification.



A simple and compatible replacement railing at Battery Thornburgh, Fort Ward. The railing clips to the original pipe rail stanchions.

Temporary replacement railings can be useful if they can be installed in a manner that does not damage historic fabric. Some original pipe railings were threaded into flanges attached to the surface with screws. The flanges can still provide an attachment for threaded pipe.

If the decision is made to replace a pipe railing system with another type, the flanges offer another possibility. They can be removed and stored, and replacement flanges that are manufactured as part of the replacement railing system can be installed in their stead; ideally the new flanges will have the same hole pattern as the originals. Structural slip-on fittings mimic the nature of pipe rail, and may be appropriate for a rehabilitation, however the same fittings would be a questionable choice in a restoration project. Providers of slip-on railing include Hollaender Manufacturing, Kee Klamp, R and B Wagner, and Morse Industries. Never weld replacement railings to the surviving components of the original railing system.

It is a great temptation to erect a railing or fence along the upper perimeter of a tall fortification. Few actions could be more insensitive to an important historic feature. The addition of a fence or guard rail will add considerable visual paraphernalia to structures that as a type were recognized for their clean lines and uncluttered appearance. Some commercial products have been developed for roof-top use that may be appropriate for temporary installation on fortifications, but no examples of their employment were found in the preparation of the *Handbook*. Among these, the KeeGuard Roof Edge Guardrail System may be worth examining further because it requires no permanent fasteners.

Our concerns for safety must also embrace the education of visitors so that they can enjoy unfamiliar surroundings with a greater sense of awareness.

Iron or steel ladders and stairways often connect different levels. They may now be missing, the result of deterioration, scrapping, or other causes. Some managers see them as little more than attractive nuisances that invite accident, and encourage their removal. While it may not be possible to recover the features already missing, any contemporary plan to remove ladders or stairs should be prefaced by a thorough examination of the need to do so. If the decision is made to remove the feature, then it must include the disassembly, identification, and protected storage of the components. These steps are important because metal work is costly and difficult to reproduce, not to mention the value of original fabric. In the past, these valuable features were often cut away and discarded, disfiguring the resource while precluding the opportunity for their return in the future. The action is notably disappointing in the case of ladders; they can be rendered temporarily unserviceable by attaching a plank outside of the rungs. No one can climb the ladder when it is fitted in such a manner, and the treatment can be quickly reversed with no impact to the resource.

Fortifications cannot be rendered safe for all. It is a highly questionable practice to alter significant features with the assumption that an increase in visitor safety will be the result, particularly if there are no data to measure before-and-after injury rates. Moreover, dismantling portions of a structure can become a justification for reduced inspection or maintenance. We need to look beyond the modification of resources. Our concerns for safety must also embrace the education of visitors so that they can enjoy unfamiliar surroundings with a greater sense of awareness.

Volunteers

"Fort Casey State Park is fortunate to have a very active and professional volunteer group. They are instrumental in keeping our interpretive center open and in providing some funding for special park maintenance and interpretive requests. Volunteers are not the long-run answer to our funding and staffing problems, but they provide us with additional assistance in interpretation and limited maintenance.

"Selection and recruitment of volunteers having the special skills to work with the public is crucial. That is why starting a volunteer group should be accomplished by using existing organizations, such as civic clubs, extension services, or community groups, that have experience with volunteers. They are a good place to begin because the members of existing organizations are, for the most part, already partially trained and possess public relations skills.

"Many people want to be volunteers. It is the park manager's responsibility to determine if the individual's skills will blend with the park's mission, goals, direction, and specific needs."

Many historic properties—perhaps most—have friends and volunteers associated with their care and operation, and historic fortifications are no exception. Friends groups are defined by their attachment to a particular location. It is a generic term, and includes all formal organizations that have come together in support of a single fortification. They typically conduct themselves under by-laws, have a mission statement or charter that establishes their purpose, and undertake a variety of programs on an annual basis. They go about their work with the blessing of the property owner. Volunteers, on the other hand, are not organized, and they come and go as various activities appeal to them. Volunteers can be recruited by the property manager or the friends organization; the volunteer pool is often a source of membership in the friends. These are useful differences, but the discussion here folds them into the collective term 'volunteers' since both friends and volunteers are unpaid, and contribute time, skill, and labor based on their interest in the historic property.

A volunteer carpenter builds a door following an historic design at Fort Pickens.

Generally speaking, there are three types of volunteers: those who perform physical labor, those who raise money, and those who represent the resource. Some of the division is age dependent since older volunteers may not be able to undertake the work called for in a maintenance routine. A friends organization whose board includes members that are business professionals will find that they are skilled at developing fund-raising programs. Other volunteers with a good grasp of history and an easy manner with visitors can form the core of tours and interpretive programs.

Here are a few groups that exhibit many of these traits.

Friends of Fort Knox. One of the most successful organizations associated with an historic fortification, FOFK began in 1991 in Prospect, Maine, as an outgrowth of the local chamber of commerce. Its immediate aim was to raise enough money to stabilize and repair the fort's roof, the deteriorated condition of which threatened closure of the state historic site. By 1996, the group had raised over $300,000, and work was underway. Through the contribution of services and materials, FOFK constructed a small, architecturally compatible building to serve as a gift shop. In 1998, the Maine Bureau of Parks and Lands, the owner of Fort Knox, collaborated with the Friends to plan the rehabilitation of an original building to serve as a visitor and education center. The project was completed in 2000. The group has been able to hire a full-time executive director, triple the revenue from the gift shop, and has also attracted new financial support for its ongoing preservation and programming efforts. The group sponsors numerous special events, has conducted a visitor survey and membership questionnaire, and has queried gubernatorial candidates regarding their stance on support for state historic sites.

Maine governor Angus King Jr. fires a Civil War cannon in August, 2000, to celebrate the opening of the visitor and education center (originally the torpedo shed) at Fort Knox.

Future projects include the installation of 23 interpretive markers, the recruitment of tour guides, and the development of curriculum materials for grades K through 12. The long-range plan is to emphasize Fort Knox as a destination and venue for historic reenactments, seminars, musical events, drama, art, and local craft work.[1]

Fort Delaware Society. The Fort Delaware Society is among the few groups that were formed to ensure the preservation of an historic resource and that have stayed active and involved. It was organized in 1950, and members began working to repair the fort as well as lobbying for the operation of the property as an historic site. In 1951, the Delaware legislature declared the property to be a state park.

The FDS brought in a diesel generator to provide power, and installed wiring and lights. Members reconstructed missing stairways, created tours and programs, opened a museum, and began a research library. It was able to secure two examples of heavy seacoast cannon that are now used in interpretive programs. The State Division of Parks and Recreation as the owner of the property is responsible for the preservation and operation of the site, and the FDS maintains a distinct

[1] "Fort Knox Times," Spring 2001 and Fall 2002; Friends of Fort Knox website, http://fortknox.maineguide.com, accessed December 30, 2002.

presence in the curation of artifacts, funding special projects, and promoting Fort Delaware in the community.[2]

Friends of Old Fort Stevens. One of the few organizations with a pronounceable acronym, FOOFS centers on direct support to Oregon Parks and Recreation Department in the interpretation of the oldest coastal fortification in the Pacific Northwest. Its members staff the park gift shop and interpretive center, and help raise funds for selected projects. It conducts tours seasonally, offering a ride in a vintage military cargo truck for those visitors not inclined to walk. Special events in the park emphasize reenactments from the Civil War to World War II. What sets FOOFS apart is its support for the reconstruction of a six-inch gun and its disappearing carriage, a major undertaking considering the size and complexity of the original. At the time of this writing, the gun has been completed and is on display, and work has begun on the carriage.

Friends of Fort Flagler. The FFF draws most of its membership from the Marrowstone Island vicinity, close to Port Townsend, Washington. It is an area favored by retirees, and the membership of the FFF reflects that demographic. The group is organized into a number of committees, and provides direct service to a small museum and other park facilities. The work of the Trails and Gun Emplacements Committee has been especially notable. Fort Flagler is densely wooded, and a heavy growth of trees and understory had completely obscured one of the defense's most interesting searchlight complexes. Clearing the area was beyond the time available to park staff, and the size of the task alone was daunting. The Friends took it on, removing the intrusive vegetation and making the area open and accessible. The group also drained and cleaned a flooded battery, and so provided an additional destination for interpretive tours. Some sense of its accomplishments is represented by the table on the following page; note that the FFF does its work in collaboration with others.

Bob Suther (seen here) and Bob Brown were key volunteers at Fort Flagler in excavating Battery Lee from a half-century of neglect.

There are many similar organizations. Some exist primarily to voice support for the preservation and interpretation for the particular fortification that is its interest, while others lead the way in planning for preservation, reuse, and interpretation. Regardless of size or focus, the most able groups share some things in common. First, they are well organized. They have an internal structure that is consistent with the ends they wish to achieve. Second, they work well with partners. They understand the need for broad involvement beyond the limits of their own membership, and welcome the assistance that others can offer. Third, they coop-

[2] "History of the Fort Delaware Society," Fort Delaware Society website, http://del.net/org/fort/FDShistory.htm, accessed December 30, 2002.

erate with the property owners in a way that is mutually beneficial. Since the majority of historic fortifications are publicly owned and staffed at minimal levels, volunteers are a key asset; on the other hand, a friends group may wither at the start if it is unable to secure the support of the owner.

There is a final piece. Some one or some small number of the group has a vision and the enthusiasm, commitment, and knowledge to bring it to reality. These are qualities that help encourage fellow members, expand the organization, and win the respect of the community. It is probably the most essential quality that a friends organization can have.

Choosing What to Preserve

Fortifications will not vanish because we regard some of them as incidental to our management approach.

Evaluating buildings, structures, and sites to determine what is important and what must be done to preserve them is the first step in managing fortifications for their significance. It is a time-consuming job, and requires preparation, organization, and dedication to see it to the end, yet it is only a beginning. In some ways, the real task comes when the choices have been made about what is essential and what is not. Oddly enough, it is more about what to do with the not-so-important than it is the important. If we concentrate on the significant aspects, what do we do with everything else?

The dilemma is less of a problem with masonry fortifications because as a rule they cannot be subdivided. If we reach the conclusion that a Fort Taber or Fort Macomb is valuable and should be preserved and interpreted for the public benefit, it is a conclusion that applies to the whole structure. We might decide that different components will receive different treatments–preservation, rehabilitation, restoration, or even reconstruction–but it is unlikely that we will determine that one architectural component can be singled out as suitable for outright abandonment. The enclosed and self-contained nature of masonry fortifications makes that an improbable choice, and there is ample evidence that the managers of such fortifications have embraced the totality of the rambling brick and stone structures as the manifest historic resource. The apparent rightness of the decision does not make the job of preservation any easier, although it may make it simpler to defend.

Late 19th and early 20th century fortifications are less convenient. They are not self-contained, and their components are scattered over the landscape. Using the various inventory and evaluation tools described in the *Handbook*, we can arrive at sound decisions about treatment (and hopefully significance, too), but it is with the almost certain understanding that some portion of them will not receive any treatment at all. The inclination in the past has been to abandon obscure or outlying batteries, fire control stations, power plants, and so on. Yet if the resources are located on property that is under the control of a public agency, they cannot be effectively abandoned because people will find them. Trash and graffiti will accumulate, hazards will multiply, and unwelcome activities will again find a home. Fortifications will not vanish because we regard some of them as incidental to our management approach.

It is the dilemma brought about by the conventions of sorting historic resources. All of our appraisal of conventional historic buildings and structures leads to three categories: critical (essential to our appreciation), constant (important to historic character but adaptable to sympathetic changes), and tradable (loss is acceptable in the face of off-setting benefits).[3] It is a convention that works well. In a downtown historic district, for example, there are always key buildings whose significance is recognized by all and whose retention is readily understood. Supporting these landmark buildings are others that may be less grand, but whose materials and features lend continuity. Finally, there are those buildings that may be simply old and not important, or whose character has been permanently altered by unsympathetic change. It is this last category that can be traded for new uses that can help support critical and constant resources. They can be removed and their sites can become the location of other benefits.

Properly prepared, a buried fortification can survive for a very long time.

As we have seen, fortifications are not conventional buildings. The method described above does not work because once we have identified a fortification element as tradable, there is nothing we can trade it for, at least not without significant cost. If we go the extra step to retain a tradable resource by walking away from it, we incur liability risks that are difficult to quantify and can potentially create circumstances that can degrade visitor experiences at other more valuable resources nearby. If we decide to get rid of it completely–to demolish it–the cost of doing so to any but a frame or a thin-wall concrete structure is prohibitive. And if we elect to do away with a tradable resource, we also run the risk of regretting in the future an irreversible decision when we might find ourselves with a greater understanding of significance or greater support for a preservation treatment.

There is one action that is applicable to all three categories of assets, and that is burial. Properly prepared, a buried fortification can survive for a very long time without significant deterioration. It carries with it the promise of sound conservation, little or no intermediate maintenance, reduced liability, and no access for troublesome activities. A tradable resource can remain buried. As circumstances warrant, the more valuable resources can be excavated and given a specific preservation treatment. There is a method for burial that creates the conditions for conservation, and it is detailed in the Long-term Conservation Project for Coastal Defenses Fortifications included in the appendices. The estimated costs are significant, which suggests that burial in the end may be useful for only small tradable fortification elements where costs can be minimized, or for more important assets whose future value is well established.

[3] Chitty and Baker, 6.

Historic Fortification Preservation Handbook

Biographies and Illustration Credits

Biographies

Alicia M. Bjornson

Alicia M. Bjornson is a graduate of Mount Holyoke College. As a member of the American Institute for Conservation of Historic and Artistic Works (AIC), she actively promotes historic preservation and the importance of cultural heritage in and around our communities. Alicia is a Resource Interpretive Specialist at Fort Mott State Park, New Jersey, where she has been for the last eight years.

Joel W. Eastman

Joel W. Eastman is Professor Emeritus of History at the University of Southern Maine in Portland. During his 31 years there he became an expert on the fortifications that defended the port, and served as a consultant to the public and private owners of the former defense sites, leading tours, giving lectures, and preparing interpretive material for articles, brochures and panels. In 1988, he was invited by the Maine Historic Preservation Commission to prepare a survey and assessment of 20th century sea coast fortifications, which was entitled, "The Modern Defenses of the Coast of Maine, 1891-1945."

Robert Fimbel

Robert Fimbel manages the Resource Stewardship Program at Washington State Parks. He is responsible for overseeing the agency's natural resource protection planning and implementation program, salmon recovery efforts, the inter-disciplinary Resource Stewardship Certification Program, and arbor crew. Previously, Rob spent eight years as a biologist with the Wildlife Conservation Society, working throughout the tropics on issues related to logging-wildlife habitat interactions, protected area design, and buffer-zone management. His academic background includes a Ph.D. in restoration ecology, MSc in Range ecology, and BSc in Forest Management.

Stephen A. Haller

Stephen A. Haller is the Park Historian for Golden Gate National Recreation Area. Formerly the Curator of Historic Documents for the San Francisco Maritime National Historical Park, he has also been an interpreter at a number historic sites, and specializes in the study of shipwrecks, military history, and historic landscapes of the Bay Area. He is the author of Post and Park, an illustrated history of the Presidio of San Francisco, The Last Word in Airfields, a special history study of Crissy Army Airfield (at the Presidio), co-author of What We Have We Shall Defend, a history of Nike Site SF-88, and Shipwrecks at the Golden Gate.

David M. Hansen

David M. Hansen is the Historic Preservation Officer for the Washington State Parks and Recreation Commission. He is an authority on the design, construction, and conservation of historic fortifications. He has received an award from the California Preservation Foundation for his contributions to the National Park Service Seacoast Fortification Preservation Manual, and has also received the Outstanding Career Achievement award from the Washington State Historic Preservation Officer. He holds degrees and certificates from the University of Washington, The Evergreen State College, and the Preservation Institute: Nantucket.

Kimberly Keagle

Kimberly Keagle received a BS in Architecture in 1993 and a BFA in Sculpture in 1995 from the University of Illinois at Urbana-Champaign. In 2003, she earned a Masters in Architecture with a

Certificate in Historic Preservation from the University of Washington. As a student, Kimber received the Gerberding Rome Studies Fellowship and the Finrow Fellowship for graduate architecture study in Rome, Italy. She is also a member of the Iota Chapter of Tau Sigma Delta, the National Academic Honor Society for Architecture. Kimber works part-time as an historical architect for the Columbia Cascade Regional Support Office of the National Park Service located in Seattle.

John A. Martini

John A. Martini served as a National Park Service ranger for 25 years at such diverse sites as Alcatraz Island, the Presidio of San Francisco, the National Maritime Museum, and the USS Arizona Memorial at Pearl Harbor. His published works include the books Fortress Alcatraz, Fort Point: Sentry at the Golden Gate, and Alcatraz At War, as well as articles for American Heritage and After the Battle magazines, and numerous historic resource and special history studies for the National Park Service. Now retired, he works as a consultant in the fields of historic preservation and interpretation.

Bill Morrow

Bill Morrow received his Masters Degree in Architecture from the University of Oregon in 2000; he also holds a degree in fine arts from the same institution. His first career included photography, video, and sports television production work. He returned to graduate school at the University of Oregon to pursue his ever-present interest in architecture and historic fortifications, and is currently completing a Masters Degree in Historic Preservation. His interest in fortifications evolved from a research class taught by David Hansen, concerning the problems and treatments of historic fortifications.

Deborah Marcella Rehn

Deborah Marcella Rehn, AIA, holds an architecture degree from Washington University, St. Louis, and a Master of Science in Historic Preservation from Columbia University. Her thesis work resulted in a handbook that explains how preservation theory and principles can best be applied by using a scientific approach to building conservation. She spent seven years in the private sector before joining the National Park Service; she is now an Historical Architect in the Southeast Region of the NPS. Her work for the agency has included the city walls and fortifications of San Juan National Historic Site and Fort Sumter National Monument.

Heidi Seidelhuber

Heidi Seidelhuber is president of Seidelhuber Iron and Bronze Works, a third generation steel fabricating plant in Seattle. The firm is best known in historic preservation circles for the restoration of the cast-iron pergola in Seattle's Pioneer Square, a National Historic Landmark. She holds a MFA from the Rhode Island School of Design and a BFA from the Art Institute of Chicago.

Dave Veart

Dave Veart, LLB, MA (hons), is an archaeologist and is employed by the New Zealand Department of Conservation in the Historic Resource Management section of the Auckland Conservancy. While this organization is concerned mainly with natural heritage matters, it also manages a large number of historic and archaeological sites, including the old coastal defense forts that surround the port of Auckland. Their management occupies a significant percentage of his work. His other main area of interest is the prehistoric Maori settlement in the volcanic areas of Auckland; he is currently at work on an education program for schools on the subject.

Illustration Credits

The following abbreviations identify the most frequently cited sources for the illustrations in the *Historic Fortification Preservation Handbook.*

HABS Library of Congress, Prints and Photographs Division, Historic American Buildings Survey collection

HAER Library of Congress, Prints and Photographs Division, Historic American Engineering Record collection

NARA National Archives and Records Administration, with Record Group (RG) number

Frontis

Fort Gaines, HABS, ALA, 49-DAUPI, 1-4.

Part One: Introduction

1.2: Fort Adams, HABS, RI-347, sheet 2. **1.3:** Fort Monroe, HABS, VA, 28-HAMP, 2C-5. **1.4:** Washington State Parks. **1.6:** Washington State Parks. **1.7:** Washington State Parks; Fort Raleigh, HABS, NC, 28-MANT.V, 1-D-1. **1.8-10:** US National Archives; Ed Drinan.

