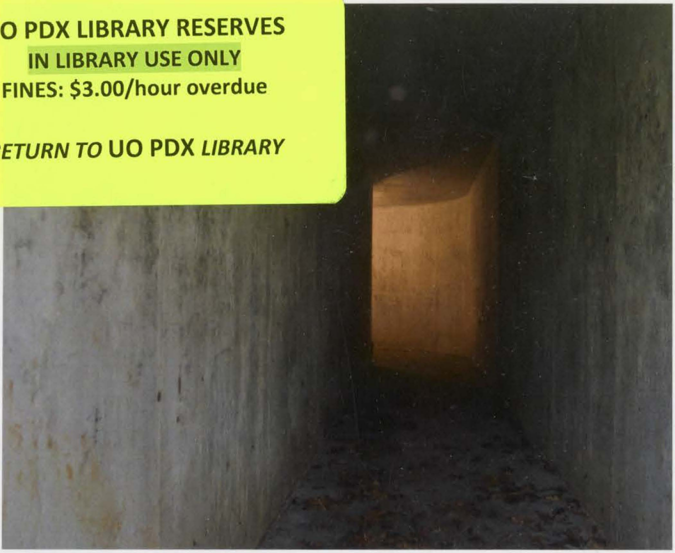
Historic Structure Report
New Mine Casemate
Fort Columbia State Park



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Introduction

This report was prepared in partial fulfilment of the requirements for the degree of Master of Science in Historic Preservation at the University of Oregon. The author hopes that it will provide a useful resource for the staff of Washington State Parks as they prepare for their centennial celebration in 2013 and that it will prove of value to those interested in the growing field of fortification preservation.

The new (though it is approaching ninety years of age) mine casemate at Fort Columbia is a unique structure. It is a subterranean structure of massive reinforced concrete, every bit as intimidating and fascinating as the Neo-Doric Art Deco gateways suggest. It still has secrets to unravel, but this report should resolve many previously unsettled questions.

This report relies more heavily on photography as a means of documentation than is usually the practice. There are several reasons for this difference. First, the author is a photographer. Second, he believes it is possible to capture certain aspects of a building, tangible and intangible, through the camera that are not conveyed by other media. This is indisputably the case with the landscape setting of the casemate.

The the photographic documentation is presented in a separate volume in order to make this report as usable as possible. By binding the photos separately it has been possible to reproduce them in larger format.

Acknowledgements

As is often said, but too little appreciated, this work would not have been possible without the help of many kind and knowledgeable people. My committee members — Don Peting and Leland Roth of the University of Oregon, and Greg Hagge of Fort Lewis Military Museum — are certainly at the top of the list. Thanks to Donella Lucero of Fort Columbia State Parks for her perseverance in looking for historic photos and other documents, and to the rest of the Washington State Parks people for their assistance with this project. To my wife, Mary Lingo, I can only express my inadequate thanks for her help and companionship, not only on this report, but throughout my time at the University of Oregon.

Executive Summary

Purpose

This report is intended to provide a resource for those responsible for the preservation of the New Mine Casemate at Fort Columbia State Park. The casemate is a subterranean concrete fortification built between 1921 and 1945 to control the mine fields that closed the Columbia River against invasion, and embodies much of the history of the United States military's important role in the Pacific Northwest. This report provides historical background and a comprehensive construction history of the structure intended to help with the interpretation of the park's history. The physical description and recommendations given are designed to facilitate sensitive and careful preservation action.

Methods

The research that led to this report was conducted using archival resources, including original Army Corps of Engineers construction drawings and historic photos, from Washington State Parks Lewis and Clark Interpretive Center and the collections at Fort Columbia State Park. The building history section relies heavily on construction documents in the National Archives obtained through the Coast Defense Study Group.

Field work was conducted in five separate trips to the casemate. Extensive site documentation included measurements and a general condition assessment. Photo-documentation was a major focus of the project.

Character Defining Features

The architectural character of the casemate is defined by a number of specific features that should be protected and maintained in any management decisions. The features discussed in Chapter 5 are :

—The high earthen embankment landscaped with native plants to conceal the casemate from detection.

—The following building components and systems: the concrete gates with their Art Deco lintel motif, the interior gas-proofing doors and pipes, and the original finishes in the tunnel, plotting room, and casemate operating area.

Findings and Recommendations

The concrete structure of the casemate is in generally good condition. There only a few areas of concern, none critical at this point. There are no signs of structural failure. Of the recommendations given, the following are of the utmost importance:

- **Perform a complete and comprehensive concrete condition survey**

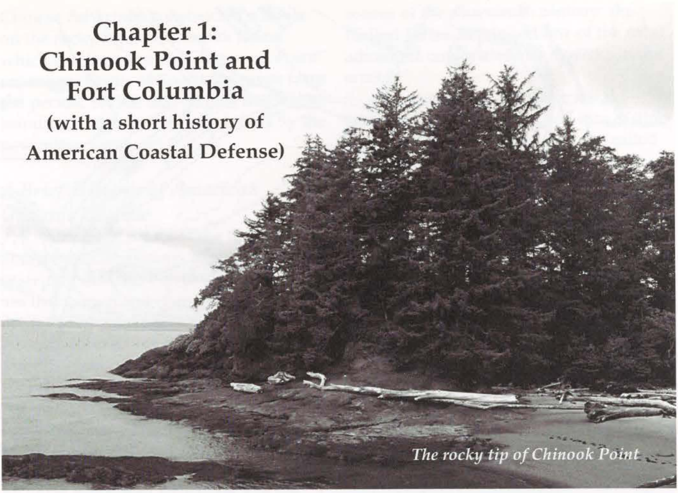
- **Resolve health and safety issues, such as fall and environmental hazards.**

- **Deal with moisture issues by clearing blocked ventilators.**

- **Treat metal features to protect them from further corrosion damage.**

Chapter 1: Chinook Point and Fort Columbia

(with a short history of American Coastal Defense)

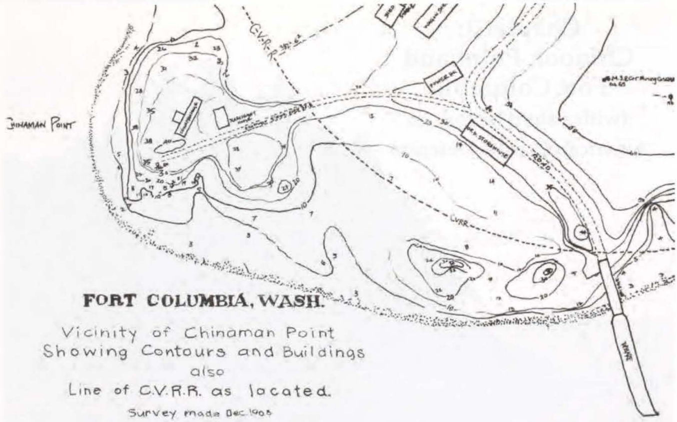


The rocky tip of Chinook Point

Chinook Point and Fort Columbia (with a short history of American Coastal Defense)

The Columbia River forms much of the border between the states of Oregon and Washington, flowing over 1,200 miles from its source in the mountains of British Columbia, and draining an area of over 250,000 square miles on its way to the Pacific Ocean. On the north the river's mouth is flanked by the rocky headland of Cape Disappointment and on the south lies Point Adams and the sands of Clatsop Spit. The big river itself is filled with shifting sand bars, some bearing the names of the ships that foundered on them. Although jetties and dredged channels have made the Columbia's bar safer, as have the lighthouses at Cape Disappointment and North Head, these are still dangerous waters. The entrance to the river has been called the "Graveyard of the Pacific" and holds the wreckage of over two thousand vessels.[1]

Chinook Point juts out from the river's north shore a few miles from the place where the Columbia churns into the Pacific Ocean. Above it Scarborough Hill rises eight hundred feet, covered, as it now appears, with thick vine maple, alder, and giant sitka spruce. Once, however, it was a broad grassy slope visible for miles and its bare top was a navigation reference for mariners.[2] The Chinook people, who called the point "No's-to-ils" and the hill behind it "No'si-misp", had their largest village near here, home of their famous chief Comcomly.[3] The smaller of the two inlets on Chinook Point is known as Comcomly's Cove. The river here is still rich with clams and fish.



FORT COLUMBIA, WASH.

Vicinity of Chinaman Point
Showing Contours and Buildings
also
Line of C.V.R.R. as located.
Survey made Dec. 1905

Camas still grows in the grassy spots. There are deer and bears in the spruce woods. The word "Chinook" originates in this spot, and has come to refer to the whole region's animal and place names - salmon, rivers, and winds.

Chinook Point is a National Historic Landmark; the status commemorates its important role in the discovery of the Columbia River by Robert Gray in 1790.[4] Here he anchored his ship, the *Columbia Rediviva,* and gave the river its current name, though it already had a name, being called "Wimahl" or "Big River" by the peoples who had lived along its shores for over 10,000 years. Fifteen years after Gray, the Lewis and Clark expedition made camp about a mile from Chinook Point in November of 1805. From Station Camp, as they named the spot of Clark's astronomical observations to create an accurate mapping reference, a party passed on their way to Cape Disappointment and the ocean. Clark describes "a point of rocks about 40 feet high, from the top of which the hill Side is open and assend with a Steep assent to the tops of the mountains."[5]

In the 1840s James Scarborough, mariner and former Hudson Bay Company employee, built a farm at Chinook Point. Scarborough (or Scarboro, as it is sometimes shortened) Hill is named after him. Several contemporary sources remark on Scarborough's fine orchards and herds of cattle. He planted many ornamental plants, including a hawthorn tree that became an additional navigational aid in the spring when its white flowers made the tree stand out distinctly on the hill.[6]

Scarborough and his Chinook wife, Ann, died in the early 1850s and the land passed through the hands of several owners. The Army purchased the 643-acre claim in 1864. During this period squatters occupied James Scarborough's now derelict farm until it was leased to a nearby resident in the 1870s. In the 1890s

Chinese fishermen constructed a house on the rocky bluff of Chinook Point, which is referred to as "Chinaman Point" on several Corps of Engineers maps from the period. A 1906 map shows this house standing in the spot now occupied by the new mine casemate.[7]

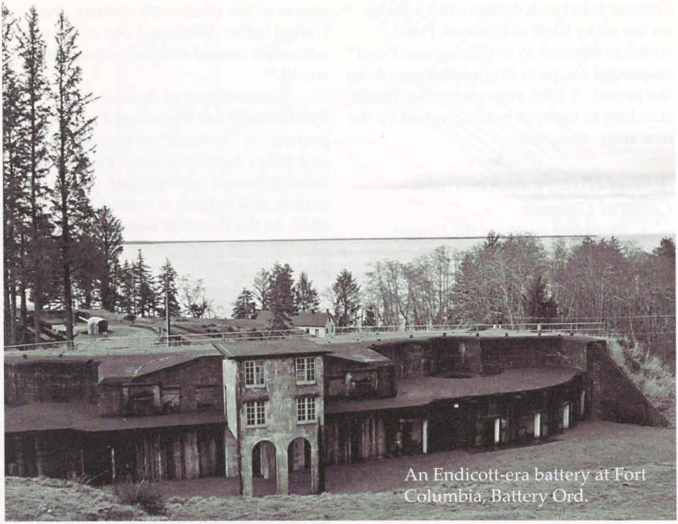
A Brief History of American Coastal Defense

Along the coasts of the United States exist the remains of an extensive system of defensive structures. Some are overgrown and crumbling, some are restored as important historic sites. All date from a time before the spy satellites and intercontinental missiles that characterize current notions of national defense. These historic defenses represent four centuries of building tradition and technology, and are part of an ancient heritage of fortification that includes renowned structures like the Great Wall of China and the fortresses of Europe.[8]

The geographical boundaries of the United States eliminated the need for large scale fortification of its land frontiers. The vast spaces and rugged mountains of the interior of North America made invasion from Canada or Mexico unlikely. Any attack would have to come from the sea, a reality borne out by our early wars with Britain. In addition, for much of American history a defensive outlook on foreign affairs was dominant (though this would radically change over the course of the 19th century), and combined with an early distrust of a standing army and reliance on militia forces, a system of coastal fortification seemed to be the most effective means of avoiding foreign entanglements and wars.[9] Over the course of the nineteenth century the United States developed one of the most advanced coastal defense systems in the world.[10]

Construction of these coastal fortifications can be grouped into distinct periods, or "systems" as they are called in military history sources. First and Second System fortifications were built mainly due to fears of war in 1794 and 1807. As the threat of war diminished, most of these works were left incomplete. These structures consisted of earth and timber with some masonry elements, and were designed to be fitted with smoothbore cannon. Most have vanished with time, but Fort Mifflin in Philadelphia is an extant First System example.[11]