Part Two: Fortifications as Historic Properties

2.1: Fort McHenry, MD-63, sheet 4; Fort Washington, HABS, MA-2-48, sheet 1. **2.2:** HABS, FL-15-5, sheet 6. **2.3:** HABS, NY, 31-NEYO, 168-1. **2.5:** HABS, FLA, 44-__, 1-23. **2.6:** NARA, 77-F-94-101-31. **2.7:** HABS, RI-347, sheet 2. **2.8:** NARA, 77-F-45-107-2. **2.11:** Fort Totten, NARA; Fort San Jacinto, NARA, NRFF-77-G13-CROCKETT-2(10); Fort Funston, NARA, NRHS-77-SFDISFORTS-110A. **2.12:** Fort Delaware, HABS, DEL, 2-PEPIS, 1-30. **2.13:** Fort Delaware, HABS, DEL, 2-PEPIS, 1-28. **2.14:** NARA, 77-F-70-60-8. **2.15:** NARA, RG338. **2.16:** Fort Totten, NARA, RG77, 35-66-2; Fort Mott, NARA, RG77, 50-55-1. **2.17:** NARA, RG77, 22-56-1. **2.18:** NARA, NWDNS-111-B-377; David M. Hansen; NARA, RG77, 39-23; NARA, RG 77, 19-36. **2.19:** NARA, RG 77, 10-33; Winslow, Notes on Seacoast Fortification Construction, Plate XIII; NARA, RG 338. **2.21:** Library of Congress, Prints and Photographs Division, Theodor Horydczak Collection, LC-H822-T-3244-x. **2.22:** NARA, RG 77, 19-58. **2.23:** Puget Sound Coast Artillery Museum, Fort Worden, Washington. **2.27:** Julia Hanuliakova. **2.37:** Fort Pickens, Gulf Islands NS. **2.40:** Fort Casey, private collection; Fort Mifflin, HABS, PA-1225, sheet 3; Fort Adams, HABS, RI-347, sheet 42; Fort Canby, Washington State Parks. **2.41:** Fort Point, HABS, CAL, 38-SANFRA, 4-34; Fort Washington, HABS, MD, 17-FOWA, 5-3; Fort Adams, HABS, RI-347, sheet 44; Fort Moultrie, HABS, SC, 10-CHAR.V, 5-14; Fort Winfield Scott, Bill Morrow; Fort Matanzas, HABS, FLA, 55-__, 1-14. **2.42:** Fort Wadsworth, HAER, NY, 43-ROSE, 2-14; Fort McHenry, HABS, MD, 4-BALT, 5-10; Fort McHenry, HABS, MD-63, sheet 7; Fort Worden, Julia Hanuliakova; Fort Mifflin, HABS, PA-1225, sheet 8; Fort Columbia, Washington State Parks. **2.43:** Forts Worden and Casey, Julia Hanuliakova; Fort Gorges, HABS, ME, 3-PORT, 20-15; Fort Point, HABS, CAL, 38-SANFRA, 4-28; Fort Columbia, Washington State Parks; Fort Rosecrans, HABS, CAL, 37-SANDI, 29-A-16; Fort Worden, Washington State Parks. **2.44:** Fort Casey, Washington State Parks. **2.46:** Washington State Parks. **Oversize:** NARA; Washington State Parks.

Part Three: Problems and Treatments

3.1: Bolling Smith. **3.2:** San Cristobal, Deborah Rehn; Fort Casey, Washington State Parks. **3.6:** New Jersey Department of Environmental Protection, Division of Parks and Forestry, Fort Mott

State Park, Watson and Henry Associates, project consultants. **3.10:** Washington State Parks. **3.11:** Alicia Bjornson. **3.12:** Fort Jackson, Mark Berhow; Fort Wadsworth, HABS, NY, 43-ROSE, 2-1. **3.13:** Fort Macomb, Mark Berhow; Fort St. Phillip, Mark Berhow. **3.15:** Channel Islands, David M. Hansen; Fort Worden, Washington State Parks; Fort Livingston, Mark Berhow. **3.17:** Fort Schuyler, HABS, NY, 3-BRONX, 3-12. **3.18:** Fort McKinley, David M. Hansen; Fort Adams, HABS, RI, 3-NEWP, 54-88. **3.19:** Fort McKinley, David M. Hansen. **3.20:** HABS, SC-194, sheet 21. **3.21:** Fort Baker, Bill Morrow. **3.22:** Mark Berhow. **3.23:** NARA, RG77, 184-9-35, No.3. **3.24:** Fort Crockett, NARA Galveston, NRFF-77-G13-CROCKETT-2(7); Fort Drum, NARA, RG77, 77-F-111-86-33; Fort Cronkhite, NARA San Bruno, image courtesy of Glen Williford. **3.32:** Bill Morrow. **3.33:** Washington State Parks. **3.34:** Pacific Northwest Testing, Inc. **3.35:** Battery Wheeler, NARA, 77-F-111-67-24. **3.36:** Battery Reed, NARA, SC249073. **3.37:** Bill Morrow. **3.38:** National Park Service, "A Glossary of Historic Masonry Deterioration Problems and Preservation Treatments," Christina Henry, 44-45. **3.39:** Washington State Parks. **3.40:** Washington State Parks. **3.42:** Washington State Parks. **3.43:** Fort Gorges, HABS, ME, 3-PORT, 20-15; Fort Stevens, NARA, RG77, F-92-91-14. **3.44:** NARA, RG77, 184-9-28. **3.45:** Fort Macomb, Mark Berhow; Fort Pickens, Washington State Parks. **3.47:** Bill Morrow. **3.49:** Washington State Parks. **3.50:** Washington State Parks. **3.52:** New Jersey Department of Environmental Protection, Division of Parks and Forestry, Fort Mott State Park, Watson and Henry Associates, project consultants. **3.53:** Washington State Parks. **3.55:** Washington State Parks. **3.56:** National Park Service, "A Glossary of Historic Masonry Deterioration Problems and Preservation Treatments," Christina Henry, 50-51. **3.57:** Bill Morrow. **3.58:** Bill Morrow. **3.59:** Washington State Parks. **3.60:** Washington State Parks. **3.62-65:** National Park Service, Golden Gate National Recreation Area, Park Archives and Records Center. **3.66-68:** Dave Veart. **3.69:** Washington State Parks. **3.70:** Bill Morrow. **3.71:** Washington State Parks. **3.72:** Bill Morrow. **3.73:** Washington State Parks. **3.74:** Bill Morrow. **3.78:** Alicia Bjornson; New Jersey Department of Environmental Protection, Division of Parks and Forestry, Fort Mott State Park, Watson and Henry Associates, project consultants. **3.79:** New Jersey Department of Environmental Protection, Division of Parks and Forestry, Fort Mott State Park, Watson and Henry Associates, project consultants. **3.80:** Alicia Bjornson; Washington State Parks. **3.81:** Bill Morrow. **3.82:** National Park Service. **3.83:** National Park Service; Bill Morrow. **3.84:** National Park Service. **3.85:** Courtesy Fort Adams Trust, Newport, RI, and Newport Collaborative Architects. **3.86:** National Park Service. **3.87:** National Park Service. **3.89:** National Park Service. **3.90:** Deborah Rehn. **3.91:** Courtesy Fort Adams Trust, Newport, RI, and Newport Collaborative Architects. **3.92:** Deborah Rehn. **3.93:** Deborah Rehn. **3.94:** Fort Wadsworth, HAER, NY, 43-ROSE, 2-12; Fort Pickens, Washington State Parks. **3.95:** Washington State Parks. **3.97:** Bob Brown. **3.98:** Washington State Parks. **3.99:** Washington State Parks. **3.101-104:** Washington State Parks except where indicated otherwise.

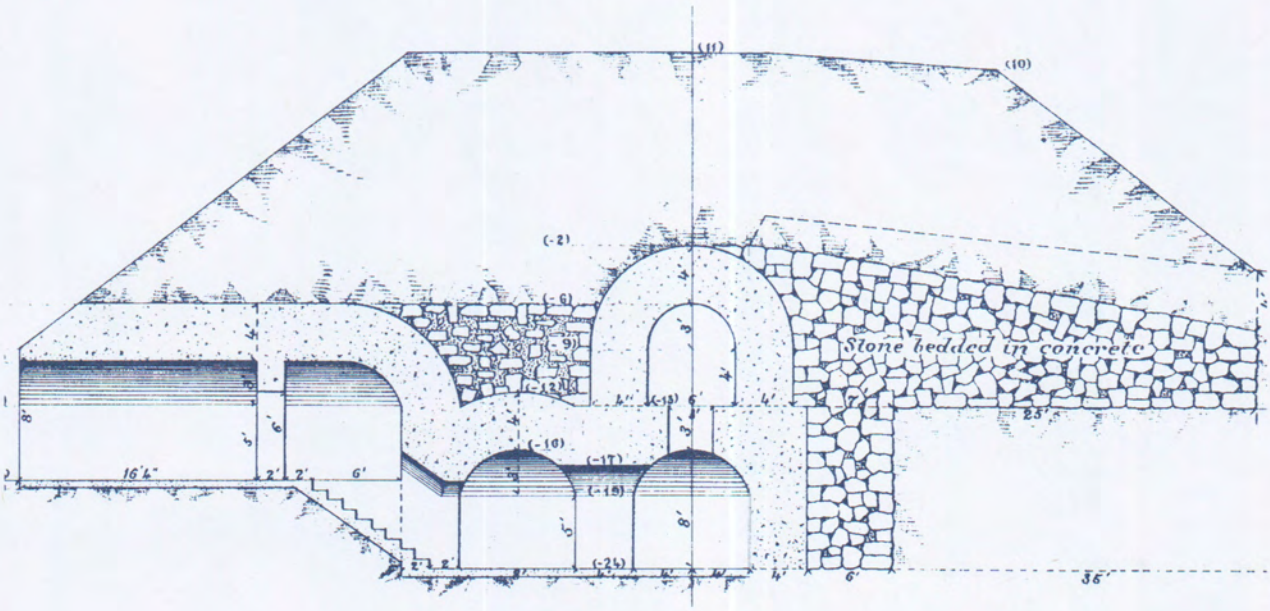
Part Four: Managing the Resources

4.1: Washington State Parks. **4.6:** Washington State Parks. **4.7:** John Martini. **4.8:** Washington State Parks. **4.9-10:** Washington State Parks. **4.12:** Washington State Parks. **4.13-14:** Washington State Parks. **4.15:** Washington State Parks. **4.16:** Washington State Parks. **4.18:** John Martini. **4.19:** John Martini; Burl Burlingame. **4.20:** John Martini; Washington State Parks; Burl Burlingame. **4.22:** John Martini. **4.23:** Washington State Parks. **4.24:** Washington State Parks. **4.25:** Washington State Parks. **4.26:** Washington State Parks. **4.28:** Washington State Parks. **4.29:** Rich Hewitt, courtesy Bangor Daily News. **4.30:** Washington State Parks.

Appendices

Cover: Plan of a Barbette Battery, NARA, RG77, Dr 39, Sht 23.

Appendices



Appendix A:

Guide for Making a Condition Survey of Concrete in Service

Prepared by
American Concrete Institute, 1992

Guide for Making a Condition Survey of Concrete in Service

Reported by ACI Committee 201

Members of Committee 201 who voted on the 1992 revisions:

Cameron MacInnis*
Chairman

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* Task group members who revised the guide.

This guide provides a system for reporting on the condition of concrete in service. It includes a check list of the many details that may be considered in making a report, and repeats the ACI 116 standard definitions of terms associated with the durability of concrete. Its purpose is to establish a uniform system for evaluating the condition of concrete.

The guide was revised by a task group chaired by K.R. Lauer. The other task group members are indicated by an asterisk.

Keywords: bridges (structures); buildings; concrete construction; concrete durability; concrete pavements; concretes; corrosion; cracking (fracturing); deterioration; environments; freeze thaw durability; inspection; joints (junctions): popouts; quality control; scaling; serviceability; spalling; strength; surveys.

CONTENTS

CHAPTER l-INTRODUCTION

This guide presents a system for making a condition survey of concrete in service. A condition survey is an examination of concrete for the purpose of identifying and defining areas of distress. The system is designed to be used in recording the history of a project from inception through construction and subsequent life of the structure.

While it probably will be used most often in connection with the survey of concrete that is showing some degree of distress, its application is recommended for all concrete structures. In any case, records of the materials and construction practices used should be maintained because they are difficult to obtain at a later date.

The committee has attempted to include pertinent items that might have a bearing on the performance of the concrete. Those making the survey should, however, not limit their investigation to the items listed, thereby possibly overlooking other contributing factors. Following the guide does not eliminate the need for intelligent observations and the use of sound judgement.

Those performing the survey should be experienced and competent in this field. In addition to verbal descriptions, numerical data obtained by laboratory tests and field tests and measurements should be obtained wherever possible. Photographs, including a scale to indicate dimensions, are of great value in showing the condition of concrete.

ACI 201.1R-92 became effective Oct. 1,1992 and supersedes ACI 201.1R-68 (Revised 1984).

The check list is provided to facilitate a thorough survey. The definition of terms and associated photographs are an attempt to standardize the reporting of the condition of the concrete in a structure.

This guide should be used in conjunction with the following:

1. ACI Committee 116 "Cement and Concrete Terminology" (ACI 116R).
2. ACI Committee 311 "Recommended Practice for Concrete Inspection" (ACI 311.1R).
3. ACI Committee 201, "Guide to Durable Concrete" (ACI 201.2R).

CHAPTER 2-CHECK LIST

Personnel conducting the condition survey must select those items important to the specific concerns relating to the reasons for the survey. Other factors may be involved and should not be overlooked during the survey.

CHECK LIST

1. Description of structure or pavement
   - 1.1 Name, location, type, and size
   - 1.2 Owner, project engineer, contractor, when built
   - 1.3 Design
     - 1.3.1 Architect and/or engineer
     - 1.3.2 Intended use and history of use
     - 1.3.3 Special features
   - 1.4 Construction
     - 1.4.1 Contractor-general
     - 1.4.2 Subcontractors-concrete placement
     - 1.4.3 Concrete supplier
     - 1.4.4 Agency responsible for testing
     - 1.4.5 Other subcontractors
   - 1.5 Photographs
     - 1.5.1 General view
     - 1.5.2. Detailed close up of condition of area
   - 1.6 Sketch map-orientation showing sunny and shady and well and poorly drained regions

3 Present condition of structure
   - 2.1 Overall alignment of structure
     - 2.1.1 Settlement
     - 2.1.2 Deflection
     - 2.1.3 Expansion
     - 2.1.4 Contraction
   - 2.2 Portions showing distress (beams, columns, pavement, walls, etc., subjected to strains and pressures)
   - 2.3 Surface condition of concrete
     - 2.3.1 General (good, satisfactory, poor, dusting, chalking, blisters)
     - 2.3.2 Cracks
       - 2.3.2.1 Location and frequency
       - 2.3.2.2 Type and size (see definitions)
       - 2.3.2.3 Leaching, stalactites
     - 2.3.3 Scaling
       - 2.3.3.1 Area, depth
       - 2.3.3.2 Type (see definitions)
     - 2.3.4 Spalls and popouts
       - 2.3.4.1 Number, size, and depth
       - 2.3.4.2 Type (see definitions)
     - 2.3.5 Extent of corrosion or chemical attack, abrasion, impact, cavitation
     - 2.3.6 Stains, efflorescence
     - 2.3.7 Exposed reinforcement
     - 2.3.8 Curling and warping
     - 2.3.9 Previous patching or other repair
     - 2.3.10 Surface coatings
       - 2.3.10.1 Type and thickness
       - 2.3.10.2 Bond to concrete
       - 2.3.10.3 Condition
     - 2.3.11 Abrasion
     - 2.3.12 Penetrating sealers
       - 2.3.12.1 Type
       - 2.3.12.2 Effectiveness
       - 2.3.12.3 Discoloration
   - 2.4 Interior condition of concrete (in situ and samples)
     - 2.4.1 Strength of cores
     - 2.4.2 Density of cores
     - 2.4.3 Moisture content
     - 2.4.4 Evidence of alkali-aggregate or other reaction
     - 2.4.5 Bond to aggregate, reinforcing steel, joints
     - 2.4.6 Pulse velocity
     - 2.4.7 Volume change
     - 2.4.8 Air content and distribution
     - 2.4.9 Chloride-ion content
     - 2.4.10 Cover over reinforcing steel
     - 2.4.11 Half-cell potential to reinforcing steel
     - 2.4.12 Evidence of reinforcement corrosion
     - 2.4.13 Evidence of corrosion of dissimilar metals
     - 2.414 Delaminations
     - 2.4.15 Depth of carbonation
     - 2.4.16 Freezing and thawing distress (frost damage)
     - 2.4.17 Extent of deterioration
     - 2.4.18 Aggregate proportioning and distribution

3. Nature of loading and detrimental elements
   - 3.1 Exposure
     - 3.1.1 Environment-arid, subtropical, marine, freshwater, industrial, etc.
     - 3.1.2 Weather-(July and January mean temperatures, mean annualrainfalland months in which 60 percent of it occurs
     - 3.1.3 Freezing and thawing
     - 3.1.4 Wetting and drying

3.1.5 Drying under dry atmosphere
3.1.6 Chemical attack-sulfates, acids, chloride
3.1.7 Abrasion, erosion, cavitation, impact
3.1.8 Electric currents
3.1.9 Deicing chemicals which contain chloride ions
3.1.10 Heat from adjacent sources

3.2 Drainage
3.2.1 Flashing
3.2.2 Weepholes
3.2.3 Contour
3.2.4 Elevation of drains

3.3 Loading
3.3.1 Dead
3.3.2 Live
3.3.3 Impact
3.3.4 Vibration
3.3.5 Traffic index
3.3.6 Other

3.4 Soils (foundation conditions)
3.4.1 Compressibility
3.4.2 Expansive soil
3.4.3 Settlement
3.4.4 Resistivity
3.4.5 Evidence of pumping
3.4.6 Water table (level and fluctuations)

4. Original condition of structure
4.1 Condition of formed and finished surfaces
4.1.1 Smoothness
4.1.2 Air pockets ("bugholes")
4.1.3 Sand streaks
4.1.4 Honeycomb
4.1.5 Soft areas (retarded hydration)
4.1.6 Cold joints
4.1.7 Staining

4.2 Defects
4.2.1 Cracking
4.2.1.1 Plastic shrinkage
4.2.1.2 Thermal shrinkage
4.2.1.3 Drying shrinkage
4.2.2 Curling

5. Materials of construction
5.1 Hydraulic cement
5.1.1 Class or classes-(portland, blended, high alumina, ground granulated blast furnace slag)
5.1.2 Type or types, and source
5.1.3 Chemical analysis (obtain certified test data if available)
5.1.4 Physical properties

5.2 Aggregates
5.2.1 Coarse
5.2.1.1 Type, source and mineral composition (representative sample available)
5.2.1.2 Quality characteristics
5.2.1.2.1 Percentage of deleterious material
5.2.1.2.2 Percentage of potentially reactive materials
5.2.1.2.3 Coatings, texture, and particle shape
5.2.1.2.4 Grading, soundness, hardness
5.2.1.2.5 Other properties as specified in ASTM Designation C 33 (C 330 for lightweight aggregate)
5.2.1.2.6 Service record on other projects
5.2.2 Fine
5.2.2.1 Type, source, and mineral composition (representative sample available)
5.2.2.2 Quality characteristics
5.2.2.2.1 Percentage of deleterious material
5.2.2.2.2 Percentage of potentially reactive materials
5.2.2.2.3 Coatings, texture, and particle shape
5.2.2.2.4 Grading, soundness, and hardness
5.2.2.2.5 Other properties as specified in ASTM Designation C33 (C 330 for lightweight aggregate)
5.2.2.2.6 Service record on other projects

5.3 Mixing water
5.3.1 Source and quality

5.4 Admixtures
5.4.1 Air entraining admixtures
5.4.1.1 Type and source
5.4.1.2 Composition
5.4.1.3 Dosage
5.4.1.4 Manner of introduction
5.4.2 Mineral admixtures
5.4.2.1 Class and source
5.4.2.2 Physical properties
5.4.2.3 Chemical properties
5.4.3 Chemical admixtures
5.4.3.1 Type and source
5.4.3.2 Composition
5.4.3.3 Dosage
5.4.3.4 Manner and time of introduction

5.5 Concrete
5.5.1 Mixture proportions
5.5.1.1 Cement content

5.5.1.2 Proportions of each size aggregate
5.5.1.3 Water-cementitious materials ratio
5.5.1.4 Water content
5.5.1.5 Chemical admixture(s)
5.5.1.6 Mineral admixture(s)
5.5.1.7 Air entraining admixture