The Third System of American coastal defense was authorized by Congress in 1816, with $800,000 allocated for its construction. The report of the first Board of Engineers for Fortifications in 1821 provided the general plan for most of the seacoast defenses of the 19th century. The fortifications were generally tall masonry structures with towers for mounting guns, influenced by the ideas put forward in the Marquis de Montalembert's eleven-volume treatise on fortification design published in 1776.[12] Third System works showed a sophistication and intention of permanence often missing from the earlier First and Second System fortifications.[13] Fort Point under the southern piers of the Golden Gate bridge is a late Third System fortification.[14] During the Civil War most coastal defense construction took the form of quickly built and inexpensive earthworks. The original work at Fort Stevens on the Oregon side of the Columbia River entrance is typical of



An Endicott-era battery at Fort Columbia, Battery Ord.

this period. A number of fortifications were begun in the 1870s, but most were not finished, and sat abandoned by the 1880s.[15]

In the years after the Civil War the coast defenses of the United States fell into disuse and disrepair. The poor state of this important element of the nation's defense prompted President Grover Cleveland to appoint a special board led by Secretary of War William Endicott. The board issued a report that decried the "utterly defenceless condition of our seacoast" and predicted "disastrous and humiliating results" in the case of war with "even the most insignificant foreign power".[16]

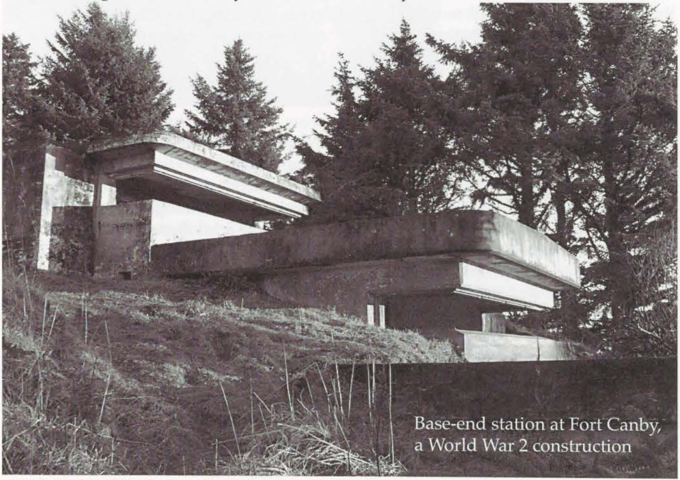
The Endicott Board made a number of recommendations to counteract this grim state of affairs. The report listed port cities in need of fortification, ranking them by the urgency of the recommended work. San Francisco ranked second only to New York City in the priority established by the Endicott report. Among Pacific Coast cities, Portland and San Diego were also deemed vitally important.[17]

The Endicott report made sweeping recommendations for providing the United States with a coast defense that would equal any then in existence. A key element of the program was a system of electrically controlled mine fields to protect shipping channels and harbors. These mine fields would be protected by extensive shore fortifications and floating fortresses. The total cost for the recommendations was estimated at $127,000,000.[18] Congress provided funding for a more modest building program that began in the 1890s. A second presidential commission was appointed by Theodore Roosevelt in 1905 and made revisions to the Endicott plan based on improvements in technology.

Fortifications constructed in the Endicott/Taft period remain in many places along the West Coast. Fort Barry, north of San Francisco; Forts Stevens and Columbia, on the Columbia River; and the forts of the Puget Sound area, all date from this period. Typical of all these forts is a system of earth and concrete gun batteries and well constructed wooden buildings to house the soldiers. The high quality concrete work in the fortifications and the sturdy, but elegant, houses of Officer's Row have survived the intervening century well, even in the harsh coastal climate.

Although the Endicott system of fortifications has not received the scholarly interest and appreciation of the more architecturally styled works of the earlier periods, these fortifications represent an important step in the history of defensive works. The Endicott system fortifications represent a departure from the historical ways of building, and of understanding, fortifications. They utilized a newly rediscovered building technology — massive concrete. As the century progressed these fortifications also mark the completion of a transition from fortifications as part of the city, created on an architectural scale, to a landscape designed by professional military engineers. In this respect they are a forerunner of the triumph of an engineering aesthetic that was an important strain in the development of modernist architecture.[19]

By 1914 the Chief of the Coast


Base-end station at Fort Canby, a World War 2 construction

Artillery Corps was able to report that, by and large, all coastal defense projects had been completed.[20] After the end of the First World War few new batteries were constructed, although there were a number of new defense plans.[21] During this time many coast defense forts were put on caretaker status, manned by a minimum number of soldiers.

As the clouds of war gathered in the late 1930s, some effort was made to rearm the nation's coast defenses with newer and heavier weapons. In late 1940 a new construction program was approved by Congress. After the attack on Pearl Harbor construction of new defenses began in earnest. New gun batteries and improvements were planned for 33 permanent coastal defense areas, but this program was suspended by the end of the war as it became apparent that there would be no invasion of the American mainland. Even so, the program had resulted in the construction of over 200 batteries and represented the strongest coastal defense works in the nation's history.[22]

As is often the case with technological innovations, the most advanced step had come when the system was already obsolete. The military developments of the Second World War had made coastal artillery emplacements and submarine mines largely irrelevant. Airplanes and missiles had taken their place in the modern arsenal. By 1950 all coastal defense batteries were deactivated, their weapons were scrapped, and the Coast Artillery Corps ceased to exist.[23] The opening of the first Nike surface-to-air missile station in 1954 marked the beginning of a new era in national defense.[24]

Harbor Defenses of the Columbia River and Fort Columbia

As early as the 1820s, the strategic importance of fortification at the Columbia River's entrance was realized in connection with the dispute with the British over the Oregon Territory.[25] In his report to the Secretary of the Navy in 1842, Lieutenant Charles Wilkes urged the necessity of occupying the mouth of the river, and recommended that ". . . a small fort on Cape Disappointment, and a few guns on Point Adams to defend the south channel with its dangerous bar, would be all sufficient for the defense of the Columbia River." Bearing witness to the charged political atmosphere of relations between the United States and Britain, his report was not made public until nearly seventy years later.[26]

The Oregon crisis was resolved by treaty in 1846, and interest in expending sizable sums of money on such a remote location waned. In 1851 a presidential commission recommended that Cape Disappointment and Point Adams be among the first and most important Pacific coast defenses. However, eight years later, Captain Thomas Jefferson Cram, in the report on his topographical survey was of the opinion that "there is no point. . . north of San Francisco. . . where the construction of permanent forts, for at least three generations to come, would be anything but an extravagant waste of the public treasure."[27]

With the outbreak of the Civil War, the neglect of coastal defenses in the Pacific Northwest began to be seen as a real liability. Though there may have been some lingering uneasiness over British intentions toward their recent possessions, the main motivation for the rapid construction of the Columbia

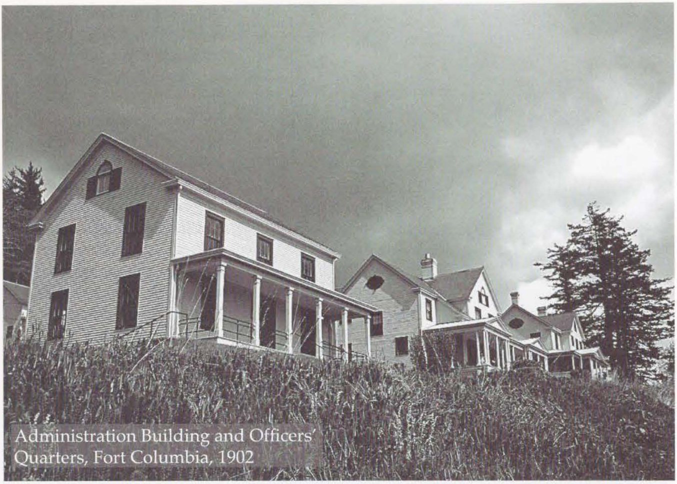
Cape Disappointment Lighthouse, 1854

River defenses was the presence of Confederate raiders, the *Shenandoah* and the *Alabama*, who had been causing great harm to Union shipping in the Pacific for a number of years.[28] After much delay, construction began at Point Adams and Cape Disappointment in August of 1863. The work did not proceed quickly and was still incomplete at the end of the war. Guns were not mounted at Fort Stevens until several months after the end of fighting and most were not in place until 1866.[29]

Due to difficulties negotiating the purchase of land at Chinook Point, work was not begun on the recommended fortifications there. By the time the property had been formally acquired in 1867 the urgency of constructing a fort there had disappeared. Known as Scarboro Hill Military Reservation the area sat unused for any military purpose for thirty years.[30]

The Endicott Board of 1886 had marked the defense of the Columbia River as a priority, but it took the Army Board of Engineers nearly ten years to come up with a complete plan. This plan called for new armaments for Fort Stevens and Fort Canby, and for construction of the new Fort Columbia at Chinook Point. This new fort would provide a submarine mine component, and its guns would cover the new mine field that was an important part of the Endicott-era coastal defense system. The estimated cost for these fortifications was nearly three million dollars.[31,32]

Work on the first of Fort Columbia's gun batteries began in March of 1897. A local outcry arose when the Army cut down Scarborough's hawthorn tree. By the next year the battery and the fort's mine casemate were completed.[33] Over the next several years additional batteries were added. Finally, in 1902, the fort's principal buildings — barracks, officer's housing, hospital, guardhouse, and administration building were completed. These handsome buildings still stand at Fort Columbia. They are balloon-



Administration Building and Officers' Quarters, Fort Columbia, 1902

framed structures, built in a U.S. Army adaptation of the Queen Anne style then popular across the United States. They are very similar to their counterparts at other military installations of the period, such as at Fort Worden and Fort Casey on Puget Sound, and at Fort Stevens across the river in Oregon.

The end of the First World War brought a steady decrease in activity at the Columbia River forts.[34] New mine casemates completed at Fort Stevens and Fort Columbia in 1921 were one of the few active projects. Forts Canby and Columbia were placed on caretaker status, and by 1936 three enlisted men made up the entire complement of forces at Fort Columbia. Their duties were apparently light since they were reported to have time to keep cows to produce milk for sale to the fort's neighbors.[35] The global unrest of the late 1930s finally disturbed the repose of Fort Columbia's dairying soldiers. According to Army Corps of Engineer records, in 1937 all mine casemate operations were consolidated from Fort Stevens to the better concealed casemate at Fort Columbia. The 249th Coast Artillery of the Oregon National Guard went on active duty in September of 1940, and were stationed at Fort Columbia in March of 1941.[36]

On December 7, 1941, the United States entered the Second World War with the attack on Pearl Harbor. Efforts to update the Columbia River coastal defenses went into high gear. A new submarine mine system was deployed. The new mine casemate at Fort Columbia was reinforced, and a plotting room addition and gas-proofing was added. Battery 246 was constructed to house rapid-fire 6-inch guns. Two of the few remaining examples of these guns were recently obtained from Canada and have been installed at the battery.

In June of 1942, as construction was underway on improvements to Fort Columbia's fortification, Fort Stevens was attacked by a submarine of the Imperial Japanese Navy. Fort Stevens became the only military post in the United States to come under fire from a foreign power since the War of 1812.[35b] The submarine fired nine shots from its 145mm deck gun. No damage was reported to the fort, and no fire was returned.[36b]

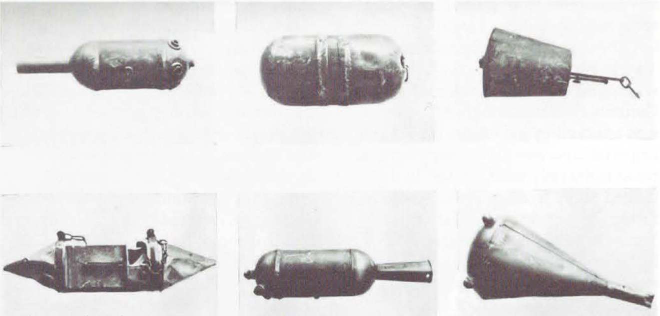
By June of 1945 it was obvious that there was no longer any need for the mines in the river's channel and they were removed. Several batteries were deactivated and the number of troops stationed at the Columbia River forts was reduced. The forts were declared surplus property in 1947, and Fort Columbia officially became a Washington State Park in 1951.

The three forts that formed the coast defenses of the Columbia River never fired a shot at an enemy target. Their historical significance does not come from their role in any great battle. They stand in testimony to a time of global conflict and to the part of the United States in the great wars of the twentieth century, wars that, fortunately for us, were not fought on these shores.[37] They also serve as reminders of a way of war, equally terrible in its implications, but seemingly romantic and noble in contrast with the spy satellites and killer drones of our day.

The use of submarine mines in American seacoast defenses

The use of submerged explosive charges to sink or damage enemy ships has long been recognized as a powerful defensive technology. But except for a few uncertain references to Chinese use of such devices and to the use of "water petards" in the 17th century the technical problems proved too great for widespread application.[38] The modern use of sea mines was an American invention, first used during the Revolutionary War.[39] David Bushnell is credited with the design and construction of the mines used against the British off Philadelphia in 1777. His mines consisted of a wooden keg filled with powder and supported a few feet beneath the surface by a float. A gun lock was set to trigger the powder if the mine came into contact with any other object. The attempt was largely unsuccessful since the mines were released too far from the ships, allowing the current and the ice in the river to prevent them from causing any damage, except for one unfortunate boat crew who was killed removing one of the mines from the water. The incident did reportedly cause alarm among the British naval forces, demonstrating from the beginning the powerful psychological effect these weapons could have.[40]

Over the next eighty years improvements were made to these "torpedoes".[41] The changing terminology surrounding the submarine mine can be confusing. The weapons were originally called torpedoes, a name which came to be connected with self-propelled explosive devices. Mines were called torpedoes until well after the beginning of the twentieth century. Robert Fulton made several successful and unsuccessful trials of submarine mines in the United States and Europe. In the 1840s Samuel Colt experimented with controlled mines fired by electrical



A collection of Civil War Mines. From Robert C. Duncan, *America's Use of Sea Mines*, U.S. Naval Ordnance Laboratory, Washington D.C.:U.S. Government Printing Office, 1962. p. 27.

impulse. The reaction to the new weapon by military authorities was mixed, and development of mine technology progressed little.[42]

The Civil War marked a dramatic increase in the use and development of mine warfare. The Confederacy sought ways to make up for its disadvantage ships and guns and settled on the submarine mine as an important defensive weapon. Under the auspices of the Torpedo Bureau and the Torpedo Corps several types of buoyant mines were developed, along with electrically controlled ground mines, some containing as much as 5,000 pounds of explosive. While ultimately not a determining factor in the outcome of the war, Confederate use of submarine mines sank 27 Unions ships, damaged many more, and generally hampered Union naval efforts.[43]

After the Civil War the U.S. Army began development of a program of mine defenses. As head of the Engineer School at Willett's Point, New York, Col. Henry L. Abbott perfected a system of submarine mine use that remained the basic approach used from the 1880s through the Second World War. Abbot's "Grand Mine Group" consisted of groups of mines controlled from a shore facility. The Endicott Commission of 1886 made controlled mine fields one of the key elements of its plan for modernizing United States coastal defenses.

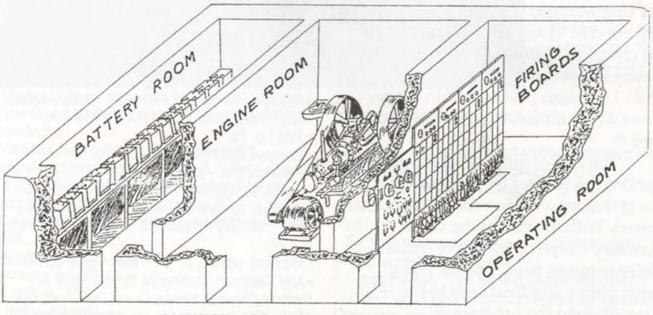
The mines used by the U.S. Army to defend coastal positions were buoyant controlled mines. This means simply that they floated at a predetermined depth in the channel where they were planted, and that they were operated by a control device on the shore. The mines were only deployed for any length of time during wartime. Otherwise they were planted for practice then retrieved and stored on shore. After the First World War most improvements to Abbot's system consisted of refinements to the electrical equipment as more sophisticated electrical cables and distribution box equipment became available.[44] During the last years of the Second World War the Army planted 4,000 larger ground mines that rested on the bottom of the channel.[45]

Controlled mines could operate in a variety of modes. The preferred method for controlled mines was 'delayed-contact fire". When operated in this fashion, the mine was set so that a light on the operating board would activate when the mine was bumped. The casemate personnel could then fire the mine after a pre-determined delay in order to allow the mine to be pulled under the hull and maximum damage to the ship. This setting could also allow the mine field to be used for surveillance against the passage of submarines.[46]

The mines could be set to fire upon contact with a ship. Contact fire was a method designed to be used only in a few specific circumstances — when multiple ships were crossing the mine field at high rate of speed or in too many different places to be individually controlled effectively. It could also be used if smoke or fog obscured observation of the mine field.[47]

Observation fire was the last resort for controlled mine attack. The firing of the mines would be directed from the mine command station by telephone. Its use was limited to a very few tactical conditions, such as when friendly and hostile vessels were in the field together, or if an attempt was made to clear the mine field. This method was less effective than either form of contact fire, especially since the position of mines could change slightly due to currents.[48]

By the end of the 1930s the basic operations of harbor defense mine systems had been refined and established for the remainder of the period of mine defense. The mine casemate was the nerve center of the mine defense system. Its basic functions were to provide power to operate the mine field and to house the operating boards that were connected to each group. Most of these facilities were not casemates in the architectural sense — a reinforced vaulted structure in a masonry fortress. Early mine operations were housed in true casemates and the name was appropriated through usage to mean any mine control structure, including lightly built Sewell stucco buildings in the first decades of the 20th century. After the First World War the



MINING CASEMATE

Illustration: Greg Hagge, from *American Seacoast Defenses: A Reference Guide,* Mark Berhow, ed. McLean, VA : CDSG Press, 2004. p. 361

advantage of more strongly constructed facilities became clear, and attempts were made to make later mine casemates resistant to bombardment and gas attack.[49]

The casemate power system was a complex affair. An engine driven generator provided DC electricity to charge a series of wet cell storage batteries housed in the casemate battery room. The DC power also operated the casemate lights and the mine control panels. The mines could only be fired by AC power, largely as a safety precaution, so two motor-generators converted the DC from the batteries to AC used to detonate the mines. This dual power system allowed the mines to be tested and set to their delayed-contact fire / detection mode while making sure that a firing voltage was not present in the system except when it was intended.[50]

The Second World War marked the high point of development for Army coastal mine defenses. Defensive mine fields were planted at all important coast defense sites along both coasts. In 1943 a new underwater defense plan provided for upgrading to the new heavier ground type mines. These mines were magnetic, an electrical impulse being sent to the casemate whenever a ship of greater than 1,000 tons passed within range. Over 4,000 of these new mines were laid.[51]

The end of the Second World War spelled the end for the Army's long involvement with controlled submarine mines. With the end of the Coast Artillery Corps operation of harbor defense mines passed to the Navy who, after a few final tests in the 1950s discontinued the program.[52]

Notes for Chapter 1.

[1] http://home.nps.gov/lewi/planyourvisit/caped.htm, accessed 05 Aug 08.

[2] John Hussey, *Chinook Point and the Story of Fort Columbia*, Olympia, WA:Washington State Parks and Recreation Commission, 1957 (1967). p. 5.

[3] Larry Weathers, "Place Names of Pacific County", *The Sou'Wester,* South Bend, WA: Pacific County Historical Society, vol. 24, nos.1-4 (1989), pp. 24, 31.

[4] Cecil McKithan, *Chinook* Point National Historic Landmark Nomination Form, Washington, D.C.: National Park Service Historic Sites Survey Division, 1977.

[5] Hussey, op. cit., p. 17. [6] Ibid., pp. 17-20.

[7] "Fort Columbia, Wash. Vicinity of Chinaman Point . . ." DMCR 369, Portland, Ore. : U.S. Engineer Office, 1906.

[8] David M. Hansen, Kimberley Keagle, Deborah Rehn. Historic Fortification Preservation Handbook, Olympia, WA: Washington State Parks and Recreation Commission, 2003. p. 1-1, 2-1.

[9] Mark A. Berhow, Joel Eastman, Bolling W. Smith. "Harbor Defenses of the United States of America", Bel Air, MD : Coast Defense Study Group, www.cdsg.org/cdghis1.htm, accessed 04 Aug 08.

[10] Quentin Jones, Military Architecture, New York : St. Martin's Press, 1974. p. 178.

[11] Mark Berhow, "United States Seacoast Defense Construction 1781-1948: A Brief History." in American Seacoast Defenses: A Reference Guide, Mark Berhow, ed. McLean, VA : CDSG Press, 2004. p. 5

[12] Hansen, p. 2.3. [13] Ibid.

[14] Berhow, "Seacoast Defense Construction". pp. 5-7. [15] Ibid.

[16] Edward Ranson, "The Endicott Board of 1885-1886 and the Coast Defenses", Military Affairs, Vol.31, No.2, (Summer 1967) pp. 74-77.

[17] Ibid., p. 76.

[18] Berhow, Brief History, pp. 9-10.

[19] Hansen, 2.6 - 2.12.

[20] Jamie W. Moore, "National Security in the American Army's Definition of Mission, 1865 - 1914", Military Affairs, Vol. 46, No. 3 (Oct 1982) p. 127.

[21] Berhow, op.cit., p. 11. [22] Ibid. [23] Ibid. pp. 12-15.

[24] Joel Eastman, Bolling W. Smith, Mark A Berhow, "United States Coast Defense Sites, 1945-2004," www.cdsg.org/cdghis7.htm, accessed 04 Aug 08. Also note that, though much had changed, the new Air Defense

Searchlight Station, Fort Canby.

Artillery chose as its avatar an updated version of the Coast Artillery's mysterious and powerful oozlefinch.

[25] Marshall Hanft, Fort Stevens: Oregon's Defender of the River of the West, Salem, OR : Oregon State Parks and Recreation Branch, 1980. p. 3. [26] Ibid., p. 5. [27] Ibid., p. 8.

[28] Gregg Hagge, personal correspondence, April 2008.

[29] Hanft, op.cit.,pp. 35-40

[30] Hussey, pp. 20-23.

[31] Hanft, p. 135.

[32] Hagge, op. cit.

[33] Hussey, pp. 24-25.

[34] Hanft, p. 247.

[35] Hussey, p. 27. [36] Ibid., p. 28.

[35b] http://www.cdsg.org/HDCRdata/stevensx.htm, retrieved December 1, 2008.

[36b] Hanft, pp. 268-269.

[37] Hansen, op.cit., p. 1.1.

[38] A.M. Low, Mine and Countermine, New York : Sheridan House, 1940. pp. 15-19.

[39] Mark Berhow, "Controlled Mines in US Army Seacoast Defenses," in American Seacoast Defenses. p. 326.

[40] Robert C. Duncan, America's Use of Sea Mines, Silver Spring, MD : U.S. Naval Ordnance Laboratory, 1962, pp. 3-6.

[41] Berhow, loc. cit.

[42] Duncan, pp. 17-22. [43] Ibid., pp. 23-25.

[44] Berhow, "Controlled Mines", pp. 326, 332.

[45] Ibid.

[46] U.S. War Department, TM 2160-20: Submarine Mining (Oct.15, 1930), Washington, D.C. : Government Printing Office, pp. 15-17.

[47] Ibid.

[48] Ibid.

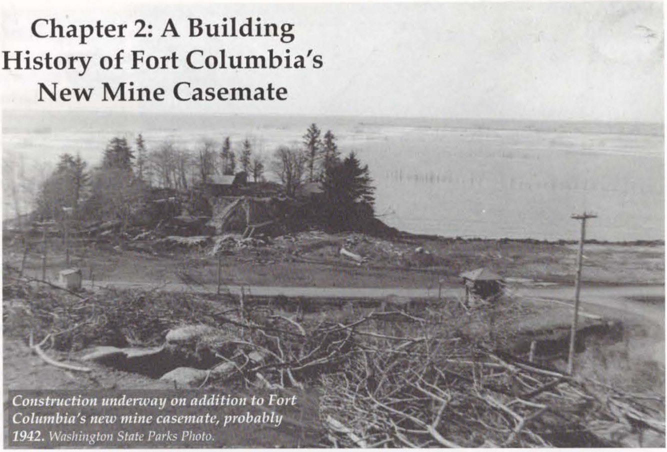
[49] Berhow, "Controlled Mines", p. 359. Hagge, personal correspondence.

[50] Gregg Hagge, "The Mining Casemate at the Middle Point Reservation", in American Seacoast Defenses, pp. 360-361.

[51] Duncan, pp. 130-131.