5.5.2 Properties of fresh concrete
5.5.2.1 Slump or other workability measure
5.5.2.2 Bleeding
5.5.2.3 Air content
5.5.2.4 Unit weight
5.5.2.5 Temperature

5.5.3 Type
5.5.3.1 Cast-in-place
5.5.3.2 Precast
5.5.3.3 Prestressed (pre-tensioned or post-tensioned)

5.5.4 Reinforcement
5.5.4.1 Type (bar, mesh or fibers)
5.5.4.2 Yield strength
5.5.4.3 Thickness and quality of cover
5.5.4.4 Field or shop fabricated
5.5.4.5 Use of welding
5.5.4.6 Presence of coating
5.5.4.6.1 Type
5.5.4.6.2 Condition

5.5.5 Initial physical properties of hardened concrete
5.5.5.1 Strength-compressive, flexural
5.5.5.2 Modulus of elasticity
5.5.5.3 Density and homogeneity of microstructure
5.5.5.4 Percentage and distribution of air
5.5.5.5 Volume change potential
5.5.5.5.1 Shrinkage or contraction
5.5.5.5.2 Expansion or swelling
5.5.5.5.3 Creep
5.5.5.6 Thermal properties

5.5.6 Field test results
5.5.6.1 Description of tests and frequency
5.5.6.2 Actual results for full project
5.5.6.3 Actual results for concrete under survey
5.5.6.4 Evaluation of strength results per ACI 214

6. Construction practices
6.1 Storage and processing of materials
6.1.1 Aggregates
6.1.1.1 Grading
6.1.1.2 Washing
6.1.1.3 Storage
6.1.1.3.1 Stockpiling
6.1.1.3.2 Bins
6.1.1.3.3 Moisture control/prewetting
6.1.1.3.4 Cooling
6.1.1.3.5 Heating

6.1.2 Cement and admixtures
6.1.2.1 Storage
6.1.2.2 Handling

6.1.3 Reinforcing steel and inserts
6.1.3.1 Storage
6.1.3.2 Placement

6.2 Forming
6.2.1 Type
6.2.2 Bracing
6.2.3 Coating-type and time of application
6.2.4 Insulation

6.3 Concreting operation
6.3.1 Batching plant
6.3.1.1 Type-automatic, manual, etc.
6.3.1.2 Condition of equipment
6.3.1.3 Batching sequence
6.3.1.4 Availability of computer printouts

6.3.2 Mixing
6.3.2.1 Type-central mix, truck mix, job mix, shrink mix, etc.
6.3.2.2 Condition of equipment
6.3.2.3 Mixing time

6.3.3 Transporting-trucks, buckets, chutes, pumps, etc.

6.3.4 Placing
6.3.4.1 Methods-conventional, underwater, slipform, etc.
6.3.4.2 Equipment-buckets, elephant trunks, vibrators, etc.
6.3.4.3 Weather conditions-time of year, rain, snow, dry wind, temperature, humidity, etc.
6.3.4.4 Site conditions--cut, fill, presence of water, etc.
6.3.4.5 Construction joints
6.3.4.6 Contraction and isolation joints

6.3.5 Finishing
6.3.5.1 Type-slabs, floors, pavements, appurtenances
6.3.5.2 Method-manual or machine
6.3.5.3 Equipment-screeds, floats, trowels, straightedge, belt, etc.
6.3.5.4 Hardeners, water, dust coat, coloring, etc.

6.3.6 Curing

6.3.6.1 Type (water, covering, curing membrane, forms in place)
6.3.6.2 Application
6.3.6.3 Duration
6.3.6.4 Efficiency
6.3.7 Form removal (time of removal)
6.3.7.1 Vertical
6.3.7.2 Shoring

CHAPTER 3-DEFINITIONS AND ASSOCIATED PHOTOGRAPHS

Distress manifestations have been categorized and illustrated by photographs. Their severity and extent of occurrence have been quantified where possible. Their purpose is to attempt to standardize the reporting of the condition of the concrete in a structure. Those performing the survey should be thoroughly familiar with the various types of distress and the rating scheme before starting the survey.

A.1 *Crack*-A complete or incomplete separation, of either concrete or masonry, into two or more parts produced by breaking or fracturing.

A.1.1 *Checking*-Development of shallow cracks at closely spaced but irregular intervals on the surface of plaster, cement paste, mortar, or concrete.

A.1.2 *Craze cracks*-Fine random cracks or fissures in a surface of plaster, cement paste, mortar, or concrete.

Crazing-The development of craze cracks; the pattern of craze cracks existing in a surface.

A.1.3 *D-cracking*-A series of cracks in concrete near and roughly parallel to joints, edges, and structural cracks.

A.1.4 *Diagonal crack*- In a flexural member, an inclined crack caused by shear stress, usually at about 45 deg to the axis; or a crack in a slab, not parallel to either the lateral or longitudinal directions.

A.1.5 *Hairline cracks*-Cracks in an exposed concrete surface having widths so small as to be barely perceptible.

A.1.6 *Pattern cracking*-Fine openings on concrete surfaces in the form of a pattern; resulting from a decrease in volume of the material near the surface, or increase in volume of the material below the surface, or both.

A.1.7 *Plastic cracking*-Cracking that occurs in the surface of fresh concrete soon after it is placed and while it is still plastic.

A.1.8 *Shrinkage cracking* -Cracking of a structure or member due to failure in tension caused by external or internal restraints as reduction in moisture content develops, or as carbonation occurs, or both.

A.1.9 *Temperature cracking* -Cracking due to tensile failure, caused by temperature gradient in members subjected to external restraints or by temperature differential in members subjected to internal restraints.

A.1.10 *Transverse cracks*-Cracks that develop at right angles to the long direction of the member.

A.2 *Deterioration*- 1) Physical manifestation of failure of a material (e.g., cracking, delamination, flaking, pitting, scaling, spalling, straining) caused by environmental or internal autogenous influences on hardened concrete as well as other materials; 2) Decomposition of material during either testing or exposure to service.

Disintegration-Reduction into small fragments and subsequently into particles.

A.2.1 *Abrasion damage*-Wearing away of a surface by rubbing and friction.

A.2.2 *Blistering*-The irregular raising of a thin layer, frequently 25 to 300 mm in diameter, at the surface of placed mortar or concrete during or soon after completion of the finishing operation; blistering is usually attributed to early closing of the surface and may be aggravated by cool temperatures. Blisters also occur in pipe after spinning or in a finish plastic coat in plastering as it separates and draws away from the base coat.

A.2.3 *Cavitation damage*-Pitting of concrete caused by implosion, i.e., the collapse of vapor bubbles in flowing water which form in areas of low pressure and collapse as they enter areas of higher pressure.

A.2.4 *Chalking*-Formation of a loose powder resulting from the disintegration of the surface of concrete or of applied coating, such as cement paint.

A.2.5 *Corrosion*- destruction of metal by chemical, electrochemical, or electrolytic reaction with its environment.

A.2.6 *Curling*-The distortion of an originally essentially linear or planar member into a curved shape such as the warping of a slab due to creep or to differences in temperature or moisture content in the zones adjacent to its opposite faces.

A.2.7 *Deflection*-Movement of a point on a structure or structural element, usually measured as a linear displacement transverse to a reference line or axis.

A.2.8 *Deformation*-A change in dimension or shape.

A.2.9 *Delamination*-A separation along a plane parallel to a surface as in the separation of a coating from a substrate or the layers of a coating from each other, or in the case of a concrete slab, a horizontal splitting, cracking or separation of a slab in a plane roughly parallel to, and generally near, the upper surface; found frequently in bridge decks and other types of elevated reinforced-concrete slabs and may be caused by the corrosion of reinforcing steel; also found in slabs on grade caused by development, during the finishing operation, of a plane of weakness below the densified surface; or caused by freezing and thawing, similar to spalling, scaling, or peeling except that delamination affects large areas and can often be detected by tapping.

A.2.10 *Distortion*-See *Deformation.*

A.2.11 *Dusting*-The development of a powdered material at the surface of hardened concrete.

A.2.12 *Efflorescence*-A deposit of salts, usually white, formed on a surface, the substance having emerged in solution from within either concrete or masonry and subsequently been precipitated by evaporation.

A.2.13 *Erosion*-Progressive disintegration of a solid by the abrasive or cavitation action of gases, fluids, or solids in motion.

A.2.14 *Exfoliation*-Disintegration occurring by peeling off in successive layers; swelling up and opening into leaves or plates like a partly opened book.

A.2.15 *Exudation*-A liquid or viscous gel-like material discharged through a pore, crack, or opening in the surface of concrete.

A.2.16 *Joint spall*-A spall adjacent to a joint.

A.2.17 *Pitting*-Development of relatively small cavities in a surface; in concrete, localized disintegration, such as a popout; in steel, localized corrosion evident as minute cavities on the surface.

A.2.18 *Peeling*-A process in which thin flakes of mortar are broken away from a concrete surface, such as by deterioration or by adherence of surface mortar to forms as forms are removed.

A.2.19 *Popout*-The breaking away of small portions of a concrete surface due to localized internal pressure which leaves a shallow, typical conical, depression.

A.2.19.1 *Popouts, small*-Popouts leaving holes up to 10 mm in diameter, or the equivalent.

A.2.19.2 *Popouts, medium*-Popouts leaving holes between 10 and 50 mm in diameter, or the equivalent.

A.2.19.3 *Popouts, large*-Popouts leaving holes greater than 50 mm in diameter, or the equivalent.

A.2.20 *Scaling*-Local flaking or peeling away of the near-surface portion of hardened concrete or mortar; also of a layer from metal.

A.2.20.1 *Scaling, light*-Loss of surface mortar without exposure of coarse aggregate.

A.2.20.2 *Scaling, medium*-Loss of surface mortar 5 to 10 mm in depth and exposure of coarse aggregate.

A.2.20.3 *Scaling, severe*-Loss of surface mortar 5 to 10 mm in depth with some loss of mortar surrounding aggregate particles 10 to 20 mm in depth.

A.2.20.4 *Scaling, very severe*-Loss of coarse aggregate particles as well as mortar, generally to a depth greater than 20 mm.

A.2.21 *Spall*-A fragment, usually in the shape of a flake, detached from a larger mass by a blow, by the action of weather, by pressure, or by expansion within the large mass.

A.2.21.1 *Small spall*-A roughly circular depression not greater than 20 mm in depth nor 50 mm in any dimension.

A.2.21.2 *Large spall*-May be roughly circular or oval or in some cases elongated, more than 20 mm in depth and 150 mm in greatest dimension.

A.2.22 *Warping*-A deviation of a slab or wall surface from its original shape, usually caused by either temperature or moisture differentials or both within the slab or wall.

A.3 *Textural features and phenomena relative to their development.*

A.3.1 *Air void*-A space in cement paste, mortar, or concrete filled with air; an entrapped air void is characteristically 1 mm or more in size and irregular in shape; an entrained air void is typically between 10 μm and 1 mm in diameter and spherical or nearly so.

A.3.2 *Bleeding*-The autogenous flow of mixing water within, or its emergence from, newly placed concrete or mortar; caused by the settlement of the solid materials within the mass; also called water gain.

A.3.3 *Bugholes*-Small regular or irregular cavities, usually not exceeding 25 mm in diameter, resulting from entrapment of air bubbles in the surface of formed concrete during placement and consolidation.

A.3.4 *Cold joint*-A joint or discontinuity resulting from a delay in placement of sufficient time to preclude a union of the material in two successive lifts.

A.3.5 *Cold-joint lines*-Visible lines on the surfaces of formed concrete indicating the presence of joints where one layer of concrete had hardened before subsequent concrete was placed.

A.3.6 *Discoloration*-Departure of color from that which is normal or desired.

A.3.7 *Honeycomb*-Voids left in concrete due to failure of the mortar to effectively fill the spaces among coarse aggregate particles.

A.3.8 *Incrustation*-A crust or coating, generally hard, formed on the surface of concrete or masonry construction or on aggregate particles.

A.3.9 *Joint*-A physical separation in concrete, whether precast or cast-in-place, including cracks if intentionally made to occur at specified locations; also the region where structural members intersect such as a beam-column joint.

A.3.10 *Laitance*-A layer of weak and nondurable material containing cement and fines from aggregates, brought by bleeding water to the top of overwet concrete; the amount is generally increased by overworking or over-manipulating concrete at the surface by improper finishing or by job traffic.

A.3.11 *Sand pocket*-A zone in concrete or mortar containing fine aggregate with little or no cement.

A.3.12 *Sand streak*-A streak of exposed fine aggregate in the surface of formed concrete, caused by bleeding.

A.3.13 *Segregation*-The differential concentration of the components of mixed concrete, aggregate, or the like, resulting in nonuniform proportions in the mass.

A.3.14 *Stalactite*-A downward-pointing deposit formed as an accretion of mineral matter produced by evaporation of dripping water from the surface of concrete, commonly shaped like an icicle.

A.3.15 *Stalagmite*-An upward-pointing deposit formed as an accretion of mineral matter produced by evaporation of dripping water, projecting from the surface of concrete, commonly conical in shape.

A.3.16 *Stratification*-The separation of overwet or overvibrated concrete into horizontal layers with increasingly lighter material toward the top; water, laitance, mortar, and coarse aggregate tend to occupy successively lower positions in that order; a layered structure in concrete resulting from placing of successive batches that differ in appearance; occurrence in aggregate stockpiles of layers of differing grading or composition; a layered structure in a rock foundation.

A.3.17 *Water void*-Void along the underside of an aggregate particle or reinforcing steel which formed during the bleeding period; initially filled with bleed water.

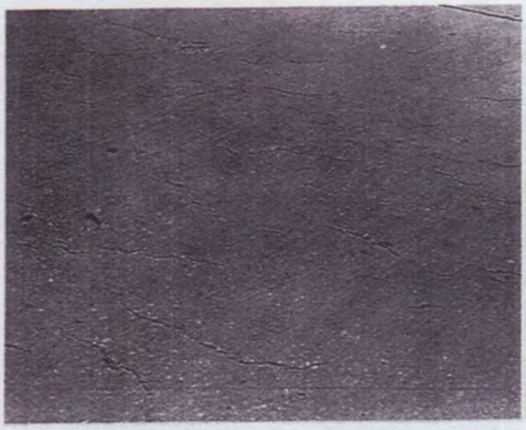


Fig. A.1.1-Checking

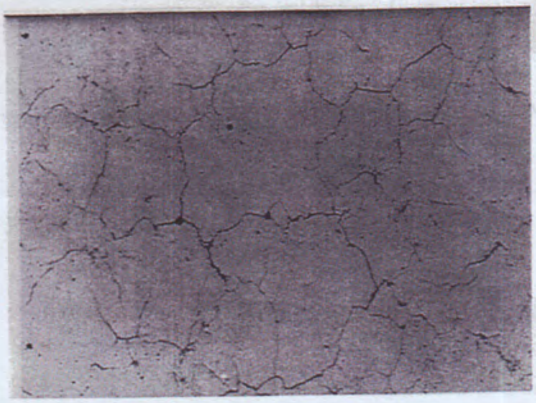


Fig. A.1.2 - Craze cracks

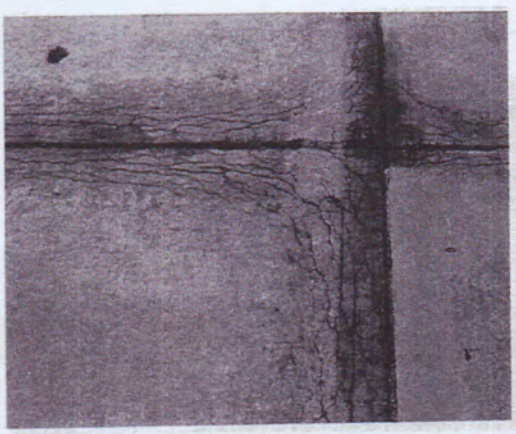


Fig. A.1.3-D-cracking (fine)

Fig. A.1.4-Diagonal cracks

Fig. A.1.6a-Pattern cracking (fine)

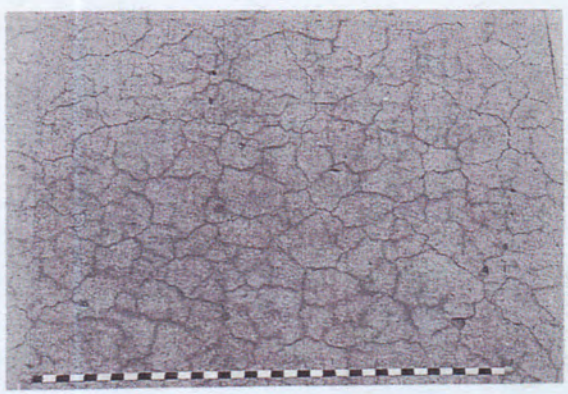


Fig. A.1.6b-Pattern cracking (medium)

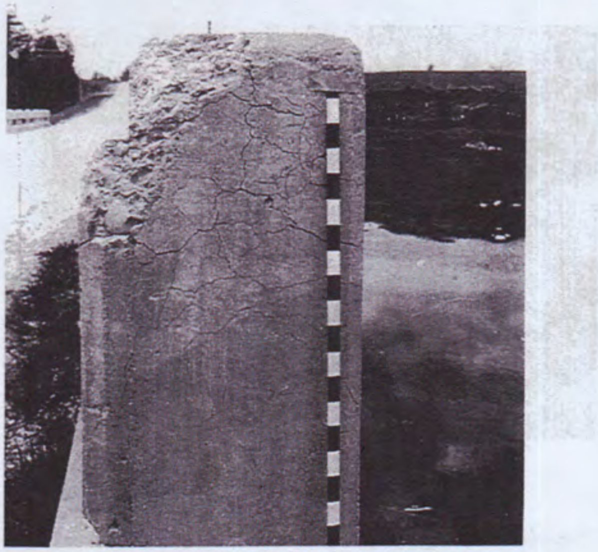


Fig. A.1.6c-Pattern cracking (wide)

Fig. A.1.6d-Pattern cracking (akali-silica reaction)

Fig. A.1.6e-Pattern cracking (restraint of volume change)

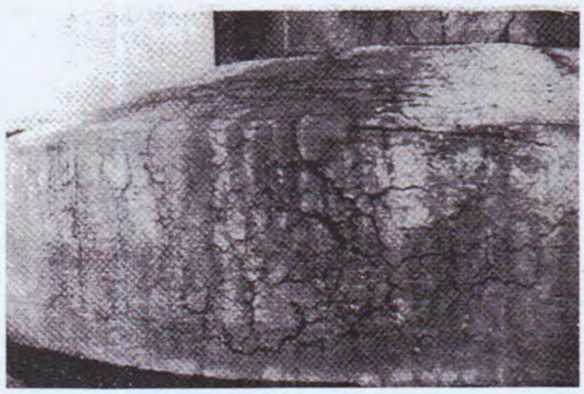


Fig. A.1.6f-Pattern cracking (alkali-carbonate reaction)

Fig. A.1.7-Plastic cracking

Fig. A.1.8-Shrinkage cracking

Fig. A.2.1-Abrasion damage

Fig. A.1.10-Transverse cracking (wide)