[52] Berhow, "Controlled Mines", p. 327.

Chapter 2: A Building History of Fort Columbia's New Mine Casemate

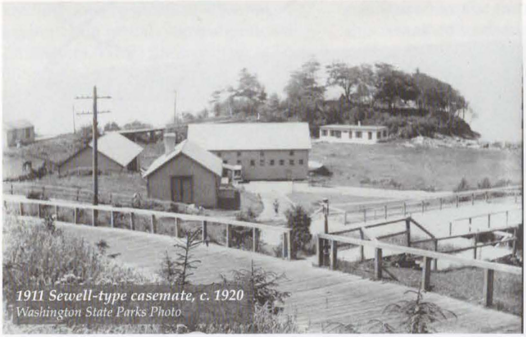


Construction underway on addition to Fort Columbia's new mine casemate, probably ***1942.*** *Washington State Parks Photo.*

Columbia River Casemates

The operation of the Columbia River defenses Endicott-era minefields was one of the main reasons for the construction of Fort Columbia. The mine casemate was the most important element in these operations, housing the mine control boards, batteries, and electrical generating system necessary to operate the mine fields.[1] The U.S. Army constructed the fort's original mine casemate in 1898 as part of the intial construction of Fort Columbia (see appendix, Reports of Completed Works). This first casemate is located southwest of Battery Murphy. A subterranean concrete structure, inadequate understanding of underground construction methods made it very damp and uncomfortable.[2] It was soon realized that this was not a suitable facility for housing electrical generating equipment and sensitive switching devices and the original casemate was abandoned in 1906 or 1907. After improvements to the ventilation system it was later converted to use as a telephone switchboard building.[3]

In 1909 construction began on Fort Columbia's second casemate. The U.S. Army Corps of Engineers completed the building March 30, 1911 for a total cost of $5,005.00.[4] This lightly-constructed building would serve as the mine casemate for a decade. It was constructed further south and west from the batteries and the earlier casemate, behind Chinook Point's rocky knoll, which provided natural protection. Such natural protection was a necessity, since the structure was a Sewell-type building of wood-framed stucco and expanded metal lath. This construction method followed a prototypes built in 1904-1905 on the east coast, including one at Fort McKinley in Portland, Maine.[5]



1911 Sewell-type casemate, c. 1920
Washington State Parks Photo

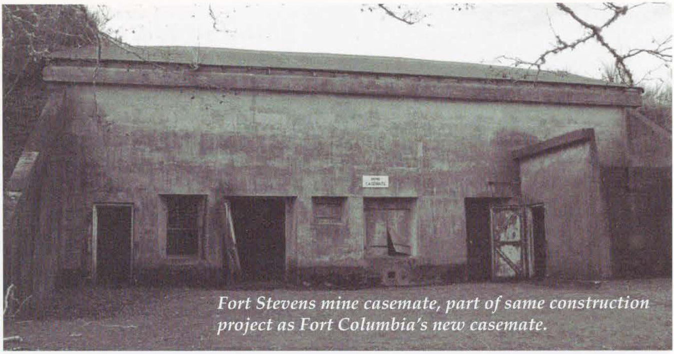
The observation station dormitory on Scarborough Hill was constructed using the same technique.

There is one historic photo of the casemate from this period. The photo clearly shows the casemate a little in front of the rocky outcropping of the point. In comparison with the stables and shop buildings that stood on the broad grassy lawn of the present site, the relatively small Sewell-type building is not imposing. No real indication of its function is revealed by a cursory examination of the photograph, and if one did not already know that this was an important military installation there is nothing to give its station away. Of course, it should be considered that the geographical isolation of Chinook Point in 1909 provided a greater measure of security than any fence.

The interior of the building was comprised by four symmetrically arranged rooms, each a little less than 22 feet deep. A battery room and engine room occupied the east side of the building, and were divided from the operating room and the cot room by a partition of closet space. This basic arrangement of space was clearly dictated by the functional needs of the mine operating system, and was essentially unchanged in the next casemate to be built.

The First World War demonstrated the inadequacy of lightly constructed command structures, and the need for fortifications resistant to heavy artillery fire became apparent.[6] Even in places as remote as the Columbia River the need was apparently seen to strengthen the command structures that enabled the gun batteries and casemates to function. The Army developed a project to build new fortified concrete casemates for both Fort Stevens and Fort Columbia. The Engineer Notebook for the Harbor Defenses of the Columbia records this plan:

> "D.E., Portland, Ore., August 21, 1917, submits estimates for bombproofing mining casemates at Forts Stevens and Columbia. New concrete casemate at Fort Stevens to be located about 50 feet from present building (25576/114). New concrete casemate, Ft. Columbia, to be located west of present building (25576/115).Total estimated cost of two buildings is $29,920. C. of E. fwds. Sept. 5, 1917, papers to AGO recommending approval, stating funds avaiable for allotment. AGO fwds. Sept. 7, 1917 to C. of C.A.



Fort Stevens mine casemate, part of same construction project as Fort Columbia's new casemate.

O.C.C.A. fwds. Oct.9,1917 to C. of E. with approved tracings. C. of E. fwds. Oct. 16, 1917 to D.E. 2nd Dist., Portland, Ore. approving plans and allotting $29,920. for purpose of building new casemate. D.E., second Dist., Portland, Ore.,returns papers Jan. 7, 1918 with notation 'Returned,noted.'"

The casemates constructed in this project are the two structures currently at Fort Stevens and Fort Columbia. The 1917 casemate at Fort Stevens is worthy of examination, since it was built as part of the same project and has seen little alteration over the intervening years. As seen in the Corps of Engineers "Report of Completed Works" it is a rectangular building roughly the same size as the 1909 Sewell-type casemate at Fort Columbia, laid out in the same fashion. We find the same storage battery room, engine room, a dividing row of closets and a latrine, and then the operating room and dormitory.

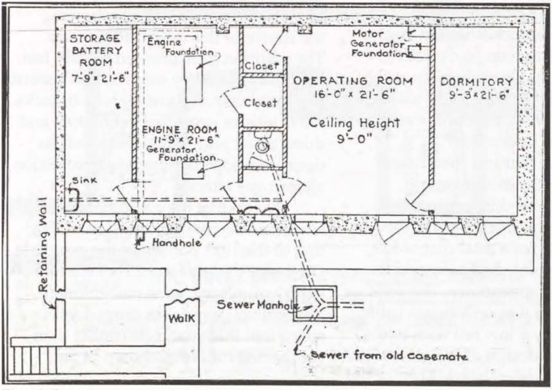
If the arrangement and function of the interiors are the same, there is a vast difference between the construction method. The 1917 casemate at Fort Stevens is constructed, not of a wood frame and stucco, but of massive concrete, much the same as the earlier Endicott-era gun batteries. The walls of the casemate are eight feet thick, and the reinforced concrete roof is five feet through. A covering of sand nine feet deep was piled over the structure, effectively camouflaging it among the dunes of the Clatsop sands and providing an additional measure of protection against artillery fire. The Fort Stevens casemate is also notable for the good condition of its interior finishes and spaces. It would be a valuable source of comparisons for any restoration attempt involving Fort Columbia's casemate, and is significant in its own right.

The New Mine Casemate at Fort Columbia

The Army approved construction of a new casemate for Fort Columbia in the same project that included Fort Stevens' new casemate. A cursory comparison of the construction documents shows that the two structures are functionally identical. Closer examination reveals some significant differences. While the casemate at Fort Stevens relies on massive concrete walls for protection from artillery fire, the new mine casemate at Fort Columbia uses the rock outcrop of Chinook Point for concealment and protection. The construction is still very stout. According to Army Corps of Engineers drawings, the walls are between two and three feet thick and are poured directly against the solid rock at the rear and the ends of the structure (Drawings 1,2). The walls are of massive concrete with little reinforcement. The roof was constructed of reinforced concrete five feet thick, though information as to placement of reinforcing steel is unavailable. A covering of earth placed over the finished casemate provided additional protection and concealment.

At the time of its completion in 1921 the visible facade of the new mine casemate at Fort Columbia would have been nearly identical to the Fort Stevens casemate, still visible in its original configuration. For the next twenty years this remained unchanged. In 1937 a new underwater defense plan was developed calling for the four mine operating boards then housed at Fort Stevens to be moved to the casemate at Fort Columbia.[7] The mine control cable was exposed during low tides at Fort Stevens, and the casemate at Fort Columbia was recognized as being better protected by the rocky knoll of Chinook Point.[8]

As the possibility of American involvement in the Second World War, already raging across Europe and Asia, increased, the Army made plans to further strengthen Fort Columbia's mine casemate. On a sheet labeled April 1941, expansion of the casemate to include gas proofing equipment, as well as a new power house for the searchlight on Chinook Point, is shown.[9] This drawing differs from the actual construction, but the essential elements remained unchanged. Two entry tunnels give access to the added rooms, although they lack the elegant curve of the final construction. A more substantial



Plan of Fort Columbia's 1921 new mine casemate. From U.S. Army Corps of Engineers Report of Completed Works.

covering of earth, along with a cap of stone rubble that was to serve as a burster course, was intended to detonate any bomb or shell before it could penetrate the covering (Drawing 3).

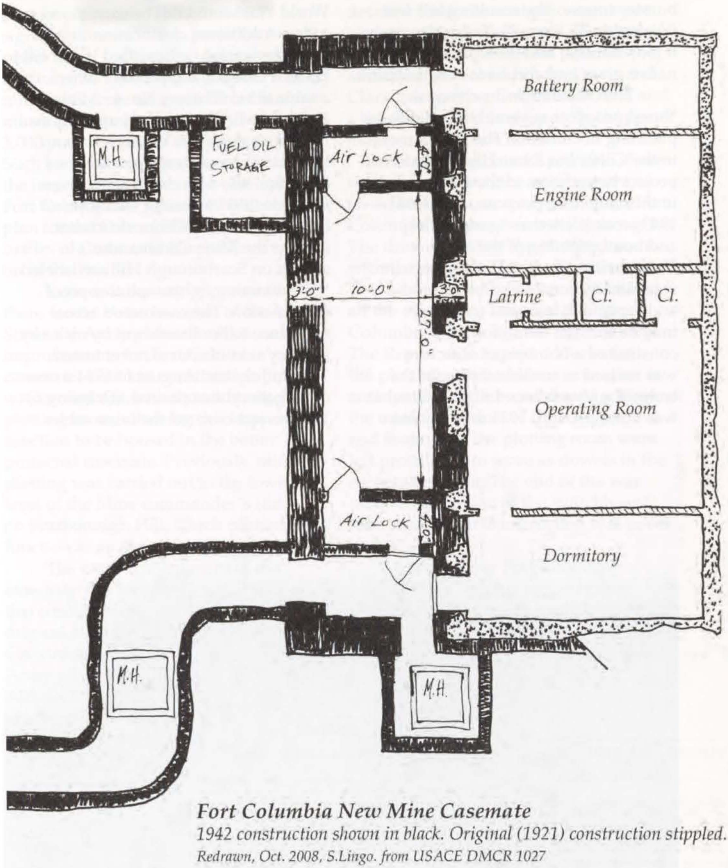
By July of 1941, engineers had worked out the plan in greater detail.[10] The next drawing in the building's development shows an arrangement closer to that actually built. The entry tunnels are no longer symmetrically angled, but curved to accommodate the existing searchlight power house at the casemate's east end. The size of the various gas removing chambers is still different from the final construction, and the burster course is shown as a layer of stone rubble, rather than concrete as actually built. (Drawing 4)

The final drawing in the series dates from May 1942 (Drawing 5).[11] Construction was already underway, and the drawing accurately depicts the final state of the casemate. The drawing on the opposite page shows relation between the original construction and the gas-proofing addition. According to the Corps of Engineers Report of Completed Works, construction began on the new addition on November 1, 1941. One can imagine the urgency the construction of coastal defense works assumed after the catastrophic events at Pearl Harbor on December 7.

Most of the features that define the character of the existing mine casemate date from this construction phase. By the time work was finished on January 31, 1943 for a total cost of $29, 957.12 , the casemate had assumed its current external appearance. The rock of Chinook Point was no longer visible, its place taken by a low hill with two entry gates. The design of the gates with their stripped classical lintel is one of the casemate's character defining features. No construction document showing the source of this design was found. The addition measures ten by fifty feet, excluding the entry tunnels, and consists of a long room flanked by two air locks. An extensive system of ventilators and ducts along with fabricated steel gas doors provided the intended protection against gas attack.


West entry gate of newly completed 1943 addtion. From USACE Report of Completed Works

The roof of the gas-proofing addition was five feet thick, matching that of the 1921 portion of the casemate. On top of the reinforced roof ten feet of earth was placed as an embankment. This embankment was capped with a two foot thick concrete (rather than compacted rubble as shown in the



Fort Columbia New Mine Casemate

1942 construction shown in black. Original (1921) construction stippled.

Redrawn, Oct. 2008, S.Lingo. from USACE DMCR 1027 drawings) burster course. An additional three feet of earth was placed over the burster course. The resulting hill was finished in an irregular fashion to make it look natural, and then planted with native grass and shrubs for concealment.

The casemate is described as "bombproof" in several Harbor defense planning documents. The 1937 annex to the Columbia River Harbor Defense project twice refers to the structure in this way. The purpose of the 1941-1943 work is cited as "gasproofing and bombproofing of the Mine Casemate" even though the structure was already considered bombproof and repeatedly referred to as such. It may be that the definition of what constituted a bombproof structure was revised as understanding of the technologies advanced. Certainly what was bombproof in 1921 may not have seemed so secure by 1942, just as what was bombproof during the Second World War would not be considered so today. Additional clarification to this characterization is provided in the 1944 Harbor Defense Supplement where a table titled "Battery No. 4 - Mines - Exhibit 13-B." breaks the fortifications into two categories. Under a column labeled "Protection against Bombs / Shell fire" the new casemate is given the code "BB" meaning "Bombproof by construction". Other structures such as the Mine Commander's station on Scarborough Hill are labeled "SB" denoting lighter splinter-proof construction. The casemate's actual resistance to bombardment by air or by artillery was of course never tested.

In July and August of 1944 a new cable gallery was poured. (Drawing 6) This project covered the mine cables

Recently completed mine casemate. Note filled beach compared with 1920s photo. Washington State Parks Photo.

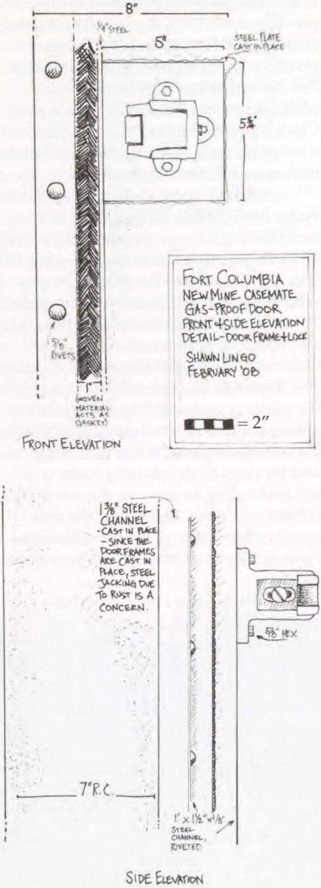
which had previously lay exposed on the river's shore for a time at each change of the tide. This small but significant construction project was part of the larger underwater defense plan instituted in 1944.[12] The Columbia River minefields were converted from buoyant mines to larger ground mines holding 3,000 pounds of high explosive each. Such an extensive effort demonstrates the importance of the mine casemate at Fort Columbia as a part of the defensive plan for the Columbia River, while the battles of Guam and New Guinea raged on in the Pacific.

Even as it became apparent that there would be no invasion of the United States the Army planned additional improvements for Fort Columbia's mine casemate. One last construction project was carried out with the addition of a plotting room, allowing this important function to be housed in the better protected casemate. Previously, mine plotting was carried out in the lower level of the Mine commander's station on Scarborough Hill, which continued to function as an observation station.

The earth embankment of the casemate was removed to allow for this construction and replaced in its original configuration after completion. Construction work was carried out by Army personnel, as were the previous additions. Totalcost for the plotting room addition came to $14,698.79 and work was completed July 28, 1945 — a few weeks before the end of the war, and a month after the Columbia River's minefields were removed.[13] The drawings prepared for this construction project seem to show an evolution in understanding of the demands of concrete fortification construction. In addition to the basic plan and elevation drawings that were prepared for the previous additions, stress diagrams and detailed reinforcement placements are given for the plotting room. (Drawings 7-9) No such drawings for previous additions were found in the Lewis and Clark Interpretive Center collection, and a list of historic drawings from the center makes no reference to them.

A drawing dated April 1945 shows that a final project, the addition of a switchboard room, was planned for Fort Columbia's mine casemate (Drawing 10). The drawing shows the plotting room with the notation "Under Construction." This addition would have consolidated all the operations essential to Fort Columbia's mine defense in one location. The Report of Completed Works for the plotting room addition notes that in anticipation of the switchboard addition, the reinforcing steel of the roof, walls and footings of the plotting room were left protruding to serve as dowels in the subsequent pour. The end of the war made construction of the switchboard room irrelevant. Construction was never begun.

After the war Fort Columbia was declared surplus property and became part of the Washington State Parks System. Since the closing of the fort in the late 1940s very little, if any, maintenance work was performed on the mine casemate. Electrical work was performed on the casemate around 2006 to provide light. In 2008 debris from the decayed floor and dividing walls in the original 1921 section was removed by work crews. Some form of restoration/ stabilization is planned in anticipation of the Washington State Parks centennial in 2013.



Notes for Chapter 2.

[1] Hagge, in American Coastal Defense, p. 361.

[2] August Grulich, David Hansen, et. al., Coast Defense Component, Washington State Parks Historic Properties Condition Assessment, Volume 6, Fort Columbia and Fort Canby. "CO-5 Switchboard." 1997.

[3] Ibid.

[4] U. S. Army Corps of Engineers, Coast Defenses of the Columbia, "Report of Completed Works - Seacoast Fortifications, Form 2. Corrected to June 30, 1921." reproduced in electronic format by Coast Defense Study Group, www.cdsg.org.

[5] Historic American Engineering Record, Fort McKinley Double Mine Building, HAER No. ME-59-D, National Park Service, Northeast Region, Philadelphia, PA, 1995.

[6] Martin A. Brice, Stronghold: A History of Military Architecture, London: B.T. Batsford, 1984. pp. 160-162.

[7] U.S. Army, "Annex to Harbor Defense Project, Harbor Defenses of the Columbia," CCA-AN-CR, 1937, p. 8.

[8] Hanft, p. 194.

[9] U.S. Engineer Office, Portland, Oregon District, "Harbor Defenses of the Columbia, Bomb and Gasproof Mine Casemate and Power Plant for S.L. No. 6, Fort COlumbia, Washington, April 1941", DMCR 920.

[10] U.S. Engineer Office, Portland, Oregon District, "Harbor Defenses of the Columbia, Bomb and Gasproof Mine Casemate, Fort COlumbia, Washington, July 1941", DMCR 938.2.

[11] U.S. Engineer Office, Portland, Oregon District, "Harbor Defenses of the Columbia, Mine Casemate, Fort Columbia, Washington, May 1942", DMCR 1027.

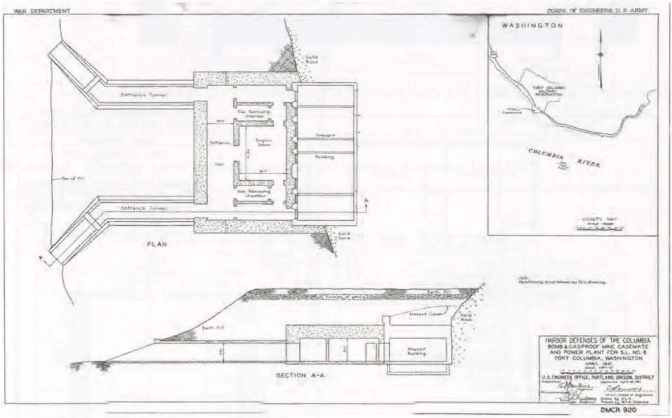
[12] U.S. Army, "Supplement to Harbor Defense Project, Harbor Defenses of the Columbia, Annex D - Underwater Defense", 1944.

[13] U.S. Army Corps of Engineers, "Report of Completed Works, Harbor Defenses of the Columbia, Fort Columbia, Washington, Mine Casemate, Supplemental Report," Part II, September 1, 1945.

Casemate construction history drawings

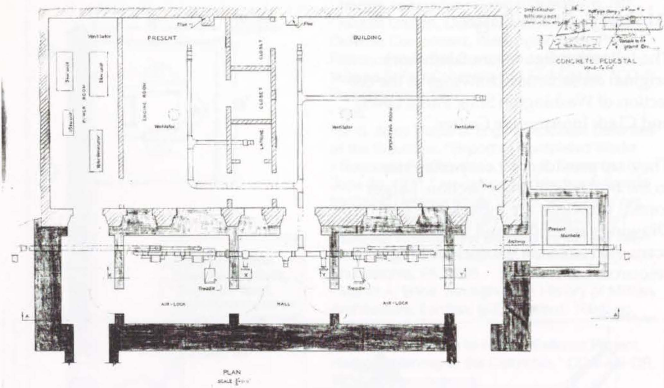
The following figures are taken from original construction drawings in the collection of Washington State Parks Lewis and Clark Interpretive Center.

They are provided for easy reference to the Building History Section. Larger format drawings are included in the Drawings appendix, and full size digital scans are found on the enclosed digital resources CD ROM.

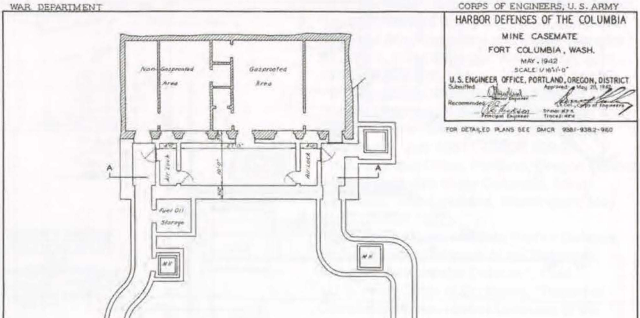


Drawing 1. (Above). Initial plan for gas-proofing addition to Fort Columbia Mine Casemate. April 1941. Note angled tunnels and section showing position of original casemate construction against rock of Chinook Point.

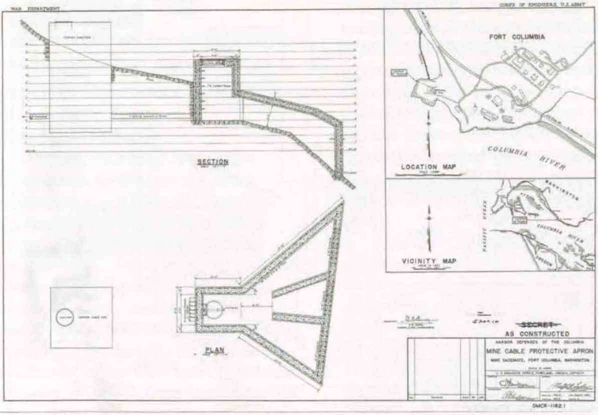
Drawing 2. July 1941, showing evolution of gas-proofing system.



Drawing 3. (Below). May 1942, construction already underway, shows plan as built.

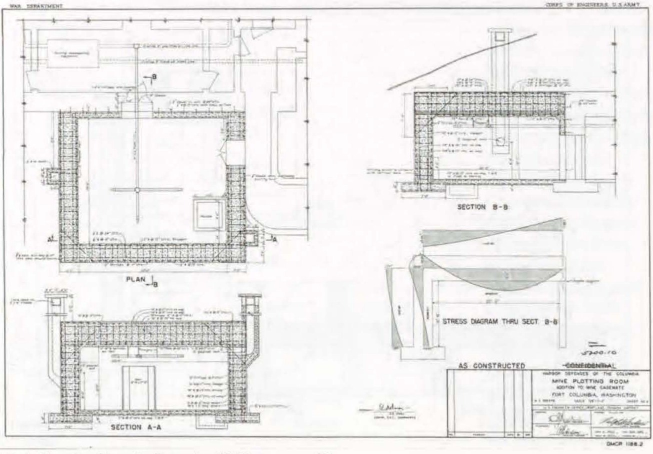


Casemate construction history drawings

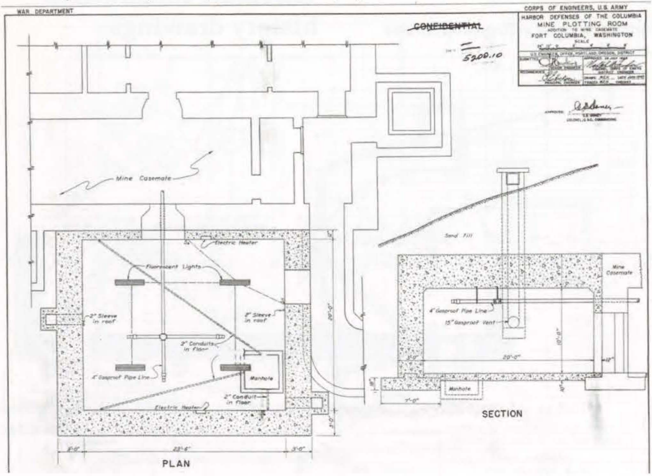


Drawing 4. Cable gallery project, 1944

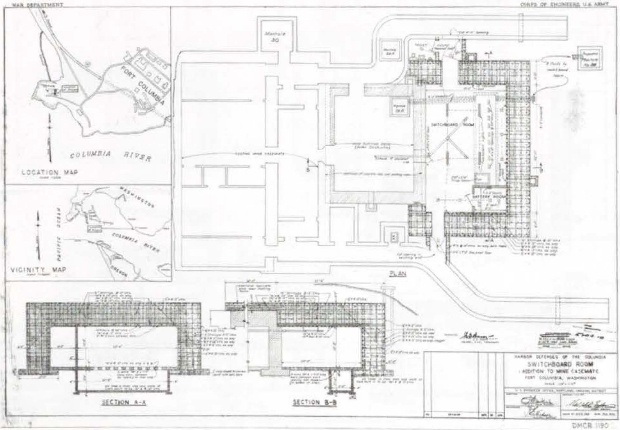
Drawing5. Plotting room plan and section with stress diagram, July 1945.