Fig. A.2.2-Blistering

Fig. A.2-Disintegration

Fig. A.2.3-Cavitation damage

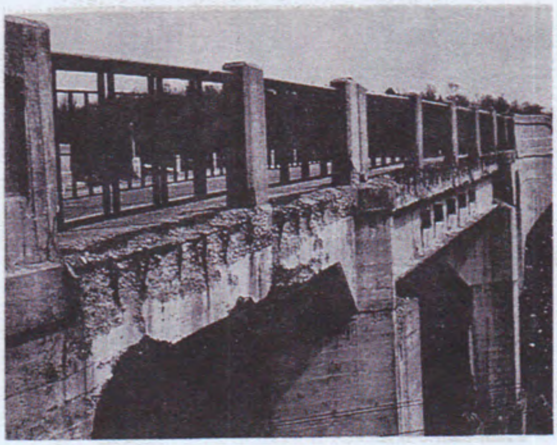


Fig. A.2.5-Corrosion damage

Fig. A.2.10-Distortion

Fig. A.2.9-Delaminations

Fig. A.2.11-Dusting

Fig. A.2.12-Efflorescense

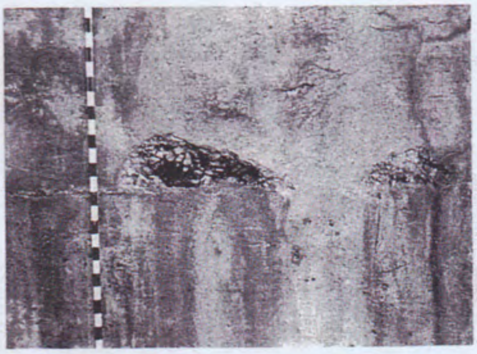


Fig. A.2.13-Erosion

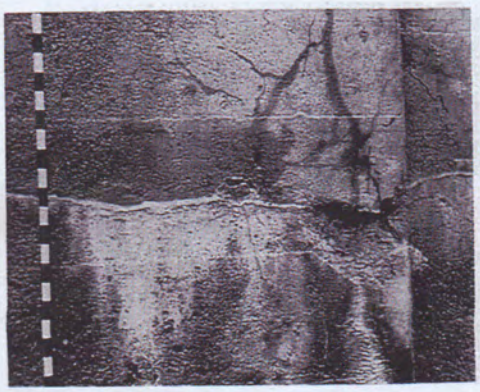


Fig. A.2.15-Exudation

Fig. A.2.16a-Joint spall

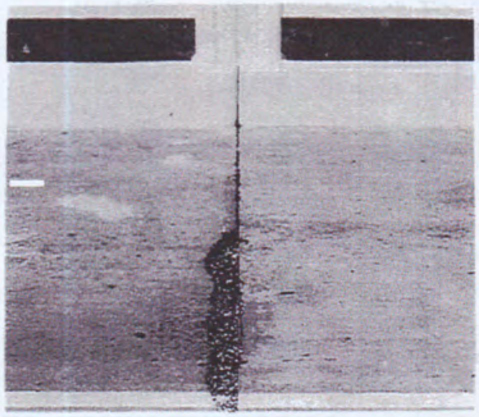


Fig. A.2.16b-Joint spall

Fig. A.2.17-Pitting

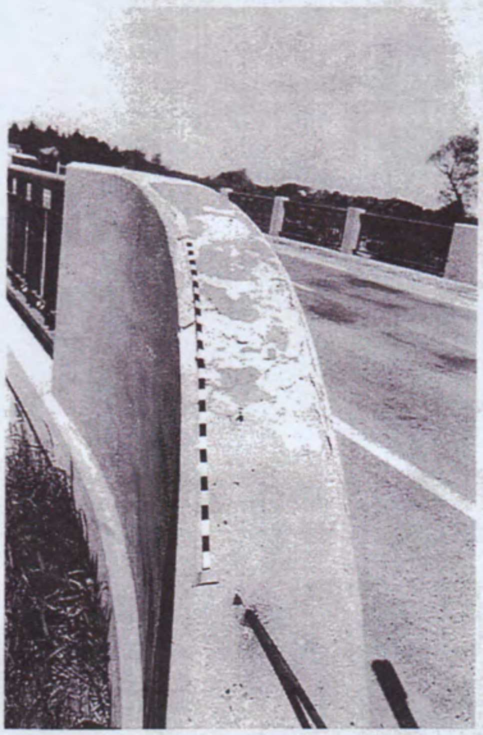


Fig. A.2.18a-Peeling

Fig. A.2.19—Popout

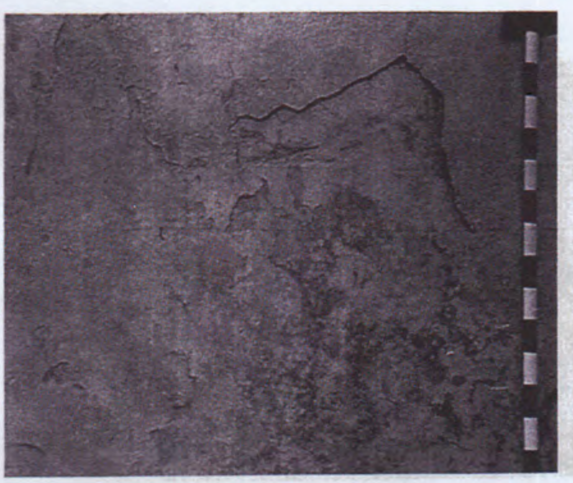


Fig. A.2.18b-Peeling (close-up)

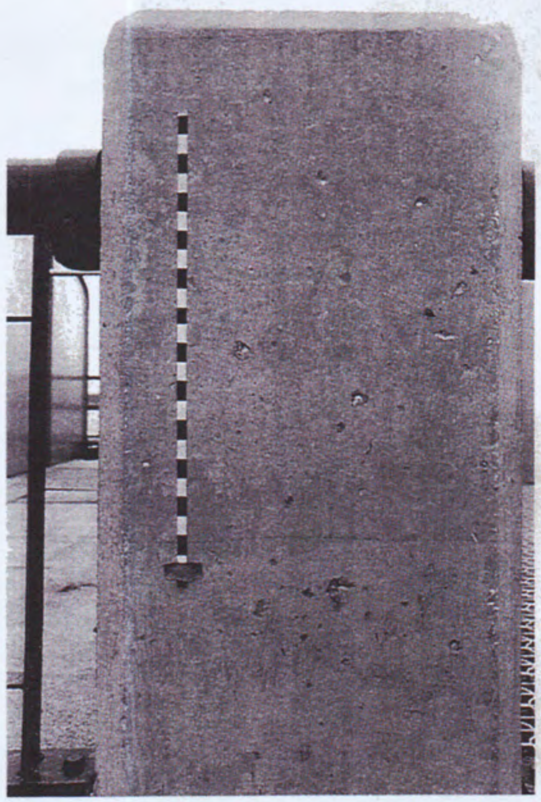


Fig. A.2.19.1-Popout (small)

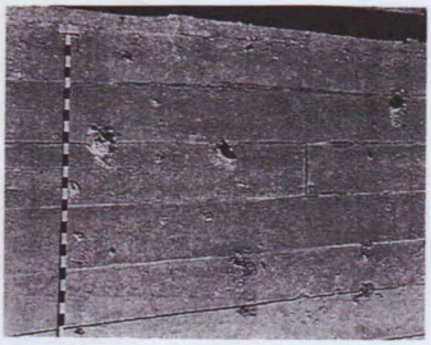


Fig. A.2.19.2-Popout (medium)

Fig. A.2.19.3-Popout (large)

Fig. A.2.20.1a-Scaling (light)

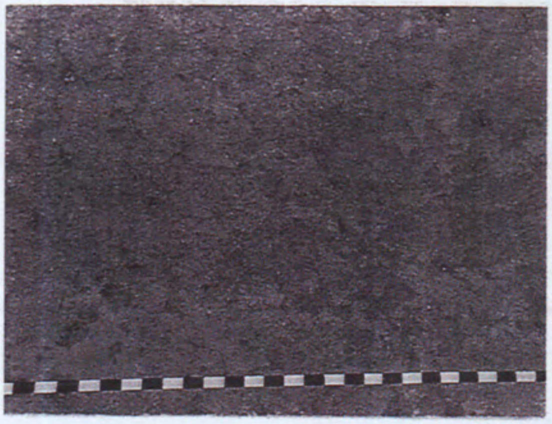


Fig. A.2.20.1b-Close-up scaling (light)

Fig. A.2.20.2a-Scaling (medium)

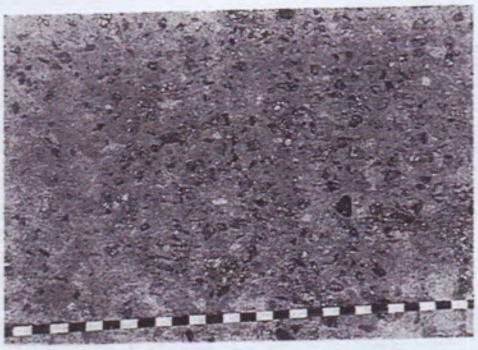


Fig. A.2.20.2b-Close-up scaling (medium)

Fig. A.2.20.4a-Scaling (very severe)

Fig. A.2.20.3a-Scaling (severe)

Fig. A.2.20.4b-Close-up scaling (very severe)

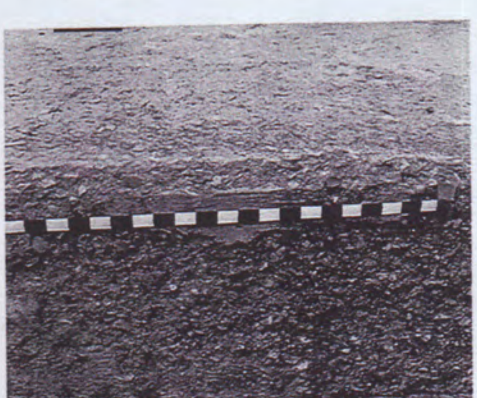


Fig. A.2.20.3b-Close-up scaling (severe)

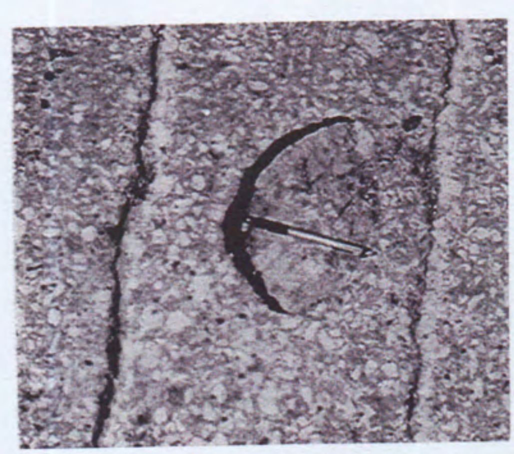


Fig. A.2.21.1-Small spall

Fig. A.2.21.2—Large spall

Fig. A.3.3—Bugholes

Fig. A.3.5—Cold joint

Fig. A.3.6—Discoloration

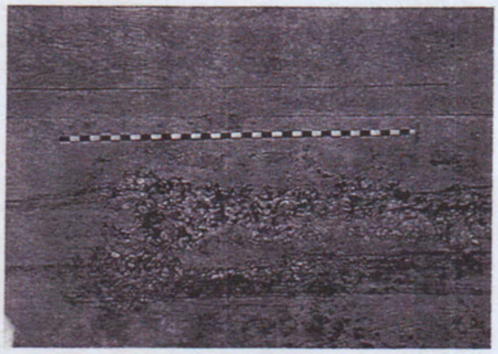


Fig. A.3.7—Honeycomb

Fig. A.3.14-Stalactite

Fig. A.3.12-Sand streak

This report was submitted to letter ballot of the committee and approved according to ACI balloting procedures.

Appendix B:

Fort Flagler—Analysis of Historic Tree Cover Patterns and Management Implications

Prepared by
Washington State Parks and Recreation Commission, 2002

Fort Flagler State Park

Analysis of Historic Tree Cover Patterns and Management Implications

January, 2002

Washington State Parks
Historic Preservation Program

Prepared by
Historic Preservation Program
Resources Development Division
Washington State Parks and Recreation Commission

I. Administrative Background

Fort Flagler became a state park in 1955 when the Washington State Parks and Recreation Commission applied for and received from the federal government all of the acreage associated with the former military reservation. The application for the property set aside the area at the north end of the park for historic purposes; the area embraced the fortifications and the garrison buildings. For reasons not now apparent, but probably related to the absence of funding, the historic area never developed along the lines of the original application, and the fortifications were classified as a restricted area to discourage visitor use of the hazardous structures.

Within the last several years, volunteers have removed many of the hazardous conditions that resulted from partial flooding and invasive vegetation. Prior to that time, park forces removed a number of large trees that were threatening historic resources, an action that was consistent with the "Coast Defense Resources Management Plan," adopted by State Parks in 1986.

Fort Flagler was listed in the National Register of Historic Places on May 3, 1976.

II. Issue Background

Park Manager Mike Zimmerman proposed the removal of trees from in front of the main battery to re-establish the historic viewshed as an aid in park interpretive programs. On December 12, 2000, he assembled a team of resource professionals to evaluate and comment on the proposal; team members included the following:

Rob Fimbel, Chief, Resource Stewardship Program, WSPRC
Wendy J. Gerstel, Geologist, Department of Natural Resources
David M. Hansen, Historic Preservation Officer, WSPRC
Dan Ingman, Environmental Planner, Resource Stewardship Program
Ted Smith, Northwest Region Regional Resource Steward.

The group examined the area in front of the main battery from the top of the bluff as well as from the beach below. It also reviewed clearing in progress in front of Battery Calwell and examined several individual trees that appeared to lifting portions of an historic sidewalk.

III. Issue Identification

There were concerns that removal of the trees in front of the main battery might destabilize the bluff, and there was ample evidence that the bluff is eroding at present. The rate of erosion, and the extent of erosion in the past, could not be determined. A single large diameter pipe was exposed at the bluff face, and it was observed that erosion was more advanced in the immediate area of the pipe. It was assumed that this was the drain from the main battery, and that efforts to clear the standing water in the battery may have encouraged further erosion of the bluff.

There was a suggestion that instead of clearing the area in front of the main battery, more trees should be planted to provide coarse woody material as an aid in regenerating the original beach condition. Such an action would be appropriate because bluff faces along Admiralty Inlet and Puget Sound have been highly altered in recent times and managing the bluffs at Fort Flagler for their conservation value would be consistent with State Parks mission. As a counter to that position, it was pointed out that the area in front of the main battery had been clear of trees for most of the previous 100 years, that the length of the bluff in front of the battery was a modest proportion of the entire undisturbed length of bluff within the park, and that Fort Flagler was an historic property and to be managed with regard to its historic resources

The group agreed that more information was needed about the extent of the tree cover from the earliest period available to the present, as well as any other data that might be brought to bear on the question of bluff erosion.

IV. Information Sources

A. Historic period information sources consist of the following materials and their locations:

1. written remarks of engineers during the original survey and construction of Fort Flagler (Record Group 77, Pacific Northwest Regional Office, National Archives and Records Administration)

2. photographs that incidentally portray tree cover or bluff condition (Fort Flagler State Park files, NARA, and private collections)

3. measured drawings that depict the horizontal contour of the bluff or extent of tree cover (State Parks engineering files and NARA).

B. Current information sources consist of the following sources and their locations:

1. Department of Ecology shoreline photo collection at www.ecy.wa.gov/apps/shorephotos/index.html

2. USGS aerial photos at www.terraserver.microsoft.com

3. Department of Natural Resources aerial photographs.

4. Aerial photographs by Dale Russell, volunteer photographer at Fort Flagler

V. Interpretation of Information Sources

A. Historic Period

1. Written Record

The correspondence files of the Chief of Engineers for the construction of fortifications in Puget Sound include incidental remarks by the constructing engineers about tree cover and soil conditions. The site of Fort Flagler as they found it in 1897 was heavily forested and their work was frustrated by multiple and overlapping tree falls that made it difficult for them to reach the actual surface of the ground. They noted that the soil was very hard; once work began, they would use dynamite to loosen the material at the site of the main battery sufficient for it to be removed. They were interested in the stability of the bluff (as can be inferred from the existence of the photograph mentioned in the next section) but concluded that it was sufficiently strong.

There is no mention of soil cores or other analytical methods capable of more precisely gauging the strength or quality of the soils.

2. Photographs

The earliest photograph of the bluff was probably taken in 1896 by Corps of Engineer officers or employees (Figure 1). It shows the north face of the bluff, looking west, although it is difficult to suggest a more specific location. Given that the main battery was the only work planned at the time, it seems likely that the photo depicts the nature of the bluff in front of the site for the battery.

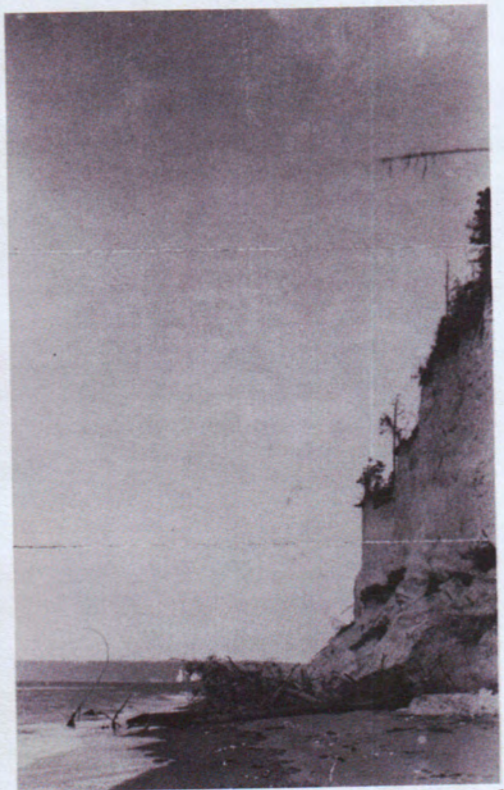


Figure 1. National Archives & Records Administration

In 1897, work began to cut down the height of the bluff as part of the modifications necessary to fortify the site. As shown in Figure 2, the area has been logged off and perhaps burned, and the steam shovel has removed earth along the crest of the bluff, creating a bench some 15 feet below the original ground surface. The photograph also documents the depth of the original top soil.

Figure 2. National Archives & Records Administration

Figure 3 is a view looking north along the main battery access road with the silhouette of Battery Wilhelm's gun number two visible in the distance. The photo is undated, but it is after 1910 and prior to 1918. As expected, there are no trees on the horizon nor is there any vegetation of appreciable scale to the rear of the main battery.

Figure 3. Park Collection

The other historical photo (Figure 4) is an aerial from 1937. It appears that large-scale vegetation has established itself along the bluff line to the west of the main battery, although the area to the south remains clear.

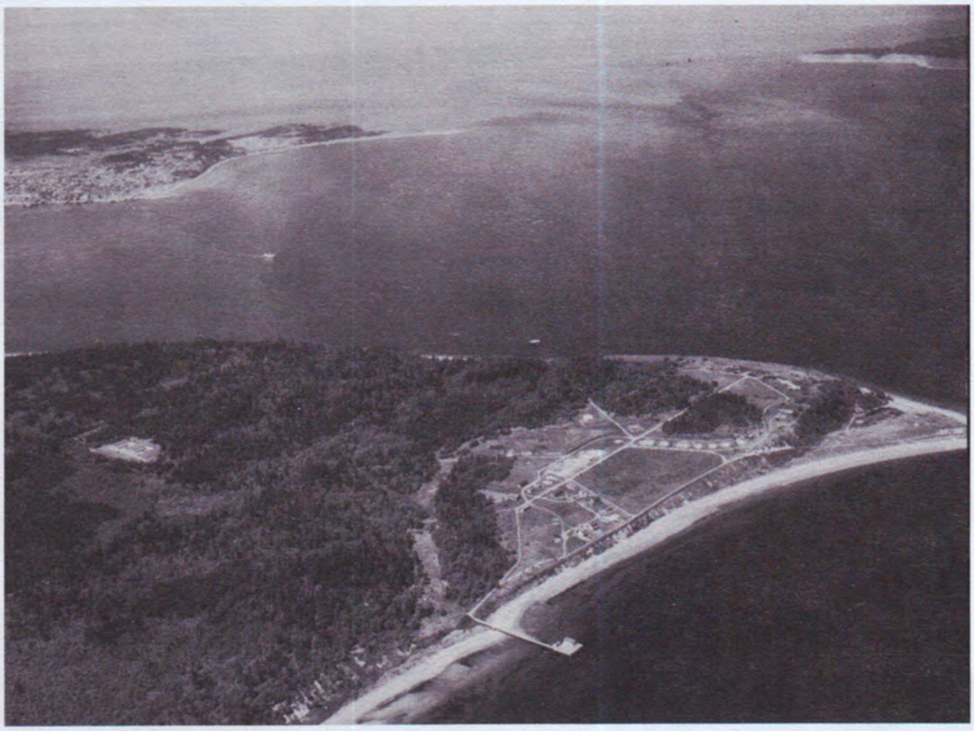


Figure 4. Private Collection

3. Measured Drawings

The Corps of Engineers completed a thorough topographic survey of the contours of the future Fort Flagler in 1897. They were preparing for a major and well-funded construction project, and their work in advance of that activity was consistent with sound project planning. It is reasonable to assume, therefore, that the contours as well as the horizontal outline of the bluff were rendered as accurately as the technology of the period would allow. A portion of the 1897 survey with the future location of the main battery superimposed upon it is at Figure 5.