Drawing 6. Plotting Room plan and section. July 1945.



Drawing 7. Planned switchboard room addition. April 1945.



Chapter 3: Physical Description and General Assessment

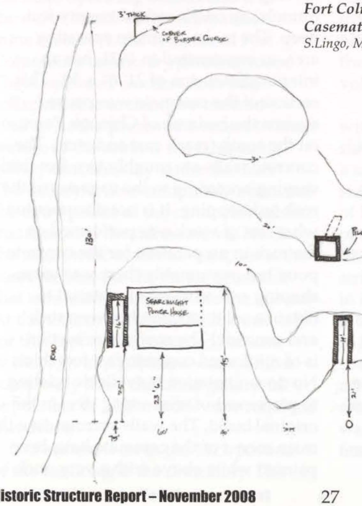
Conditions as of October 2008. Photo reference numbers correspond to images in Volume 2: Photographic Documentation.

Site (Photos 90-109)

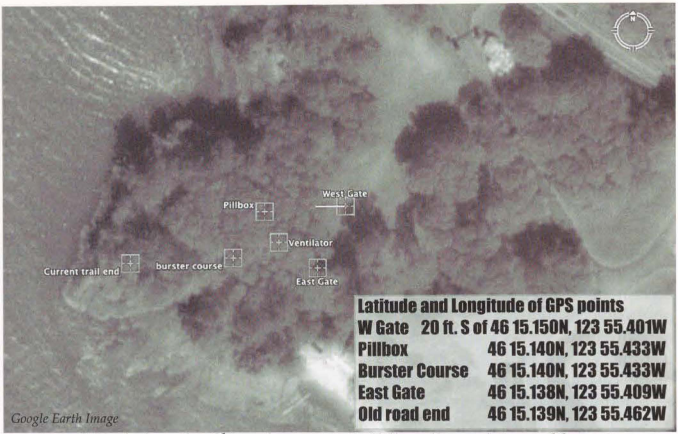
Fort Columbia's New Mine Casemate is located on the rocky outcropping of Chinook Point. The accompanying chart and aerial photo give latitude and longitude measurements for several key casemate features. The top of the hill created by the casemate and its earthen embankment is dotted with secondary features. A pillbox sits slightly to the southwest of the west gate, positioned to cover approach from land. Chinook Point itself conceals the view from the river. A number of ventilation stacks rise from the casemate at various spots around the hill. At a point that roughly corresponds to the southeast corner of the main casemate the corner of a concrete slab has been exposed by slumping of the earthen cover. It is probable that this is the corner of the burster course. The burster course was originally covered by three feet of earth. It is two feet thick and was separated by ten feet of earth fill from the casemate roof.

Immediately adjacent to the casemate's east gate is a rectangular building constructed of concrete and expanded metal lath panels. This structure is not related to the casemate functionally, but is the power house for a searchlight station that was located on Chinook Point. The powerhouse obscures view of the east gate from the road.

The site is currently heavily wooded, but the first available historic photo of the 1911 casemate shows a few relatively large trees on a much different looking Chinook Point (See Appendix: Historic Photos). Based on examination of historic photos and comparison with current conditions, it seems apparent that there have been significant modifications to the site over time.



Fort Columbia, New Mine Casemate, Site Plan
S.Lingo, M.Lingo 11 June 08



Latitude and Longitude of GPS points	
W Gate	20 ft. S of 46 15.150N, 123 55.401W
Pillbox	46 15.140N, 123 55.433W
Burster Course	46 15.140N, 123 55.433W
East Gate	46 15.138N, 123 55.409W
Old road end	46 15.139N, 123 55.462W

Google Earth Image

Lewis and Clark describe Chinook point as a high rocky outcropping. This has changed significantly due to the construction of the new mine casemate and the earth embankment placed over it in several stages. To the east of the casemate the site has been changed by earth roadbed constructed to take the place of the bridge visible in the earliest historic photo. One of the most significant changes made to the site was the filling of the beach to the west of the casemate. This beach is clearly visible in the early photo, but in the two subsequent images earth has been placed in the low area, giving the site what is essentially its current topographic profile.

In these three historic photos the radical changes to the area around the casemate are clearly seen. Most notable is the removal of the stables and wagon sheds that originally stood in what is now the broad grassy lawn north of the casemate.

Building dimensions and layout

The new mine casemate is roughly seventy five feet wide (at the entry tunnels) by one-hundred twenty feet deep. The main casemate operating area, as constructed in 1921, has an interior dimension of 21′ 6″ x 50′. This section of the casemate was poured against the bedrock of Chinook Point on the south (rear), east and west. The concrete walls are roughly two feet thick, varying according to the vagaries of the rock outcropping. It is not documented what sort of work was performed on the rock in preparation for the concrete pour, but presumably there was some shaping and removal of material to obtain a solid junction between rock and concrete. The roof of this section is of reinforced concrete five feet thick. No documentation is available relating to placement of reinforcing steel in the original build. The walls surrounding the main rooms of the casemate have been painted white above with a very dark band of blue-black at wainscot height below.

At the east end of the 1921 casemate were the battery room and the engine room. The partition walls between the casemate rooms are gone with the exception of the wall dividing the dormitory at the west end from the rest of the space. On the east wall the battery room sink is still in place. The two concrete bases on the floor of the casemate originally held the diesel engine and generating equipment. Two original electrical control boxes remain in place.

Between the engine/battery rooms and the operating room were a row of closets and latrine facilities. The twin sinks to the immediate left of the central operating room entry are the only remains of these rooms.

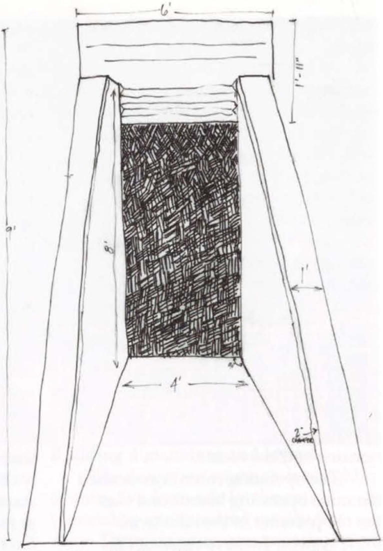
The operating room once housed the mine operating boards and was the nerve center of the submarine mine system.[1] Little remains of Fort Columbia's casemate operating room. The suspended wooden floor had collapsed due to decay by the mid-1960's.[2] At the present the most obvious feature of the room is the large cable gallery that once lay under the floor. The gallery is now completely open and the entry points of the conductor cables that operated the mines are visible. In the south west corner of the room is the concrete base for the motor generator that was used to actually fire the mines. At the time of the initial field work for this report, the collapsed remains of the floor and partition walls almost completely filled the cable gallery. In September of 2008 a work crew removed this debris.

Farthest west in the 1921 portion of the casemate is the dormitory. The partition wall that separates it from the rest of the casemate is the only one still intact. There is no light source in this section at present, and detailed observations are difficult. The wall is clad with bead board and several colors of paint are in evidence. The paint colors are very close to those used in the Fort Stevens casemate. The dormitory space is mostly filled by a double row of plywood cabinets. Based on the construction material these would date from the Second World War, since that is the period in which plywood became widely used.

The entry tunnels, their associated utility rooms, and the gas-proofing system date from the 1941-1943 construction phase. The tunnels are 4' wide with a 7' ceiling height. Wall thickness is given as 12" in the *Report of Completed Works* for this build. A standard concrete mix of 1:2:4 was used in the construction of the 1943 addition. No mention was made as to whether the mix was computed by weight or by volume.

The entry to both tunnels is closed with a steel gate constructed of welded steel angles. The gates are crowned by a massive concrete lintel decorated in a stark but elegant Art Deco arrangement of horizontal fluting. This motif is one of the few decorative elements found in this very utilitarian structure, and the stripped down classicism is appropriate in its evocation of raw strength. The interior surface of the tunnels appears to have been finished with a skim coat of plaster to fill voids left in the construction process. A two-inch chamfer acts as a transition between the walls and ceiling, another rare decorative feature.

The west tunnel runs



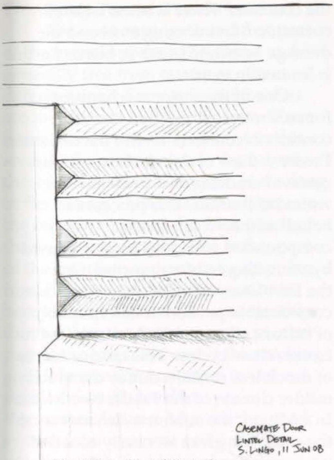
Fort Columbia, New Mine Casemate, West Gate
Mary Lingo, Sketch; S. Lingo, measurements, tracing

approximately 50′ from the beginning of the 14′ exterior apron, then makes two ninety degree turns before continuing on into the gas removing area. At the first turn the tunnel widens to about 7′ and there is a large manhole in the floor. After the second turn the tunnel returns to its standard 4′ width, runs about 14′, then widens slightly to accommodate the gas-proof doors leading to the gas removing chambers and the dormitory.

The eastern entry is identical in dimension to that on the west, but the exterior apron is longer and the entry sits back toward the hill about 6′ compared with the west gate. The differing angle and placement of the east gate seems to have been an accommodation to the existing searchlight power house that sits very close to the entry. This tunnel runs straight for about 15′, then makes 45-degree turn and holds this line for approximately twenty feet before turning again parallel to its original line. The two small rooms on the right-hand side were used for fuel oil storage. The final 30′ of tunnel lead to the east airlock with its gas-proof door and to the entry to the battery room. The louvered non-gasproof steel door for the battery room has been removed from its hinges and sits in the tunnel.

The gas-proof doors of the casemate are one of the character defining features of the structure, essential for an understanding of the building's function. The doors were fabricated of steel, with the door frames cast in place. The doors themselves are of riveted construction. The door seals of woven material are still in place. They are extensively rusted, as are all metal components of the casemate, but some of the original bright red-orange paint is still evident in a few places. The locking mechanisms use a lever handle on the outside, with a freezer-type release on the inside. Gas proof doors are present on openings leading in to the dormitory from the entry hall, and into the two small air lock rooms on either side of the casemate.

The air locks measure 4′ x 10′ and are located on the west and east ends of the large gas-proofing chamber. Each has one gas-proof door leading from the entry tunnels, and a treadle apparatus hooked to the ventilation pipes. Access to the inner gas removal



West Gate Lintel Detail.

room is through a steel non-gasproof door. The gas-proofing equipment is no longer in place, with the exception of the 6″ air pipes, but originally consisted of a series of air pumps and canister filters at the east end of the large gas system room(Figure X). The remaining pipes are a character defining feature of the casemate, providing, along with the gas-proof doors, insight into the function and purpose of the building. From the small gas-proofing rooms access is obtained to a hall 10′ x 27′. Doorways provide access to the casemate operations area and to the plotting room addition. A map case spans the west end of this room, blocking access to the airlock on that side.

A louvered steel door identical to that of the battery room originally closed the passage between the plotting room and the gas system facility. This door has been removed and is currently (2008) in the long gas proofing room. The doorway to the plotting room addition was cut through the north wall of the gas system room. This wall was originally three feet thick, but an extra foot of concrete was added for the plotting room. This doorway widens from three feet on the hallway side to five feet on the plotting room interior.