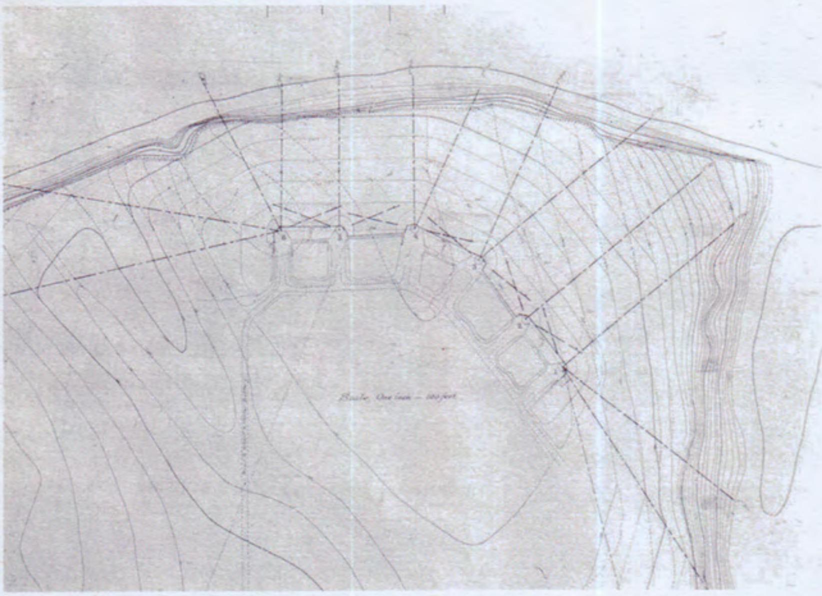


Figure 5. National Archives & Records Administration

A second site plan (Figure 6) dating to about 1910 shows the contours and wooded areas subsequent to construction. Extensive wooded areas are indicated to the south and west of the main battery, and appear to press tightly upon the roadways that have been made through them.

It is not possible to tell if the horizontal outline of the bluff is the result of a re-survey associated with the production of the site plan or if it is based upon the initial 1897 survey. In any case, the drawings that predate WWI can be regarded generally as the most accurate of those produced during the military use of the facility.

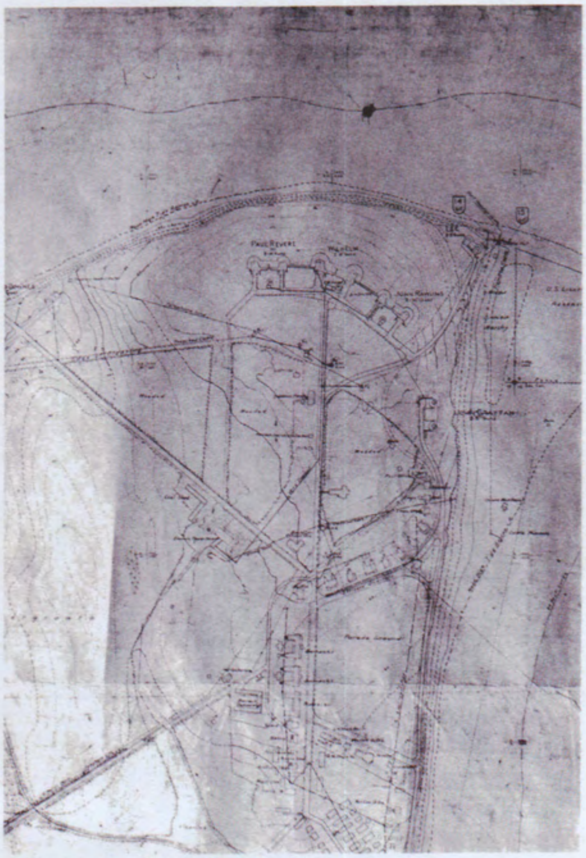


Figure 6. State Parks Engineering

State Parks engineering files and the National Archives and Records Administration do not contain any large-scale site plans of Fort Flagler that show the extent or type of vegetation of later date until the World War II and post-war period. As a group, these later maps conflict in their portrayal of tree cover in the vicinity of the main battery.

Two undated drawings were most probably produced in the late war or immediate post-war period; the legend still refers to the Harbor Defenses of Puget Sound. Although the drawings do not carry any dates, they are close in time since they carry similar Corps of Engineers sequence numbers.

Figure 7 is a portion of drawing F-26-3-6, and is considered the earlier of the two. There is no tree cover to the north of the main battery with the exception of a linear area on the bluff edge to the immediate front of Battery Rawlins. A larger area of tree cover is to the northeast of Battery Rawlins and west of the approach road to Battery Lee.

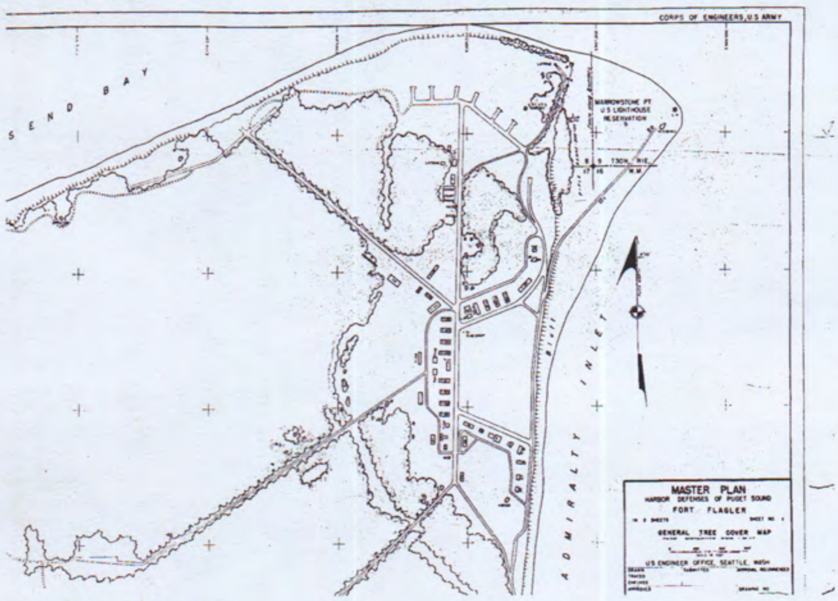


Figure 7. State Parks Engineering

Figure 8 is drawing F-26-3-21, in the same series as the drawing in Figure 7, and by its title of "Detail Tree Cover Map" presumably should show with greater clarity the extent of tree cover. Instead it depicts a pattern that is distinctly different from its companion drawing F-26-3-6.

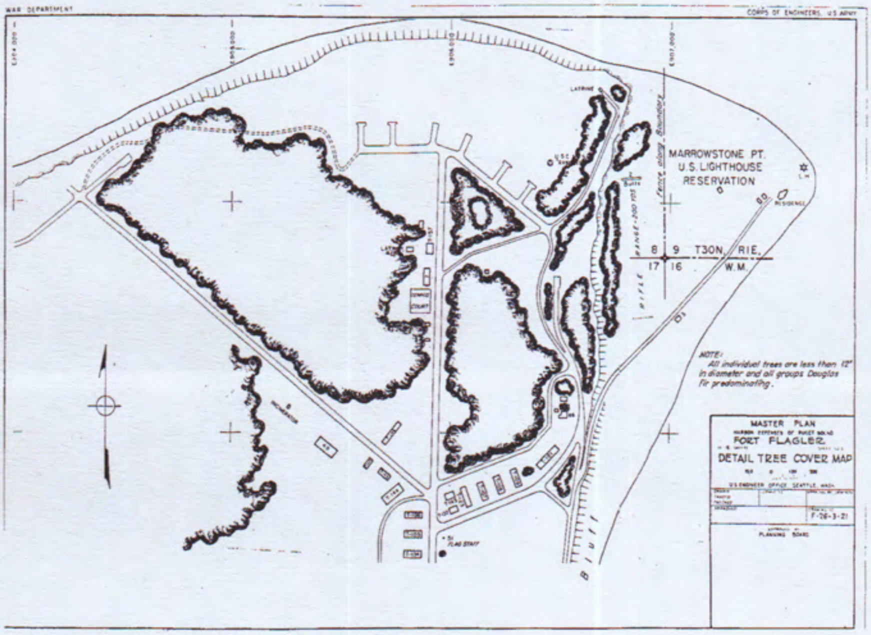


Figure 8. State Parks Engineering

There is no tree growth represented on the bluff line in front of the main battery but now trees appear immediately to the rear of Battery Rawlins although none were indicated in that location on the previous drawing. Moreover, the shape and extent of the individual coverage areas has changed significantly.

The final drawing with tree cover content is dated 1951, and is presented here as Figure 9. Since Figure 8 depicts buildings that were not built until 1942-43, not more than nine years has elapsed between the time that these two drawings were prepared. However, Figure 9 portrays massive growth in front of the main battery even to the extent of extending over the forward edge of the concrete fortifications

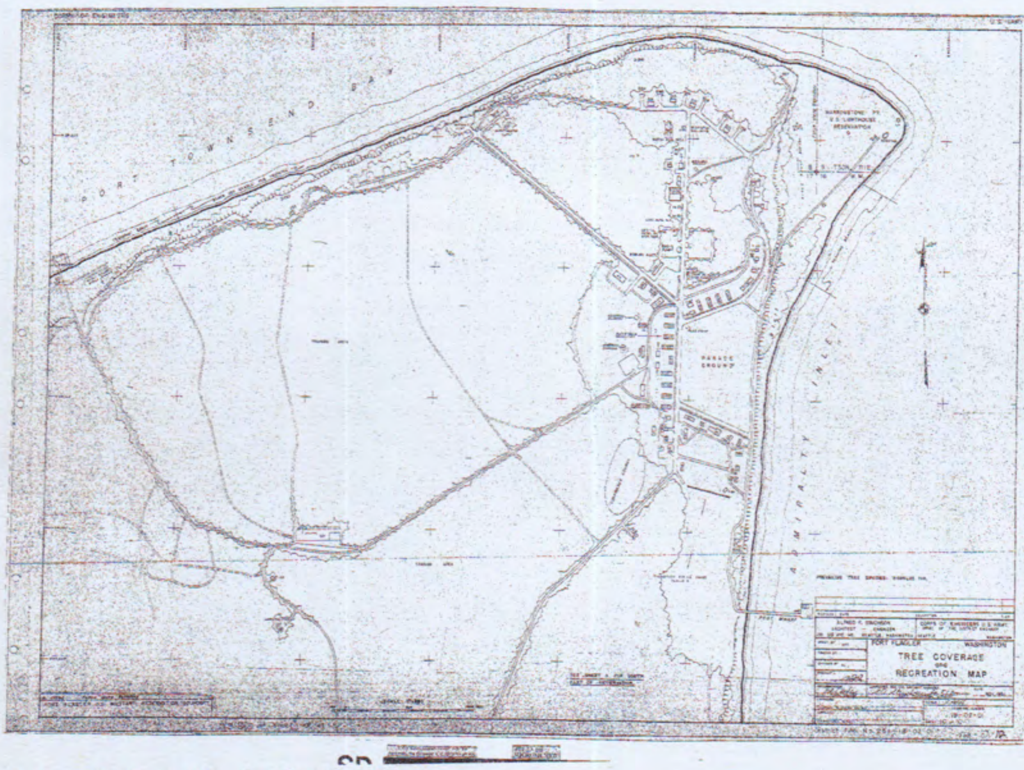


Figure 9 State Parks Engineering

There is a significant discrepancy between Figures 8 and 9. One explanation is that Figure 9 depicts brush as well as trees rather than trees alone as the title might suggest.

A single drawing answers questions regarding the relationship between the advancing erosion around the single drain emerging from the bluff and the increase in drainage that may have resulted from the clearing the drains in the main battery.

Figure 10 is an undated drawing from the same sequence as Figures 8 and 9. As presented in this drawing, two drains extend from the battery. The most western drain connects to the two emplacements of Battery Revere, and it is this drain that projects visibly from the bluff. The eastern drain connects the emplacements of Batteries Wilhelm and Rawlins, but it runs to the northeast and terminates in the woods (probably in a sump) and does not reach the bluff. Since only the drains in Battery Rawlins were completely inoperable, clearing them and therefore increasing the material in the drains could not be part of any erosion associated with the separate drain at Battery Revere.

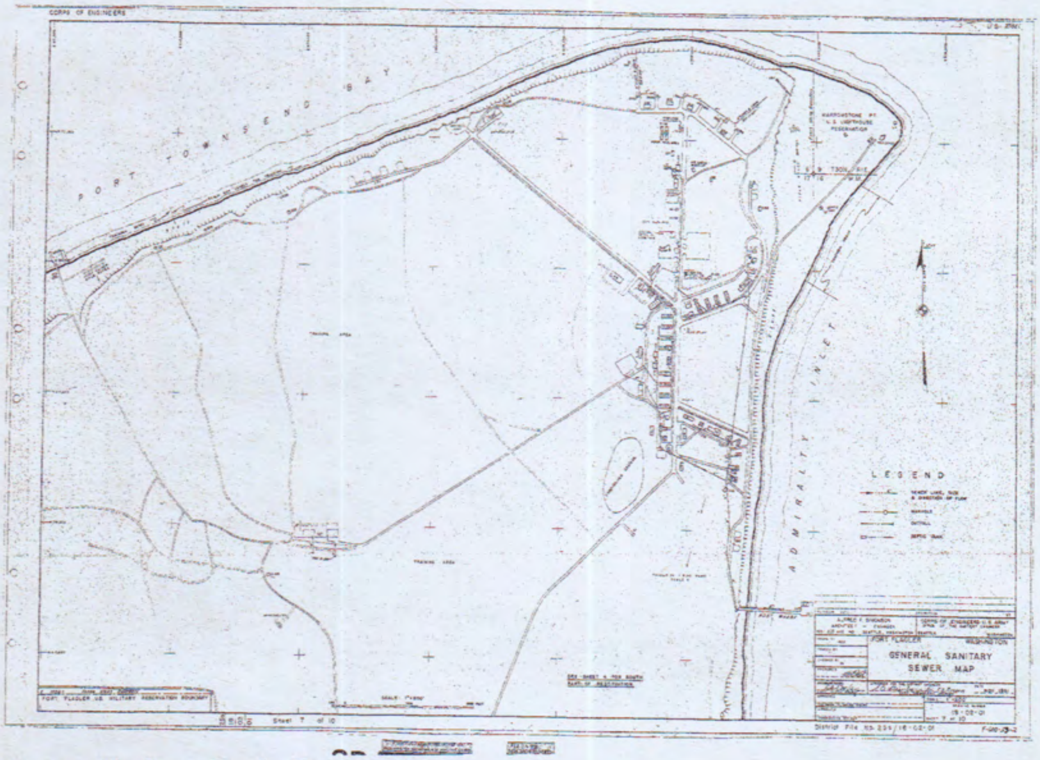


Figure 10 State Parks Engineering

VI. Conclusions

The bluff was heavily disturbed during the construction of the fortifications in 1897, and has eroded at an uncertain rate since that time. Any character that it has now dates from the period of construction.

The return to operating condition of drains in a portion of the main battery has had no impact on the rate of erosion since the drains in question do not terminate at the bluff face.

VII. Recommendations

A. Install tight line from exposed daylight end of drain to the beach.

B. Remove tree growth and heavy vegetation from selected sample areas in front of the main battery and observe if accelerated erosion can be associated with the clearing.

C. If no evidence of accelerated erosion is present, remove tree growth and heavy vegetation sufficient to establish a viewshed adequate for interpretive purposes.

D. Maintain the area in front of the main battery (including the areas that have been cleared) as an open field. Small trees and shrubs may be planted in the open field provided that they do not obstruct the view from the main battery to the water, and that their height does not exceed eight feet.

Appendix C:

Long-term Conservation Project for Coastal Defense Fortifications

Prepared by
Grulich Architecture + Planning Services, 2002

Long-term Conservation Project for Coastal Defense Fortifications

FOR

Washington State Parks and Recreation Commission

30 OCTOBER 2002

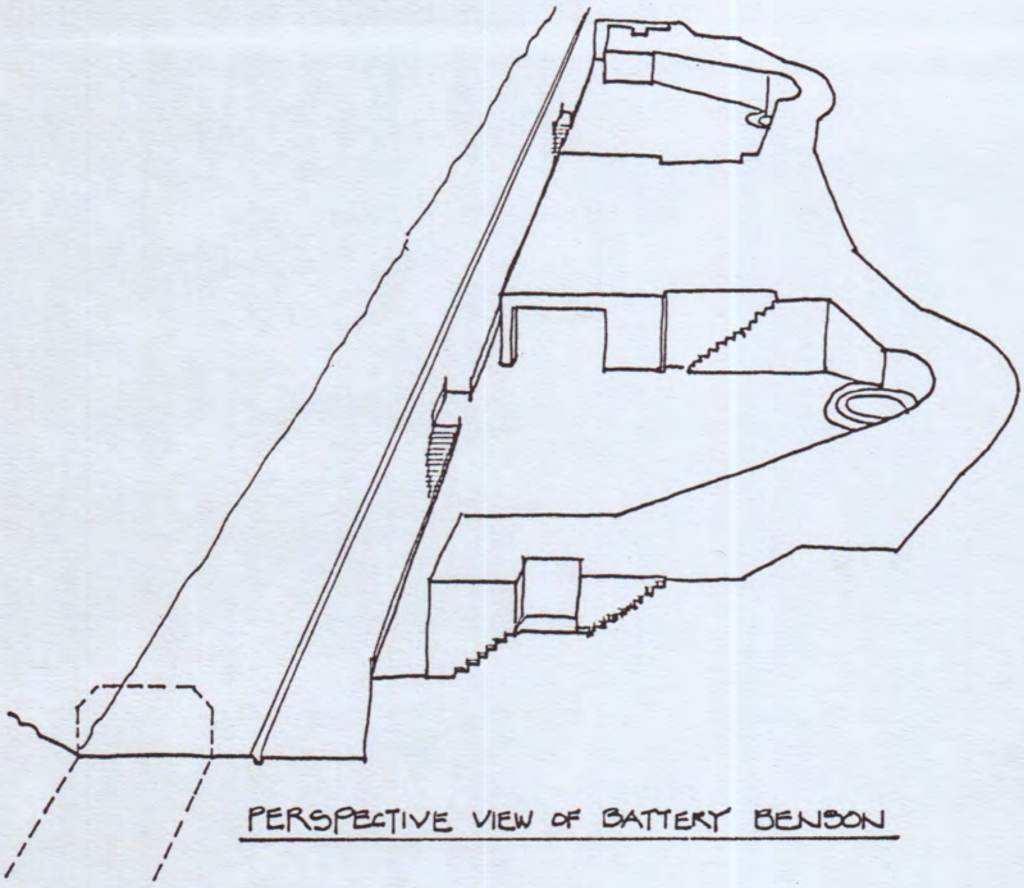
GRULICH ARCHITECTURE + PLANNING SERVICES
49 BROADWAY, STE, 200, TACOMA, WASHINGTON
253-272-0007

INTRODUCTION

The long-term conservation of structures in the Coastal Defense Fortifications include several different types of structures. The purpose of this study is to attempt to find conservation solutions for two of these types at Fort Worden: small predominately subterranean structures represented by the Switchboard; and large, open, mass-concrete structures such as the gun emplacements of Battery Benson at Fort Worden. The conservation efforts are meant to be actions that will slow the deterioration for at least 30 years during which time normal maintenance would be minimal. The objective during the period of the conservation is for the historic fabric of the subject structure to survive with minimal deterioration.