The plotting room addition was the last construction associated with the casemate. It measures 20′ x 24′, although the Report of Completed Works and the construction drawings describe it as 23′6″. The room was measured repeatedly (with different tape measures and different assistants) and measured 24′ each time, leading us to conclude that this is the actual dimension. The ceiling is 10′ in height and 5′ in thickness. The north, east, and west walls are 3′ thick. The floor is 10″ thick . The addition rests on footings 7′ wide and 18″ thick. According to construction drawings 5/8″ reinforcing steel was placed in a matrix 12″ on center in walls and ceiling. The floor and footings have 1/2″ rebar on 12″ centers top and bottom.

The walls of the plotting room are bare concrete, with the form work of plywood sheets clearly in evidence. The ceiling was board-formed and originally covered with acoustic tile. Several of these tiles are laying on the floor in the south-east corner of the room. Black and red asbestos floor tiles forming a checkerboard pattern are still in evidence in several spots in the plotting room. The current fluorescent light fixtures were recently added. The original lighting system was four fluorescent fixtures with four 48″ tubes each. One of the original light fixtures is on the floor in the south-east corner of the plotting room.

The east and west walls are penetrated by a 15" gas-proof vent. The south wall is penetrated by a 4" gas-proofing pipe. A 4'x4' manhole is located adjacent to the west wall, 2' from the north wall. This manhole is connected to the manholes in the two entry tunnels by four 3" conduits in the floor. On the North and south walls metal boxes were cast in place to accommodate electric heaters. The original 2000-watt, 220 volt wall heaters have been removed.

General Condition Assessment and Preservation Treatments

In September of 2008 the author was able to perform a brief walk-through of Fort Columbia's new mine casemate with Paul Gaudette of Wiss, Janney, Elstner Associates of Chicago. Mr. Gaudette is an internationally recognized expert on preservation of historic concrete. The result of that walk-through and subsequent conversation allowed the author to make some generalized observations about the current condition of the casemate.

The casemate is structurally in good condition. Paul Gaudette remarked during the walk-through that he was surprised at how "tight" the concrete itself was for a structure of its age and type. There are only a few places that show any real sign of the deterioration typical of historic concrete.

The mechanisms that cause concrete to break down are largely due to two factors - the presence of water and the related corrosion of the reinforcing steel embedded within the concrete. While the interior of the casemate is very damp, it appears that much of this moisture is caused by condensation within the casemate, and not by movement of water through the concrete.[3] There is some isolated corrosion of reinforcing steel and the damage associated with it, but so far this is limited in extent.

One of the major mechanisms for concrete deterioration is of little concern in connection with the casemate. Freeze / thaw cycles can be a serious cause of cracking and an avenue for water infiltration. This process can be self amplifying, especially when compounded with steel jacking caused by corroding reinforcing steel. On the East Coast of the United States a considerable portion of deterioration of historic concrete can be attributed to freeze/thaw cycles.[4] This mechanism is of much less concern due to the much milder climate of the Pacific Northwest. In addition, the subterranean nature of the casemate gives an nearly constant year round temperature and this thermal stability may be credited for the extraordinarily solid character of the concrete.

This report will give a very basic overall assessment of the casemate, focusing on areas where there are problems apparent and discussing some appropriate preservation treatments. The discussion is keyed to photos in the documentation section of this report. Also, see the attached appendices "Preservation of Historic Concrete: NPS Preservation Brief 15", and "Protecting reinforcing steel in concrete from corrosion" for a more detailed discussion of the properties and treatments for historic concrete.

Following is a brief discussion of preservation concerns for each section of the casemate and basic recommendations for treatment. Recommendations are presented in a project format in the next chapter.

West Entry Tunnel (Photos 1-10)

The west entry gate and first part of the tunnel appear to be sound and generally free from cracks or other deterioration. Some original finishes are in evidence in the entry area. There is one preservation issue noted in this area. At the second turn in the tunnel there is a substantial amount of cracking in the ceiling. These cracks converge on the outside corner of the turn. Much of the water that accumulates in this part of the casemate appears to be dripping from this crack system. The concrete here is about a foot thick, considerably thinner than the massive walls in other part of the casemate, and if the cracking and deterioration continues structural problems could develop.

Recommendations: Monitor this crack system for movement and further deterioration. If additional problems develop consult a structural engineer experienced in evaluation of historic concrete.

Plotting Room (Photos 18-40)

As with the rest of the casemate, problems in the plotting room are not serious, but warrant a watchful eye. The main concrete issue is the efflorescence around the south door into the gas proofing room. This efflorescence is the result of water moving through the concrete above, dissolving calcium carbonate from the mix, and redepositing it where the water seeps from cracks. There is some exposed reinforcing steel around the door, as well as steel covered by less than 1/4" of concrete. At the east corner of the south wall there is some cracking with efflorescence.

The presence of efflorescence does indicate that water is moving through the concrete. However, the structure of the casemate is so massive here, the south wall is four feet thick and the ceiling is five feet thick, that the small amount of material precipitated from the concrete presents no structural concern at the present. The exposed rebar over the doorway may present a safety hazard for visitors if the problem accelerates.

There are two gas-proof vents in the plotting room. They are currently blocked by debris, shutting off airflow.

Recommendations: Monitor cracks for movement or change that may indicate more significant problems. Repair the exposed rebar and the spalls created by corrosion following standard historic concrete repair practices. Clear debris from the existing vents to restore air flow. This may help with reducing dampness in the casemate.

Gas-Proofing Rooms (Photos 41-60)

The concrete in the gas-proofing rooms seems to be in very good condition. No significant problems were noted. The gas-proof doors, pipes, and other remnants of the gas-proofing system are all rusted. The wooden map case shows signs of serious decay, as is to be expected of wooden elements in such a damp environment.

Recommendations: The metal doors and gas-proofing elements should be treated with a rust converter. A rust converter chemically changes the iron oxide to a chemically stable compound. Although it is usually recommended that items treated with such a converter be painted, this may not be necessary in the casemate since the materials will not be exposed to the weather. This approach would also leave the traces of original paint on the doors visible.

Main Casemate — Battery, Engine, and Operating Rooms (Photos 67-83)

The concrete of the original 1921 section of the casemate appears to be in good shape. The walls have retained much of their original finish, aside from some fading and peeling. The only immediately apparent preservation concern is the spalling concrete on the ceiling of the structure. It appears that in the construction process wooden members were cast into the concrete to provide nailing blocks for the interior walls and surface coverings. These wooden nailing blocks have absorbed moisture and expanded, causing some concrete to crack and fail.

The reinforced ceiling is five feet thick in the casemate operating areas, so the concerns are not structural. However, from the point of view of visitor safety this situation should be addressed. Also in connection with visitor safety is the open cable gallery under the casemate operating room.

In the doorway that connects the gas-proofing room and the original casemate there are cracks with stalactite formation. Although this indicates that concrete above this point is satuarted with water and that the calcium carbonate is leaching it is probably not an immediate concern.

Recommendations: Leave walls as they currently are to protect historic finishes. If it is indeed the wooden nailing blocks that are causing the failure of the concrete on the ceiling, these members should be removed. They are currently in a decayed state and serve no functional purpose. Thorough documentation should take place as the the position and dimensions of the nailers in case it is decided to replace the dividing walls in the future. The cable gallery should be covered with a suspended floor as it originally was. This will not only protect the unwary visitor, but will convey a more accurate impression of the operating room space.

Dormitory (Photos 61-67)

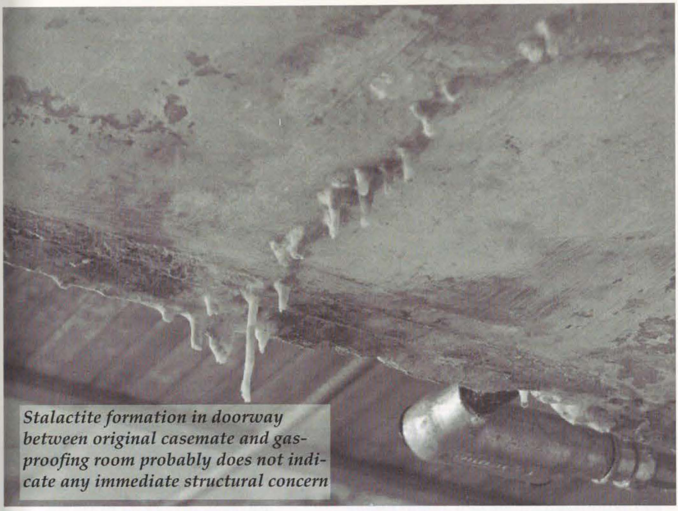
The dormitory is currently the only space in the original casemate that is still enclosed by a wooden partition wall. This wall has lost a portion of its connection to the north wall of the casemate. The interior of the dormitory was altered from its original configuration by the installation of the double row of wooden storage cabinets that currently occupy most of the space. The original finishes are intact in this area, and there are several areas where paint shadows show the progression of paint colors and materials.

Recommendations: Stabilize partition wall by restoring connection to casemate's north wall. The wooden storage lockers are historic fabric and should be retained. There seems to be very little available documentary evidence as to the appearance of the dormitory when used as living quarters. In its present state the dormitory does not seem to be suitable for visitor access. Interpretive materials could provide visitors with basic information as to the original function of the space. The dormitory could be a suitable place for housing any improvements to the ventilation or lighting systems that are necessary to make the casemate readily accessible to visitors.

Cable hatch room

The cable hatch room is located directly across from the west air lock and adjacent to the dormitory. The large metal hatch doors are rusted and the hatch itself presents a fall hazard for visitors. No concrete issues were identified.

Recommendations: Treat hatch doors with rust converter. Place barrier to prevent falling hazard for visitors.



Stalactite formation in doorway between original casemate and gas-proofing room probably does not indicate any immediate structural concern

East Entry Gate and Tunnel (Photos 11-16)

The east entry tunnel is in very good condition. No immediate concrete preservation issues were noted. The original steel gate has been damaged and is currently covered with plywood. Recommendations: Repair steel gate and remove plywood covering.

East Tunnel Utility Rooms

No preservation issues were identified in connection with these rooms. The floor openings present fall hazards.

Recommendations: Provide barrier to prevent fall hazard.

Notes for Chapter 3

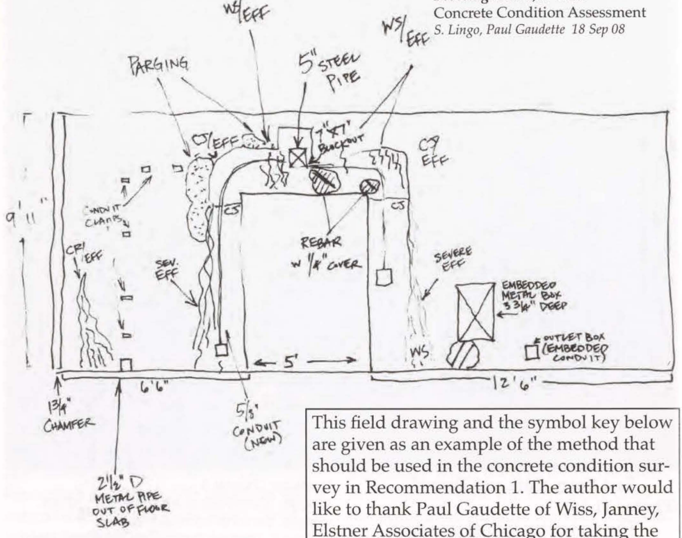
[1] Hagge, "Casemate at Middle Point", p. 361.

[2] Hagge, personal correspondence

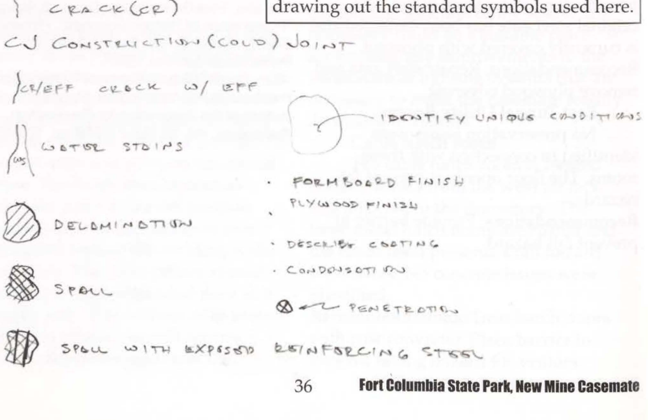
[3] Martin E. Weaver, *Conserving Buildings*, New York: John Wiley & Sons, 1997, pp. 145, 146. See also, Paul Gaudette and Deborah Slaton, "Preservation of Historic Concrete", *Preservation Brief 15*, National Park Service, Heritage Preservation Services, 2007.