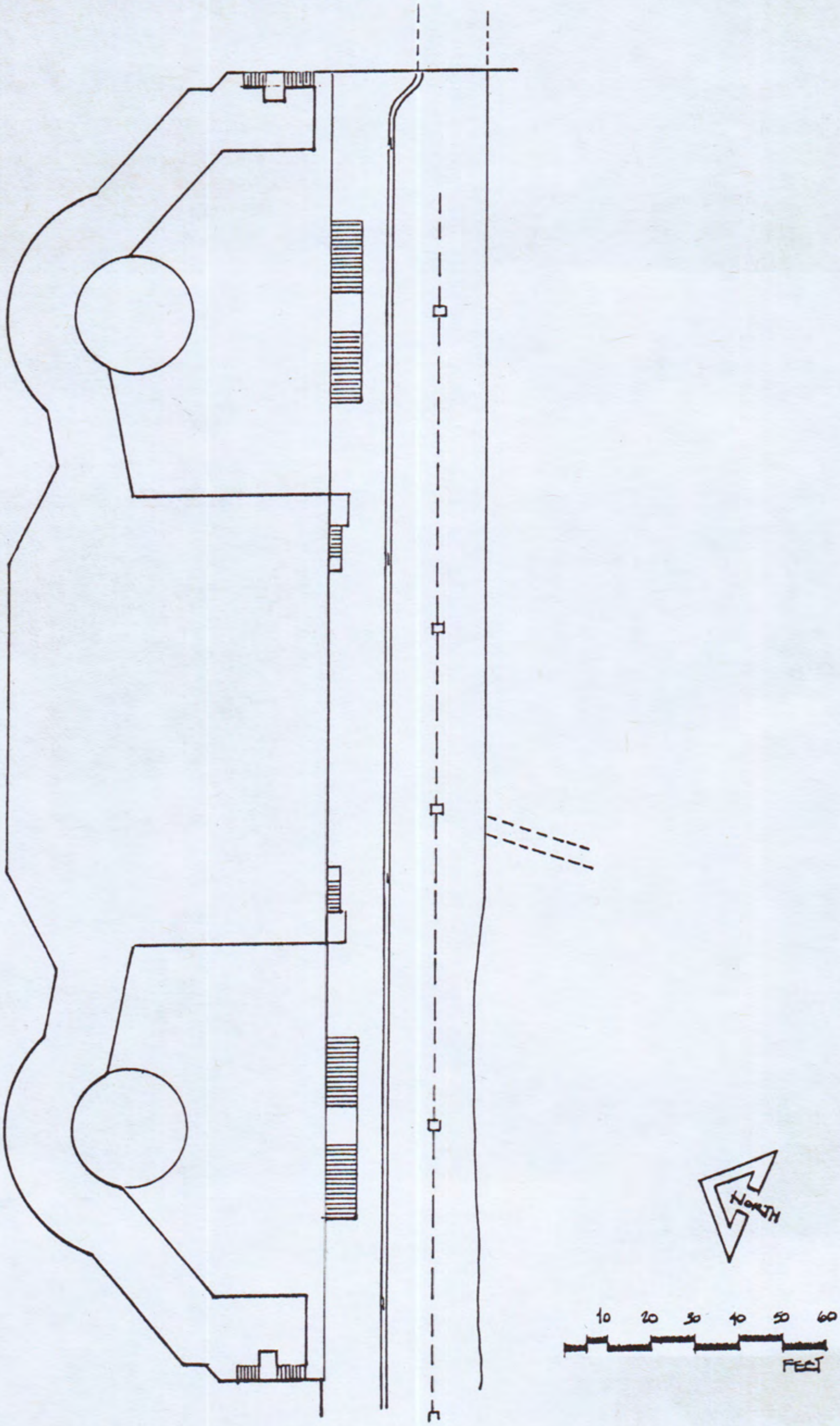
The Switchboard is a single room located beneath an earthen mound with access via a doorway and corridor to the interior space. The Switchboard is similar in design and size to various smaller fortification structures, approximately 30 feet by 15 feet; while Battery Benson represents gun emplacements both large and small.

Battery Benson is a typical gun emplacement for two 10 inch disappearing rifles. The battery measures approximately 280 feet in length, 80 feet in width and over 20 feet in height from the blast apron crest to the battery's base.



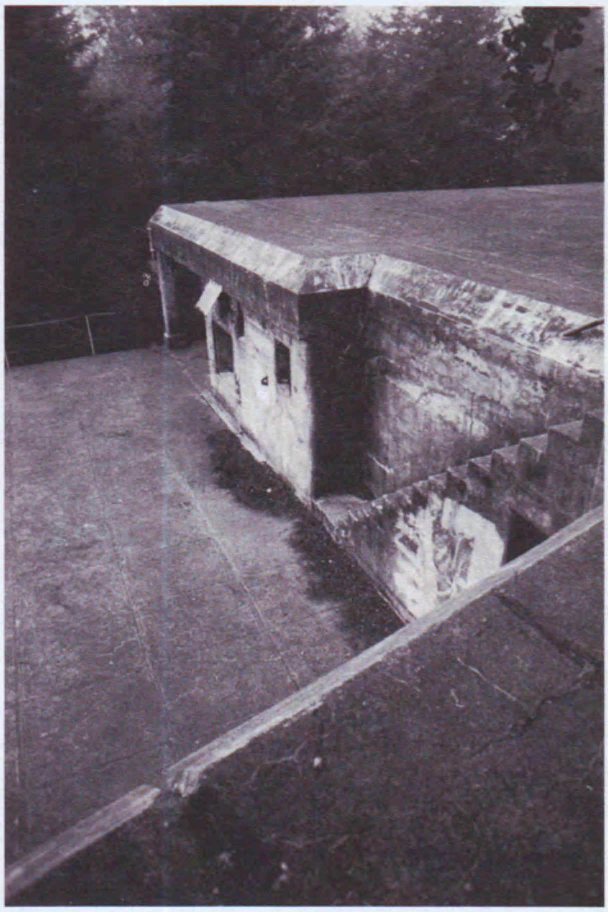
PERSPECTIVE VIEW OF BATTERY BENSON

The long-term conservation of Battery Benson involves two concepts: first, the concept of entombment or the burying of the gun emplacement; while the second is a roof-over concept of placing a structure over the gun emplacement.


NORTH
10 20 30 40 50 60
FEET

EXISTING CONDITIONS

The conditions found at Battery Benson, constructed in 1904, are similar to those found in most gun emplacements in the Washington State and now in the ownership of Washington State Parks and Recreation Commission. Most of these fortifications were constructed during the same time period from the late 19^{th} to the early 20^{th} century. The general condition of these large mass concrete structures shows varying degrees of deterioration from exposure to the elements. The deterioration is promoted by exposure to the weather and specifically exposure to constant moisture both on the surface and at sub-surface levels. The mass concrete structure was constructed when modern use of concrete was in its infancy, and there was not a comprehensive understanding of the materials. These massive concrete structures were batched and poured on-site under various climatic weather conditions at differing locations and under different construction managers.



Detail of the sidewall of the magazine section dividing the two guns. A portion of the blast apron is in the foreground.

MASS-CONCRETE

The concrete used in the construction of Battery Benson was mixed in batches using beach sand and large rounded stone aggregate. Existing spalls in the concrete reveal the interior concrete core. The concrete was placed without vertical expansion joints and the inconsistent separation of the horizontal lifts of concrete did not promote horizontal consolidation. Therefore the mass concrete sections have been isolated both vertically and horizontally. The fractures in the concrete promote the growth of organic material and vegetation along with accumulated debris. Plant material within the fractures has caused additional spalls and deterioration. The fractures also allow moisture to penetrate into the interior of the concrete mass.

The western edge of Battery Benson viewed from the roadway at the rear of the gun emplacement.

EMBEDDED METAL

Moisture penetration has been a continuous problem, and this is verified by the various coatings the Army applied to the surface in an attempt to seal the concrete surfaces and retard moisture penetration.

The embedded metal features found are railings, doors and other features associated with the gun emplacement. The expansion of rusted metal has caused concrete spalls. To preserve the metal features from continuing deterioration, all metal should be cleaned of paint and rust, and coated with a protective material.

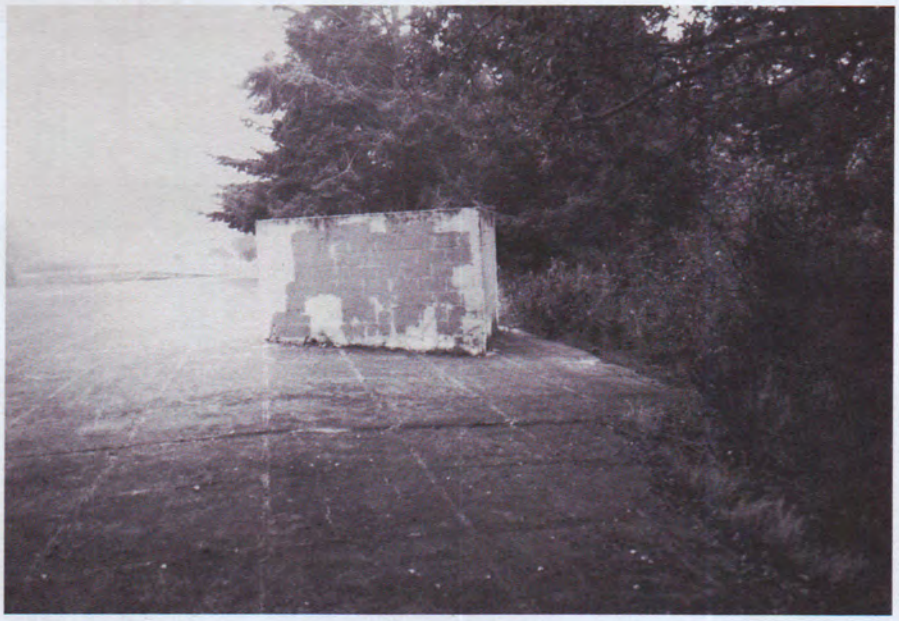
STABILIZATION

In order to properly conserve Battery Benson several activities are required to stabilize the existing structure. Soil, vegetation and other accumulation of debris must be removed. A herbicide should be applied to all areas in which plants have grown. All debris should be removed and the existing drainage system should be cleaned throughout. All exposed metal should be cleaned and coated with a protective material. The short term conservation of metal features can be accomplished by an application of a protection coating over active rust; while the long-term conservation will require removal of the previous coatings and all rust, and the application of a rust-inhibiting coating. With a large number of protective coatings for metal available, it can be a matter of cost in determining the degree of protection and the duration of the protection desired.

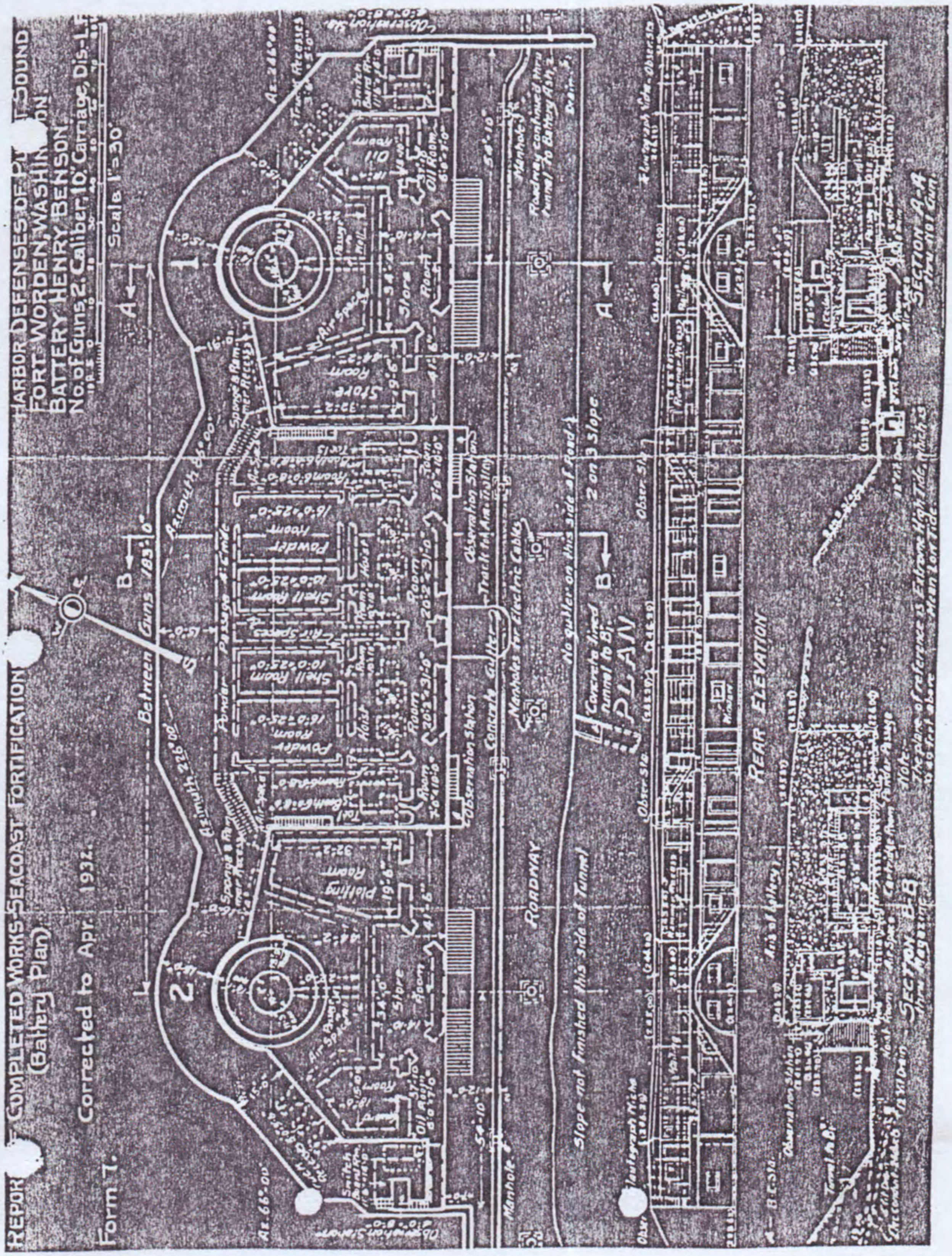
Detail of gutter filled with debris and soil at rear edge of gun emplacement. The gutter and drainage system should be cleaned and restored to a functioning system.

PREPARATION FOR CONSERVATION

All of the conservation concepts require the removal of debris from the gun emplacement site. Large trees, shrubs, vines, and grasses have been established on or near the gun emplacements. Vegetation in the immediate area of the gun emplacements should be removed including roots of large trees. The entombment concept will require some additional preparation of the gun emplacements. The gun emplacements have various openings and depressions which should not be filled with the gravel or other fill materials. In preparation for entombment, the fill materials are to be used to cover the gun emplacement. At the platform base of the disappearing rifles are depressions which should be covered by a structural-cover before the installation of fill materials. Other openings lead to passages, stairs and equipment rooms, each of these openings should be sealed to preserve these interior spaces from the fill material. Galvanized metal panels could be used for horizontal openings such as vents in the platform. Corrugated galvanized metal would be adequate for large openings. Where the openings are larger the metal panels may require additional structural support to withstand the pressure of the fill material.



A concrete masonry-unit base is located atop Battery Benson's blast apron. The base is square, approximately 12 feet by 12 feet, and has several steel anchor bolts projecting from its top.

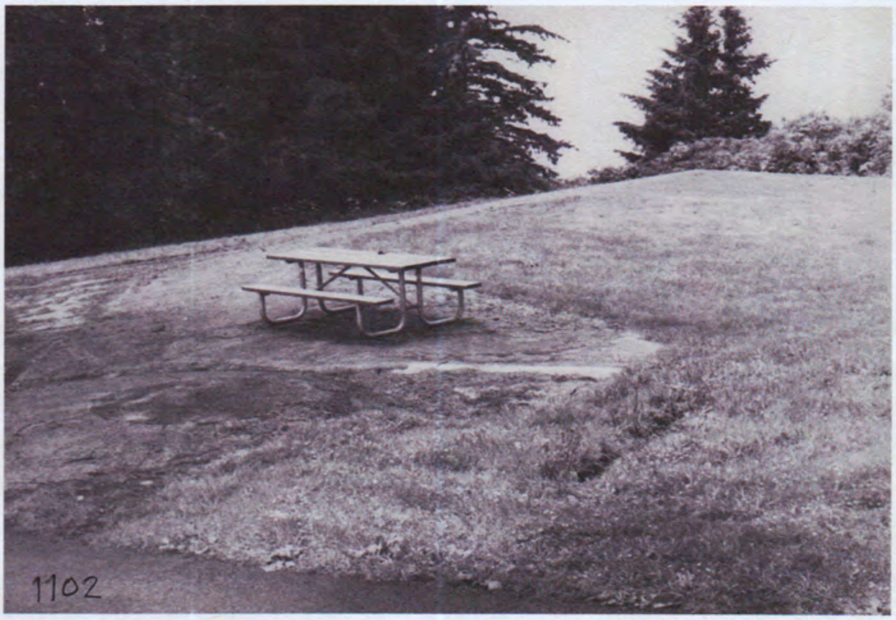

Form 7.
Corrected to Apr. 1932.
(Battery Plan)
FORT WORDEN, WASHIN
BATTERY HENRY BENSON
Scale 1"=30'
PLAN
REAR ELEVATION
ROADWAY

ENTOMBMENT CONCEPT

Although Battery Benson is the design model for the long-term conservation plan, there are similar coastal fortifications which are located in environments unlike that of Battery Benson. Battery Benson is located in a remote area away from the average park patron and therefore can be analyzed as a remote facility with little contact by the public. At a site in which the public has significantly more contact, such as Ft. Casey on Whidbey Island or Fort Columbia at the mouth of the Columbia River, long-term conservation must also address the safety issues of direct contact with the park patron as well as the need for recreational space for park activities.

Battery Benson is one of four gun emplacements for the 10 inch disappearing rifles at the crest of Artillery Hill. Battery Benson is separated from Batteries Ash, Quarles and Randol by a parados.

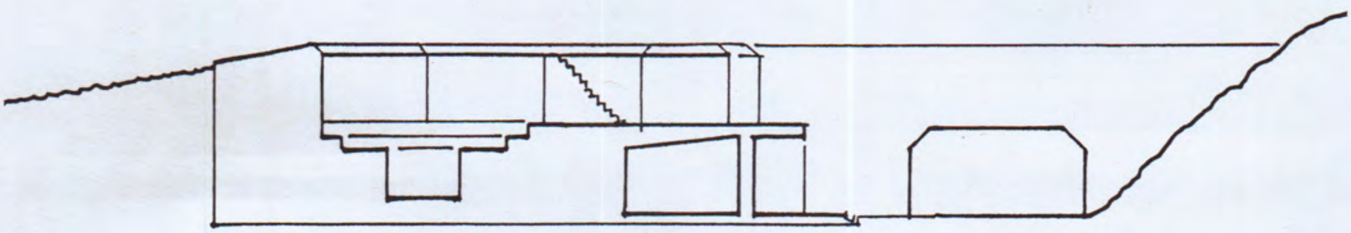
The need for a conservation plan which addresses the issues of recreational space as well as park patron safety establishes the viability of entombment of the facility. This has been done at Ft. Columbia with the burying of Battery Ord. #3. Battery Ord #3 was buried over 50 years ago and has continued to deteriorate with the migration of moisture through the structure. Battery Ord #3 was entombed without the benefit of an interior drainage system. The burying of Battery Ord #3 gun emplacement has provided additional recreational space to the Ft. Colombia park campus.



View of large recreational area atop Battery Ord #3. Ord #3 was buried with sand as fill material. The area is covered with grass.

The entombment of Battery Ord #3 was accomplished with the importation of sand to fill the gun emplacement platform and to fill in the area adjacent to the battery to form a smooth transition with the surrounding natural surfaces.

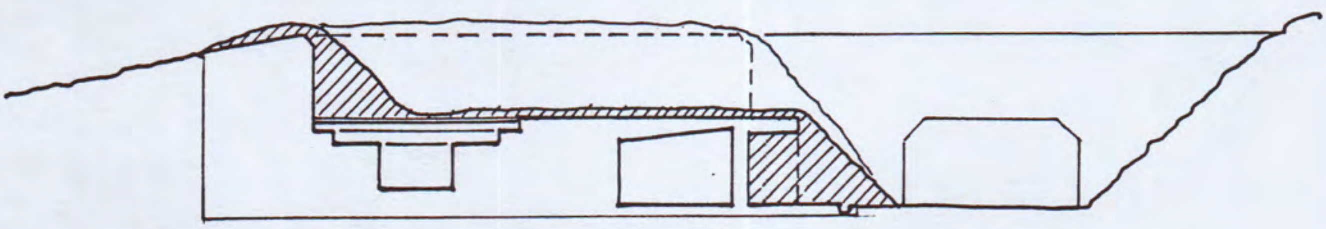
The concept of burial of a gun emplacement should include the issues of the structure's conservation, safety to the park patron, as well as the technical issues of storm water control and management. This would include the protection from the release of contaminates into the storm and ground water.



BATTERY BENSON · SECTION THROUGH GUN EMPLACEMENT

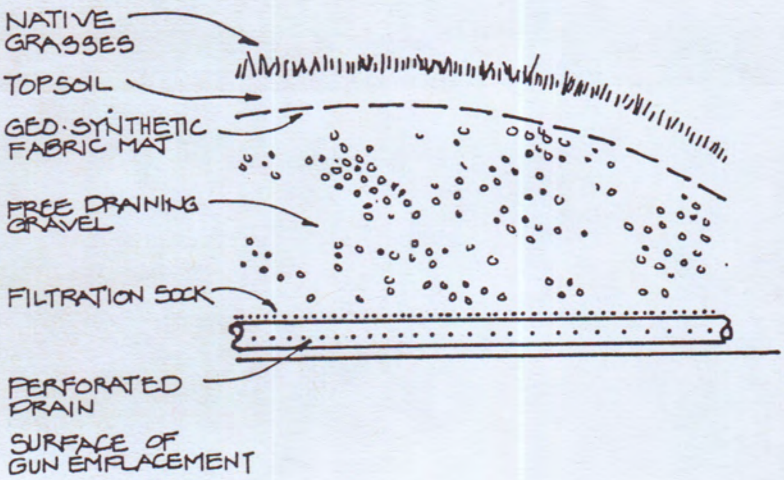
The burial of the facility should be accomplished with the removal of all vegetation and organic materials within the burial site. Because lead containing paints and surface coatings were in common use during the years the gun emplacement was in service, their removal or encapsulation will be required. Removal of lead containing coatings would insure that the surrounding soil and the storm water would not be subjected to contamination. Because removal of all lead containing coatings would expose unprotected metal to contact with moisture and cause deterioration by rust the installation of a replacement coating material will be necessary.

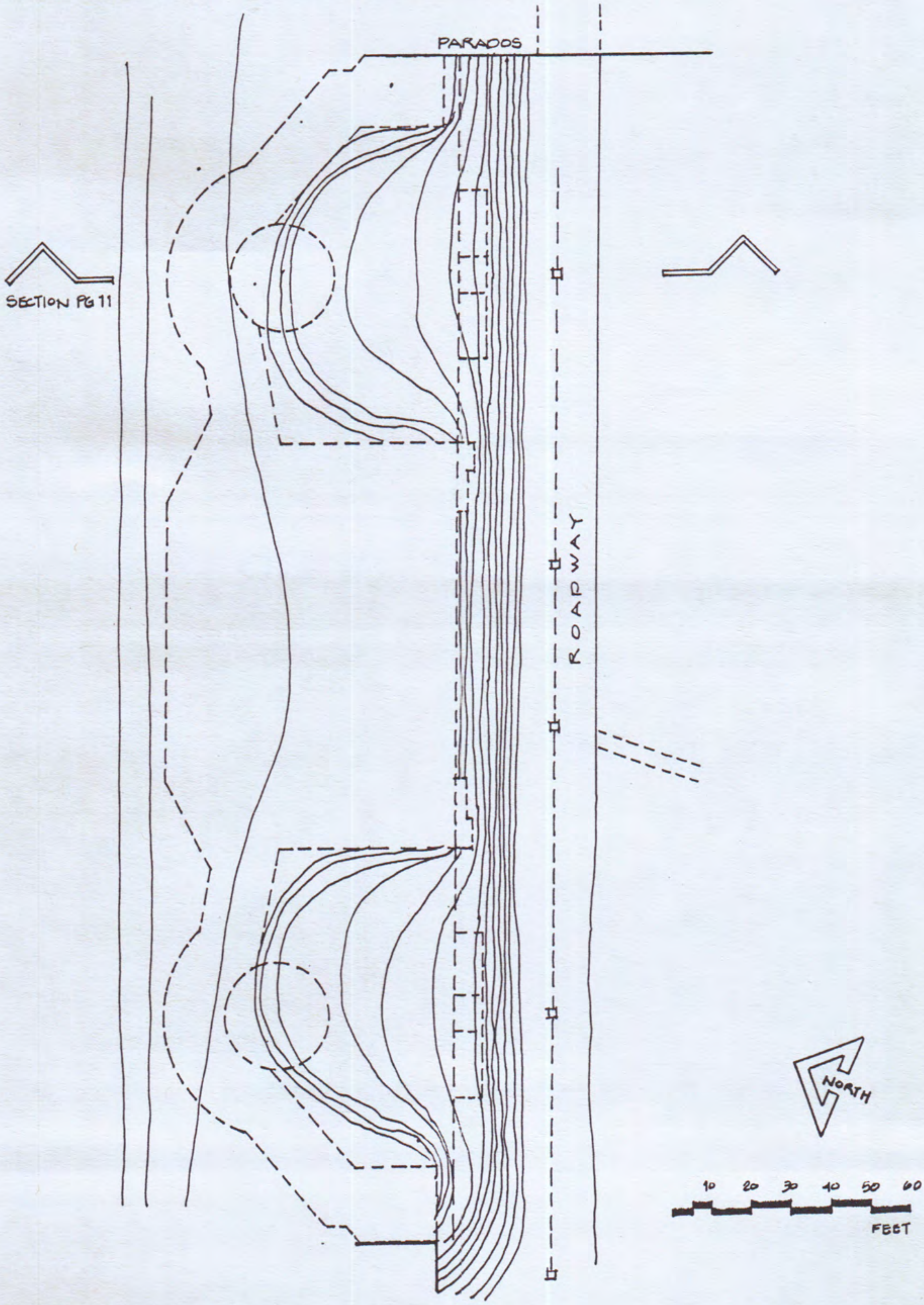
Following the protection of all metal surfaces with a protective coating, a drainage system laid on the surface of the gun emplacement would collect and channel all ground water to functioning storm drains. The drainage system should be composed of commercial drainage pipe installed with a filtration sock. The system should be covered with a layer of free drainage gravel. The gravel should be free of contaminants and should not have a high mineral content. The selection of the gravel shall be based on being free of contaminates, ease of installation and its future removal, and availability at the burial site.



BATTERY BENSON · SECTION THROUGH GUN EMPLACEMENT

The location of gun emplacements at coastal sites which receive significant rainfall over extended time periods would require an additional membrane material placed near the surface of the completed burial. The burial should be shaped in a mound that promotes free drainage of surface water. In areas of significant activity including areas in which equipment is to be used, the earth mound will require armoring with an open weave mat to protect the fill material from displacement. The mat is meant to reinforce the mound and help preserve the shape of the mound. Atop the reinforcing mat additional gravel topped with top soil and grass will allow long term conservation of the gun emplacement while providing a landscape feature for recreational activities.


NATIVE GRASSES
TOPSOIL
GEO·SYNTHETIC FABRIC MAT
FREE DRAINING GRAVEL
FILTRATION SOCK
PERFORATED DRAIN
SURFACE OF GUN EMPLACEMENT

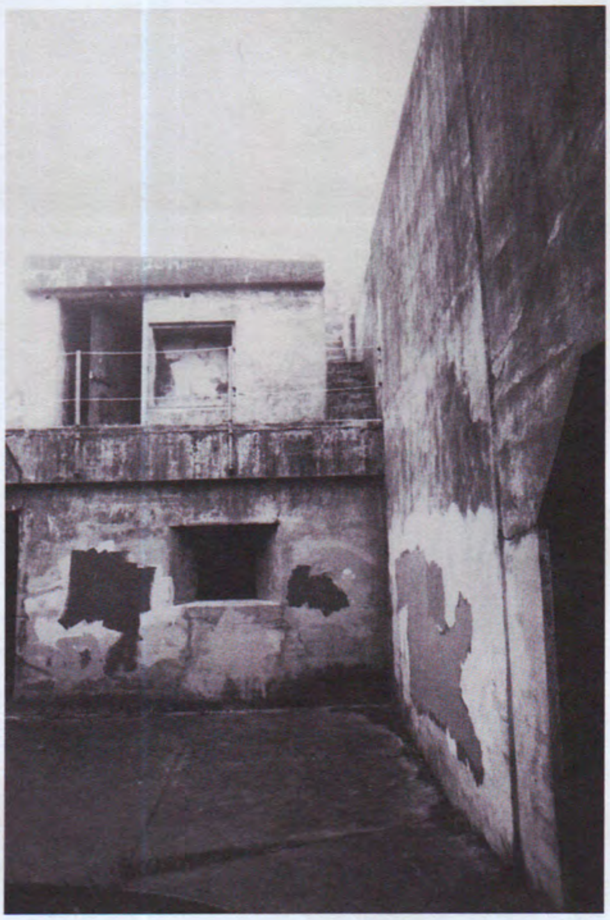


PARADOS
SECTION PG 11
ROADWAY
NORTH
10 20 30 40 50 60
FEET

ENTOMBMENT COST ESTIMATE CONCEPT

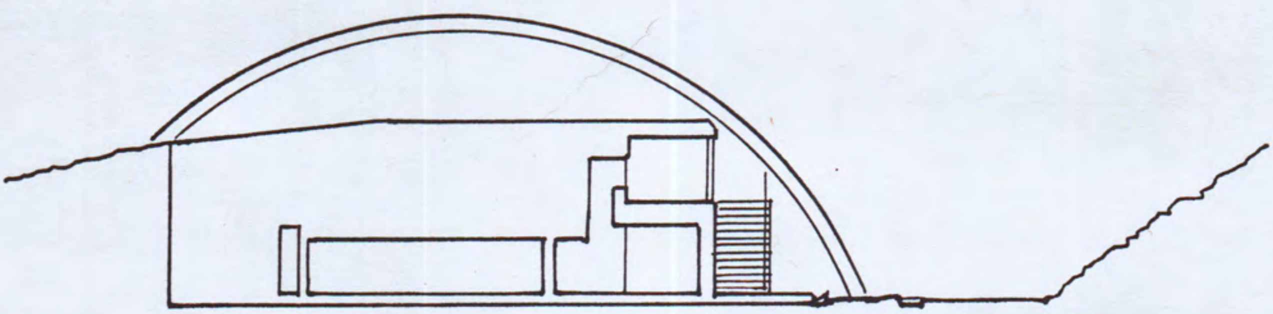
Debris removal and clean-up	$24,000.00
Dump charges	2,000.00
Site clearing	8,800.00
Temporary power	2,000.00
Drainage system	
Clean-up and repair	5,000.00
Additional drains	12,600.00
Steel coating	9,200.00
Geomat- drainage mat	32,000.00
Fill material	85,600.00
Retaining mat	18,800.00
Top soil	4,000.00
Seeding	2,500.00
	$206,500.00
Location multiplier @ 5%	216,800.00
Contractor overhead & profit @ 16%	251,500.00
Washington State Sales Tax @ 8.8%	273,650.00
Contingency @ 20%	$328,400.00
Probable Cost	**$330,000.00**

ROOF-OVER CONCEPT



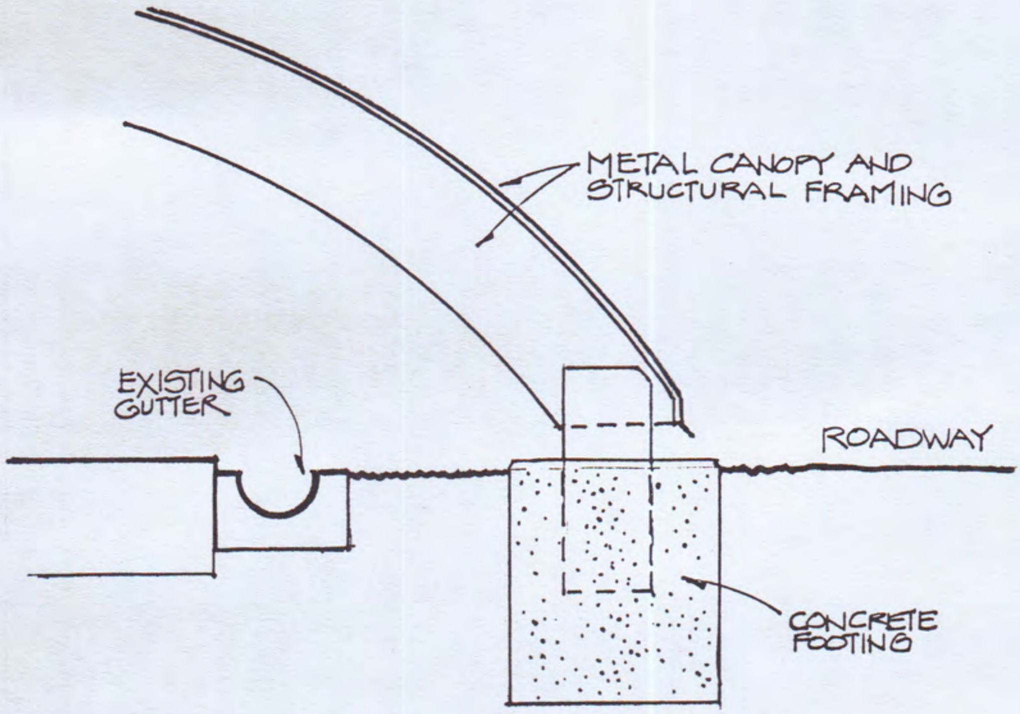
The eastern edge of Battery Benson with the end wall forming the retaining wall for the parados.

The roof-over concept is proposed for gun emplacements in remote sites in which the demand for recreational space is low and the completed conservation structure is not of aesthetic concern. The roof-over concept is the introduction of a structure which extends over the gun emplacements and forms a roof over the entire facility. The roof-over concept can be described as a structure which in a single span extends from the front of the blast apron to a point beyond the rear of the gun emplacement.

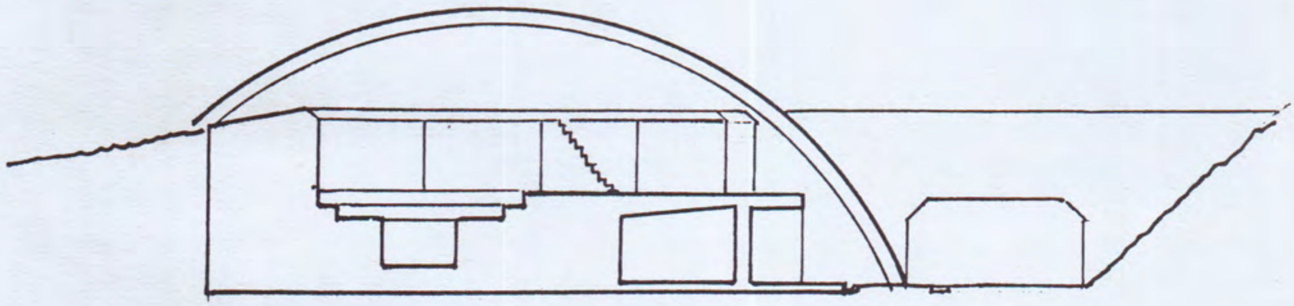


BATTERY BENSON - SECTION AT MAGAZINE

The structure may be formed by a series of steel arches or steel space-frames in the form of an arch. The optimum form of the structure would be in the form of a barrel vault with a series of structural arches spaced twenty to thirty feet on-center with intermediate purlins spanning between arches. The arches will be anchored and supported by concrete footings placed below grade. The footings will be in the form of spot footings designed to fit between features of the gun emplacements and other adjacent site features.



In the case of Battery Benson, the front footings will be beyond the blast apron. In other batteries the blast apron is a separate element placed in front of the parapet. As at Battery Ord at Ft. Columbia, the blast apron has separated from the front edge of the gun emplacement and the blast apron has settled. In these cases the support footings for the structure will need to be separate. While at Battery Benson where the blast apron is integral with the gun emplacement, the foundation supporting the structural framework could be anchored to the blast apron.

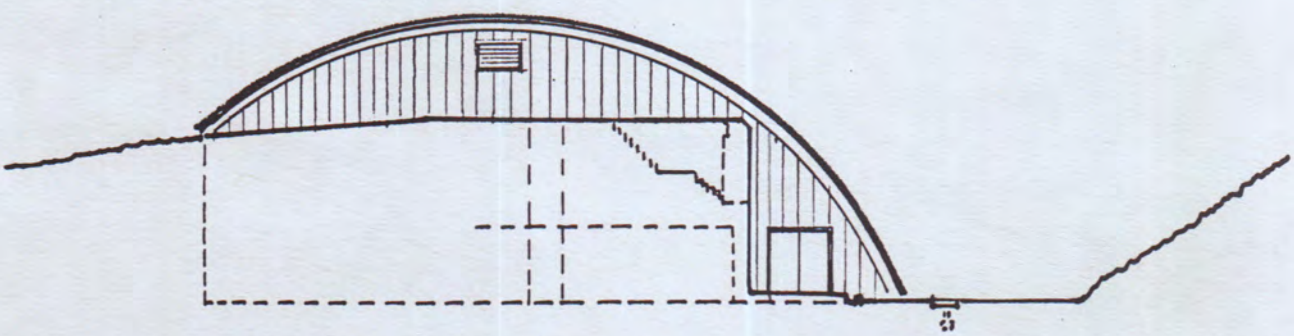


BATTERY BENSON - SECTION AT GUN EMPLACEMENT

The roof-over concept is similar in design to the commonly used metal buildings found in industrial construction. Metal buildings must be designed to compensate for uplift and usually the foundation of the building must have adequate weight to resist uplift forces. Attaching the roof structure to the gun emplacement provides sufficient weight and requires no additional structural component to be constructed. The configuration of Battery Benson does not offer the opportunity to anchor the rear of the arch to the structure. Here the foundation should be placed between the rear of the battery and the electrical chase located in the center of the roadway. The arched structure would be sheathed with standard metal roofing panels. As a deterrent to vandalism and unauthorized entry, the edge of the roof will need to be strengthened and protected.

This can be accomplished in several ways. Heavy flashing can be extended from the roof into the adjacent soil and beneath the existing grade. An alternative would be to place a series of large immovable objects such as Jersey Barriers along the perimeter of the roof. The barriers would be moved into place by a front loader or another piece of heavy equipment.

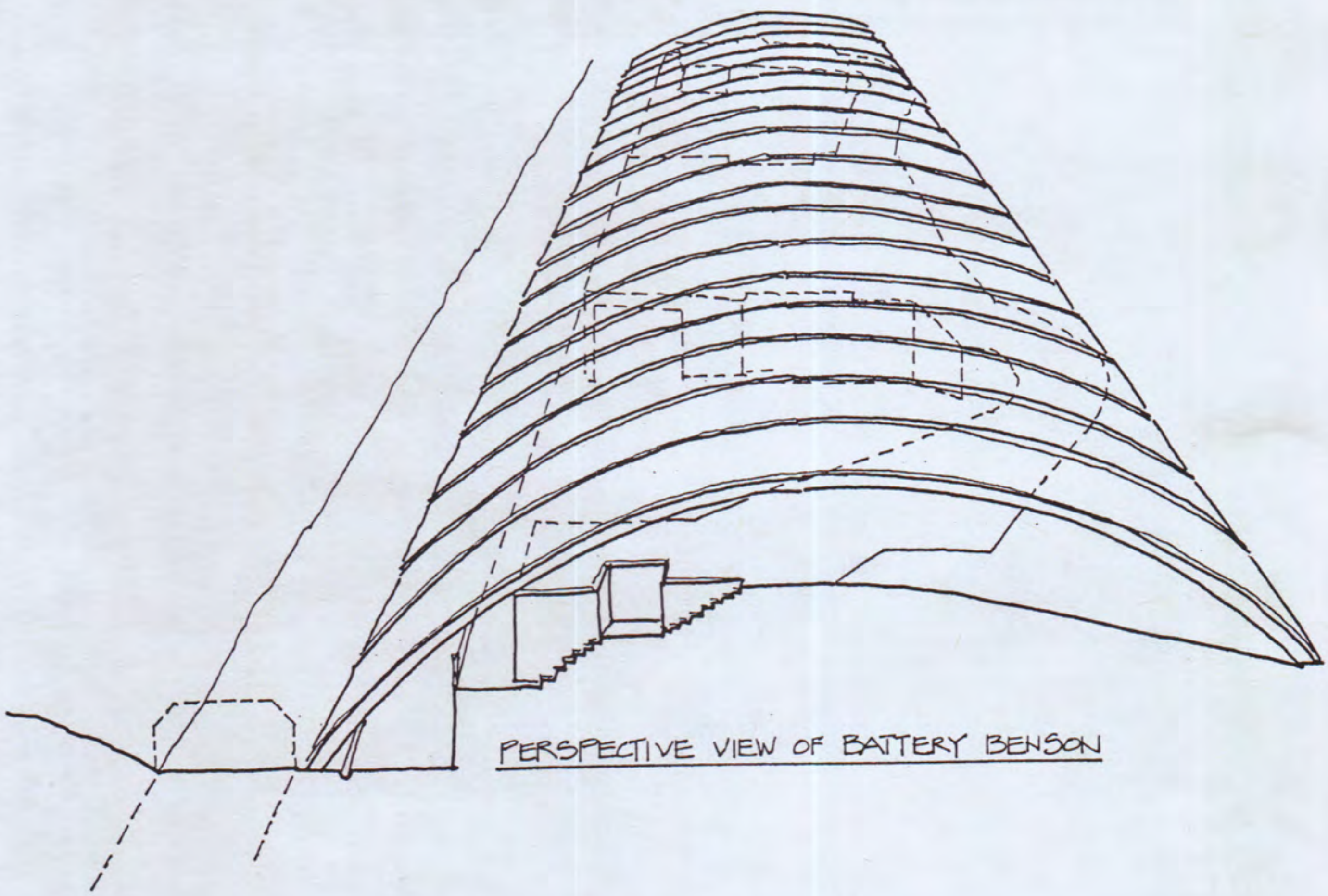
The end walls would be fabricated and installed in a manner that formed a wall fitted to the contour of the gun emplacement. The end walls would also provide for a large vent at each end to promote ventilation of the space, as well as providing space for doors allowing park personnel access to the interior for inspection.



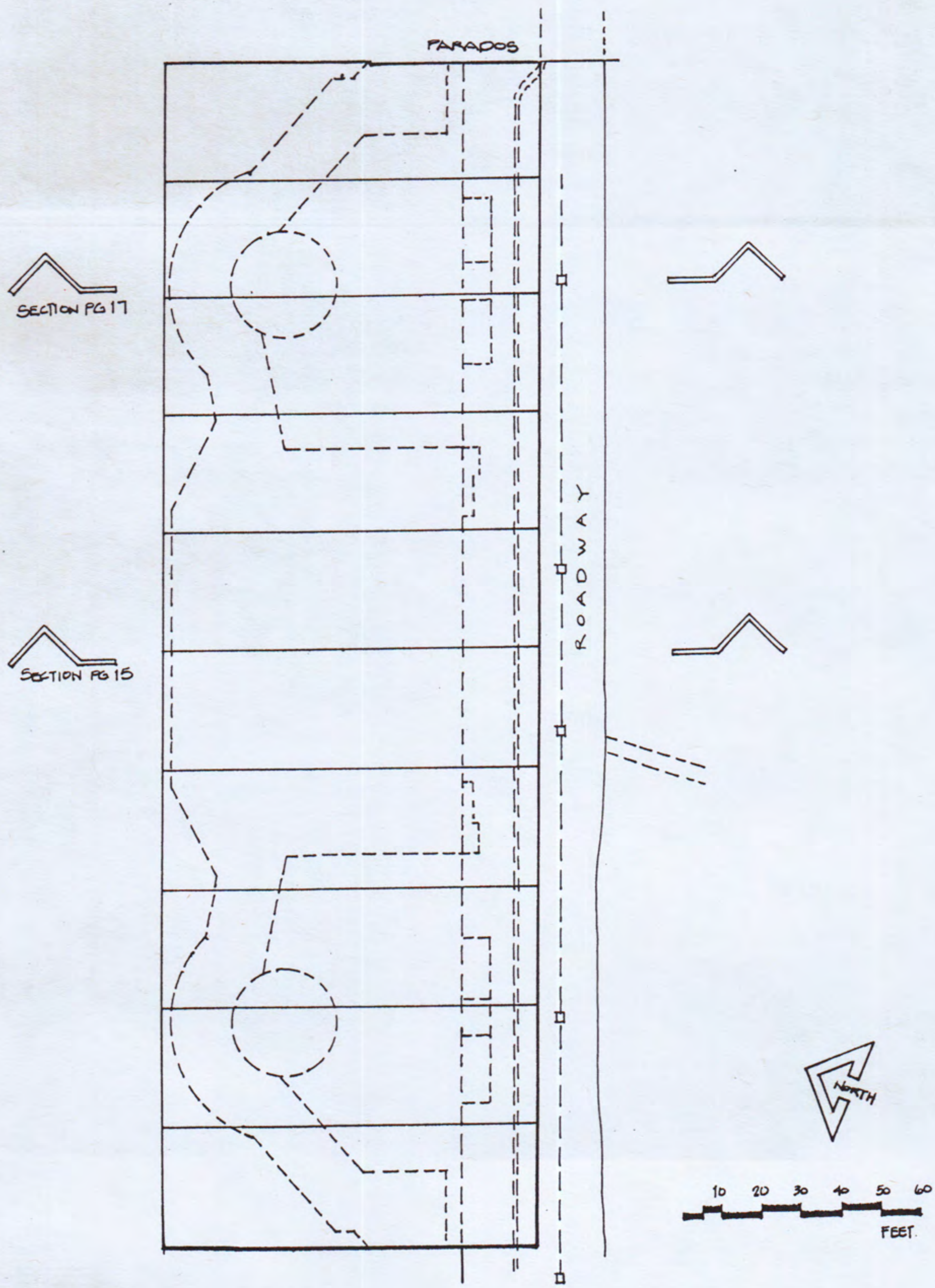
BATTERY BENSON - WEST ELEVATION

The structure supporting the roof of the roof-over concept can be fabricated from various structural elements. The optimum structure would be one that is easily erected from small modular components. A space-frame structural system would allow a large structure to be formed by a series of small components which can be easily transported and erected in confined areas. The space-frame system could be adjusted to meet the specific form needs of the different conditions found at Battery Benson. The space-frame system will allow for a future dismantling when the need for the structure has ended and for re-use of the system at another gun emplacement.

Every component of this concept should be viewed with the goal of re-use on another gun emplacement. This concept also supports the long-term preservation of the gun emplacement by providing a sheltered environment during the restoration of Battery Benson. Within the enclosed space all elements of Battery Benson would be protected from weather, vandalism and other elements while providing a working environment for restoration activities. This concept promotes restoration in stages. Specific restoration activities can be pursued while other parts of the gun emplacement are not being restored. This concept promotes the first roof-over structure to serve as a laboratory for restoration techniques on the various components found within Battery Benson and common to similar structures.



PERSPECTIVE VIEW OF BATTERY BENSON

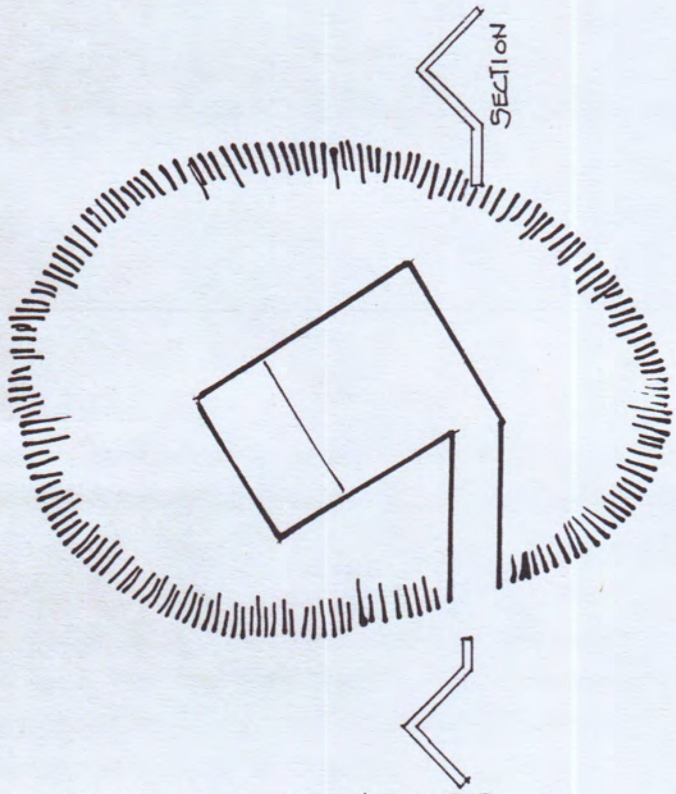


PARADOS
SECTION PG 17
SECTION PG 15
ROADWAY
NORTH
10 20 30 40 50 60
FEET

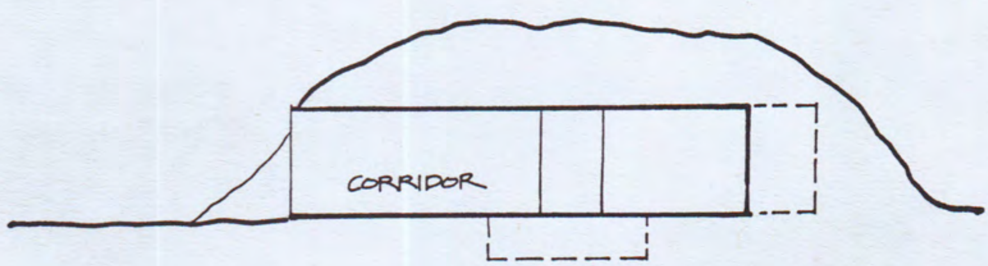
ROOF-OVER COST ESTIMATE CONCEPT

Debris removal and clean-up	$24,000.00
Dump charges	2,000.00
Site clearing	8,800.00
Utilities	
Temporary power	8,000.00
Temporary water	3,000.00
Drainage system	
Clean-up and repair	5,000.00
Additional drains	3,500.00
Concrete foundation	42,800.00
Misc. metals	3,600.00
Metal building	
structure, roof, & walls panels	386,000.00
ventilators	4,000.00
doors	3,000.00
door hardware	2,000.00
Steel coating	9,200.00
	$504,900.00
Location multiplier @ 5%	530,150.00
Contractor overhead & profit @ 20%	636,200.00
Washington State Sales Tax @ 8.8%	692,200.00
Contingency @ 20%	$830,600.00
Probable Cost	**$832,000.00**

SWITCHBOARD



PLAN VIEW OF SWITCHBOARD

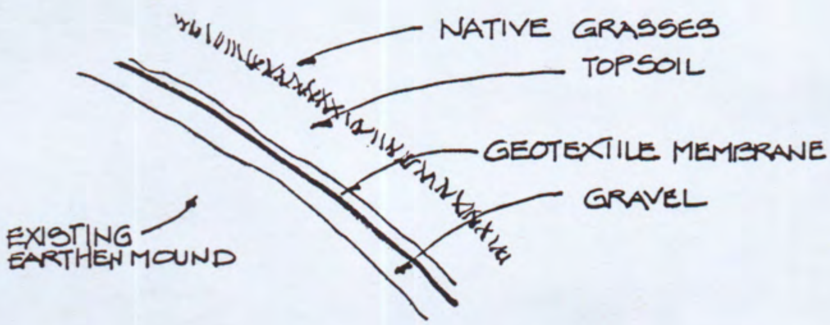


SECTION THROUGH ENTRY TO SWITCHBOARD

The concept for the Switchboard is to repair the earthen mound which protects the structure and to control the access to the interior spaces. The Switchboard earthen mound is in-place and has been covered with vegetation including several trees, large shrubs, and well established English Ivy.

View of mound covering the Switchboard. Heavy growth of English Ivy covers the entrance to the corridor leading to the Switchboard.

The long-term conservation of the Switchboard can retain the existing earthen cover; however, the size and density of the vegetation has compromised the integrity of the water proofing qualities of the mound. The mound relies on its shape to direct rain water away from the structure. Numerous plants with their root systems have formed depressions and other irregularities in the mound's surface causing water to pond and drain into the Switchboard. The long-term conservation solution would be to remove the vegetation, re-construct the mound and add an additional waterproof membrane.



SECTION THROUGH EXISTING MOUND

Once there is a re-developed mound shape, a synthetic waterproof membrane could be placed over the mound. Atop the membrane could be placed a layer of top soil where native grasses could be seeded for a sod cover.

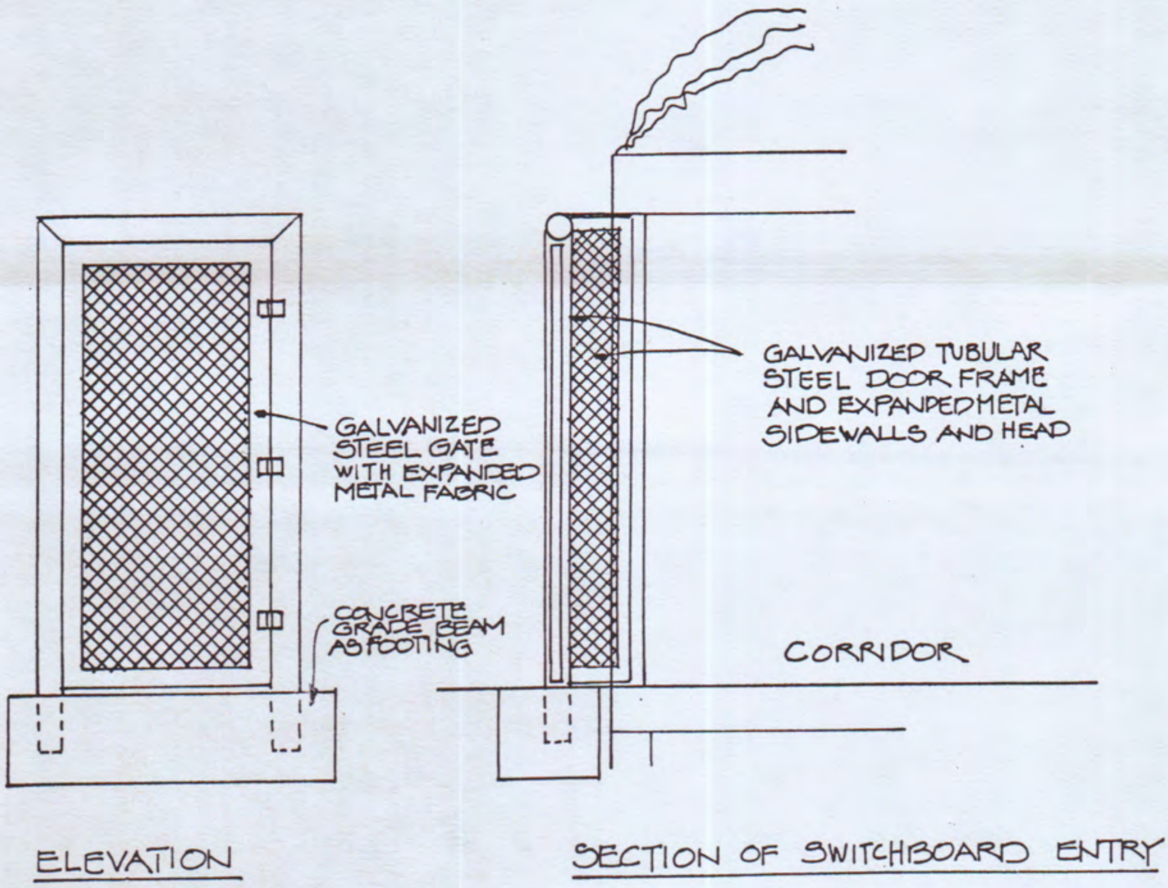
ALTERNATE

An alternate solution would be to remove the large trees and shrubs from the earthen mound and import fill to reshape the mound into its original shape, thereby relying on the mound shape alone to direct rain water from the mound and the building below.

CONTROLLED ACCESS

The entrance to the subterranean corridor leading to the Switchboard. The door at the entrance has been removed allowing uncontrolled access to the Switchboard. The corridor is formed by concrete walls, floor and ceiling.

Unauthorized access to the interior of the Switchboard has been a major problem. Vandals have set fire to debris placed in the Switchboard. The single door providing access to the corridor and Switchboard room has been removed and no barriers prevent access. The entry to the Switchboard is overgrown with vegetation. The concept for controlling access includes the addition of a gate to be placed as close to the doorway as possible without making physical contact or promoting damage to the structure.



The gate should be placed within a tubular steel frame with the frame's base set in a concrete grade beam. The gate's frame, formed of tubular steel either round or square, should enclose a heavy gauge, expanded metal fabric welded to the frame. Both the gate and frame should be constructed with welded corners and each galvanized. Sidewalls of expanded metal should be attached to the tubular gate frame and extend into the doorway of the Switchboard corridor and attached to the door frame; thereby allowing the sidewalls to seal the existing doorway to the new entry gate. The gate should be out-swinging. To insure control of the access, a large concrete mass such as a Jersey Barrier could be placed in front of the gate. The concrete barrier would require a fork lift, front loader or other form of heavy equipment to be used when access is needed.

SWITCHBOARD - COST ESTIMATE CONCEPT

Debris removal and clean-up	$500.00
Dump charges	100.00
Site clearing	6,000.00
Temporary power	200.00
Geomat	6,000.00
Topsoil	2,000.00
Seeding	1,000.00
Steel fabrication	8,000.00
Gate hardware	2,000.00
	$25,800.00
Location multiplier @ 1%	30,000.00
Contractor overhead & profit @ 16%	35,900.00
Washington State Sales Tax @ 8.8%	39,100.00
Contingency @ 10%	$43,000.00
Probable Cost	**$43,000.00**

Historic Fortifications Preservation Handbook

ERRATA

Page 1.3, illustration caption

"from the early 18^{th} century" should read "from the early 19^{th} century."

Page 1.6, top illustration caption

"metal work on an disassembled" should read "metal work on a disassembled."

Page 2.21, illustration caption

"Battery Spenser" should read "Battery Spencer."

Page 3.40

The line at the top of the page reading "Some granites, many sandstones" is the last line on the chart at the bottom of page 3.39.

Page 4.30

The table outlining the activities of the Friends of Fort Flagler and others was omitted; it is reproduced on the attached page.

Fort Flagler Battery Preservation Matrix

Battery / Task	Wansboro	Downes	Grattan	Bankhead	Calwell	Revere	Wilhelm	Rawlins	Lee	Searchlights	Primary Sta.
Routinely sweep	■	■	■	■☼	■	■	■	■	■	■	■
Routinely cut grass	■	■	■☼	■	■☼	■☼	■☼	■☼	■	■	
Cut bushes by hand		■☼	■		■	■☼	■☼	■☼		■	■
Remove trees			▲		▲	■		■	■		■
Spray weeds	■	■	■	■	■	■	■	■			
Uncover gutter		■									
Open view areas		■☼			■				■		■
Scrape, paint metal doors, upper/lower	▼	■				■	■	■			
Scrape, apply rust inhibitor						■	■	■			
Scrape, paint stair railing	▼	■				■	■	■			
Scrape, paint safety railing						■					
Remove graffiti	■	■	■	■	■	■	■	■	■	■	■
Cut brush		▲	▲		▲	▲	▲	▲			
Burn cut brush					■	■	■	■			
Install railing									■		■
Scrape, paint 3-inch guns	▼										
Build searchlight cover									■		
Interpretive items			■					■	■	■	■

September, 2001

■ volunteers ☼ hosts ▲ State Parks ▼ Friends of Fort Flagler

Original matrix prepared by Bob Brown, Friends of Fort Flagler

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