[4] Gary Scott, "Historic Concrete Preservation Problems at Fort Washington, Maryland", *Bulletin of the Association for Preservation Technology*, Vol. 10, No. 2 (1978) pp. 129-131.

New Mine Casemate, Fort Columbia
Plotting Room, S Wall
Concrete Condition Assessment
S. Lingo, Paul Gaudette 18 Sep 08



This field drawing and the symbol key below are given as an example of the method that should be used in the concrete condition survey in Recommendation 1. The author would like to thank Paul Gaudette of Wiss, Janney, Elstner Associates of Chicago for taking the time to walk through the process and for drawing out the standard symbols used here.



Chapter 4: Recommendations for Treatment

A set of brief recommendations for each section of the casemate has been given in the previous section. This chapter will give more general recommendations organized in the form of potential projects, and presented in what seems to be a logical priority for Fort Columbia's casemate.

Level of Treatment

Preservation, restoration, rehabilitation, and reconstruction are the levels of treatment for historic resources as outlined in the Secretary of Interior's standards for historic preservation. Preservation is the level of treatment appropriate for Fort Columbia's mine casemate. The standards describe preservation as:

> the act or process of applying measures necessary to sustain the existing form, integrity, and materials of an historic property. Work, including preliminary measures to protect and stabilize the property, generally focuses upon the ongoing maintenance and repair of historic materials and features rather than extensive replacement and new construction. New exterior additions are not within the scope of this treatment; however, the limited and sensitive upgrading of mechanical, electrical, and plumbing systems and other code-required work to make properties functional is appropriate within a preservation project.

The expense involved in a complete restoration effort would be impractical. Some important elements need to be replaced to accurately convey the history of the building to the visitor, but the overall approach must be focused on preserving the structural stability and the functional usefulness of the casemate. Efforts must be made to prevent further decay of the building fabric, but no attempt is made to return the building to new condition. Repairs and additions for making the casemate accessible to the public are to be kept to a minimum.

Some changes that have taken place within the casemate in recent years should be reversed. The large mercury vapor lights in the casemate engine and operating room should be removed and replaced with period appropriate lighting. Likewise, some seemingly-commonsense practices such as painting interior surfaces should be avoided, since they will damage the existing historic finishes.

This is not a "do nothing" approach, but rather "do wisely". It can be thought of as a program of controlled preservation, that allows for approaches usually taken in other levels of treatment. Such a limited approach to preservation will naturally reduce the demand on the park's limited financial and labor resources, but demands park personnel be careful and craftsmanlike in their treatment of historic fabric. There is an additional aesthetic reason for choosing this approach in that it avoids "over-restoring" the casemate, and allows visitors' natural curiosity and imagination to function.

This report does not address technical issues of concrete repair and methods for preventing corrosion to reinforcing steel. After a preliminary assessment, the casemate does not appear to be in need of these measures at the current time. National Park Service Preservation Brief 15 "Preservation of Historic Concrete" deals briefly with these subjects and has been attached as an appendix, as has a short piece by the author dealing with protecting reinforcing steel. The first recommendation, performing a complete condition survey, will be invaluable if such measures are needed in the future.

Recommendation 1 — Perform complete concrete condition assessment[1]

In preparation for this report, the author performed a preliminary field assessment. The casemate is a highly engineered structure, and analysis of problems is made more complicated by the additive nature of its building process. A complete concrete condition assessment is the first priority in further development of a practical preservation plan. Such an assessment fixes in time the condition of the mine casemate's main building material, and serves as a baseline for comparison of changes. At the present there do not appear to be any critical structural repairs that need to be undertaken immediately; a complete condition assessment would provide a way to monitor the structural stability of the casemate.

The procedure for performing the assessment is relatively simple. It relies on close observation of each casemate surface, mapping problems and construction details using symbols. Basic concrete assessment tools such as hammer and chisel or large screwdriver should be used. The drawing for the assessment does not need to be to scale; measurements are noted on the form. A total of six drawings are made for each room, or section, of the casemate. A sample of the type of drawing to be made and the symbols used is shown in the illustrations immediately preceding this chapter.

The assessing team should note any sign of concrete problems. It is important to draw out the extent of cracks and to use a standard crack gauge to measure their width. Cracks of less than .005" (5 mil) in width are considered hairline cracks and are not generally significant. Large areas of hairline cracking can be noted on the drawing, but it is not necessary to draw them out. Other important defects that should be noted are: the location of construction (cold) joints, efflorescence, water stains, delamination, spalls, the presence of exposed reinforcing steel, and condensation. Any unique conditions should be identified and keyed to a brief explanatory note. The type of formboard finish, whether board or plywood, is significant, and the presence of any applied coating should be described.

Recommendation 2 — Mitigate potential safety hazards.

The partition wall separating the dormitory from the rest of the casemate shows some deflection and the connection with the casemate north wall appears tenuous. This wall should be stabilized as soon as possible to protect historic fabric and visitor safety.

The open manholes in the cable hatch room and the east corridor oil rooms present fall hazards. These rooms should be made secure from public access in a way that still allows visitors to see the room contents.

Local lore says that the casemate can be accessed via the cable gallery and tunnel. The presence of graffiti in the casemate prior to September 2008 shows that there has been unauthorized access by some means. Access should be carefully controlled to safeguard visitors (even visitors) and protect the historic fabric of the casemate.

In September of 2008 debris was cleared from the casemate, and the casemate was cleaned with hepavac equipment. Results of asbestos testing were not known at the time of this report. The oil tank in the casemate should be drained, and the battery and engine rooms checked for hazardous chemical residue.

Recommendation 3 — Address moisture problems. Clear blocked ventilators.

The casemate is a subterranean structure and a certain amount of moisture accumulation is inevitable. The level of moisture in the casemate varies seasonally according to ambient temperature and relative humidity. In February of 2008 I encountered relatively dry conditions, while in May and June there were substantial puddles and condensation on almost all wall surfaces. Some water infiltration seems to be from drainage issues, but this is not the general cause of the moisture issues.

Dealing with drainage issues on the hill above the casemate presents a challenge on several fronts. Most importantly is the fact that the hill and the vegetation are part of the planned appearance of the structure. Any changes to these would mean altering the historic fabric of the casemate and should be avoided. The presence of the large concrete burster course over the earth fill on top of the casemate would make any excavation difficult.

In any case, the primary cause of the moisture accumulation in the casemate is environmental. The original design of the casemate provided the building with a number of ventilation stacks to vent the fumes from the diesel engines and to accommodate the gas-proofing system. These stacks probably would have helped dissipate some of the moisture, although the structure was probably always damp.

The ventilators are all blocked by plant debris or by trash that has been dropped down them. Reopening some or all of the ventilator stacks would alleviate some of the moisture problems. If more air-flow was needed, small in-stack electric fans, such as used in vault toilets, could be fit with little impact on the appearance of the casemate.

Since the source of the moisture is condensation, concrete sealers are not likely to help the problem. Dehumidifiers would likely be very expensive and could have unanticipated effects in the subterranean environment.

Recommendation 4 — Treat metal casemate components with rust converter.

The metal components of the casemate interior are very corroded, as is to be expected in such a damp environment. The doors and their frames, especially the gas-proof doors are important features of the casemate and if corrosion is allowed to continue they will eventually be severely damaged. Presently, the corrosion, although heavy, seems to be even and mostly on the surface. They retain little of their original finishes, but what does exist should be protected.

Rust converters are commercial formulations that chemically react with iron oxide and change it to ferric tannate, an insoluble and very stable iron compound.[2] There are numerous proprietary formulae available. Martin

Weaver in his *APT Bulletin* article recommends Fertan® based on several apparent advantages; it is easily applied, penetrates well since it is water-based, is relatively non-toxic, has a long shelf life, and can be reapplied as needed in contrast to resin-based compounds.[3] This product has been used in maritime restoration and is marketed to auto restorers. Information on this product has been included as an appendix.[4]

Rust converters change the appearance of metal that has been treated with them to a blue-black color. This would not seem to be offensive in the setting of the casemate. It is generally recommended that metal treated with rust converters be painted, but this is not necessary or recommended in the casemate. Aside from its extreme dampness, the casemate is a very stable environment and features are not exposed to sun, wind, or rain. Even the temperature does not change much due to the subterranean location. In this situation it would be expected that additional paint would not be necessary. If using a material that allows repeated application, this could take the place of painting, and presumably, would build up an impermeable layer of ferrous tannate.

Further, treated surfaces should be left unpainted since there is little evidence of the original finish on most of the metal features. The gas-doors do have traces of red-orange and possibly gray paint. Treatment with rust converter should not affect these traces of the original finish. The gas-proofing pipes do not have any readily discernible traces of paint. Since the original appearance of these features is unknown it is better to leave them as they are after the corrosion has been halted. The gas-proof doors seem to be in very good condition, so it may be possible to to return one or more to operating condition if this is desirale from an interpretive (and a safety) perspective.

Recommendation 5 — Replace floor in operating room

The operating room originally had a suspended floor covering the cable gallery. This floor had collapsed by the mid-1960s. Its configuration and materials are not definitively known, but examination of the debris that filled the cable gallery reveal a fair amount of fir tongue-and-groove boards that were likely the remains of the floor. This is the type of floor still existing in Fort Stevens' casemate. Restoration of this floor is important for several reasons. First is the public safety issue created by the open cable gallery. The substantial drop causes a serious fall hazard. Second, the space is difficult to understand without the floor. The operating room was the center of the submarine mine operation, holding the firing boards and other control equipment. The cables connected to the mine came through the floor and were there connected to the control panels. To give visitors an accurate idea of what took place in the building a floor is necessary to provide continuity to the space.

Although a tongue and groove floor is preferred for reasons of historical accuracy, the damp conditions of the casemate would present difficulties for maintenance. Such a floor would also hide the cable gallery (where the ends of the mine cables are still visible) from visitors' view. Some sort of composite grate would provide a serviceable floor, possibly for less cost, and allow visitors to see the cable gallery. A composite floor would be more durable in the difficult conditions of the casemate. Since there is no effort to restore the casemate to a period of significance, installation of such an obviously new floor executed in a modern material would hopefully not prove too confusing to the visitor. Confusion of visitors as to the historic authenticity of such a floor could be addressed through interpretive methods, perhaps reconstructing a corner of the room in the original materials. This recommendation may not strictly conform with the Secretary of Interior's Standards for Preservation, but is a reasonable measure and would conform to rehabilitation standards.

Recommendation 6 — Restoration work in plotting room

This recommendation is one situation in which restoration work is easily enough accomplished to warrant consideration, even with the minimal treatment recommended for the casemate. A few remains of the black and red checkerboard tile floor is still in evidence in the plotting room. Some of these tiles are loose and would probably not withstand visitor traffic if the casemate was open to the public. Similar tiles are readily available and easily installed.

There is one original early fluorescent-tube lighting fixture in the casemate plotting room. If it is in suitable condition it should be refurbished and reinstalled. It should be possible to use this fixture as a pattern to fabricate the three additional fixtures originally in place.

If the floor and the lighting were restored the large open space of the plotting room would prove useful for display of interpretive exhibits.

Recommendation 7 — Interpretive work in main casemate.

Washington State Parks has a number of skilled interpreters dealing with such issues, but, though the focus of this report is the structure itself, a few interpretive recommendations are made here. The main casemate is the area in which most of the building's activity took place, and was the heart of the Columbia River submarine mine operation. Most of the important features of the casemate operation are missing. What remains — engine bases, fuel tank, electrical boxes — are not really sufficient to convey to visitors the function or history of the building. Numerous photographs of the equipment can be found in military manuals. These photos could be displayed on interpretive plaques of materials durable in the casemate's damp environment. A recommendation that pertains more to the structure itself would be the installation of "ghost" walls that delineate the original configuration of battery room, engine room, storage and latrine facilities, and operating room.

Public access to the space could prove problematic given the presence of objective hazards and the relative isolation of the casemate from the rest of Fort Columbia. One possibility would be to organize tours of the casemate leaving from the barracks at set times.

The dramatic character of the casemate would seem to encourage a dramatic presentation. Visitors would come in from the bright meadow into the dark entry tunnel. and pass through the plotting room. They would then pass straight through the large gasproofing room into the main casemate space. Exiting through the battery room the visitor returns through the gas doors and out through the plotting room.

The need to have active guidance for the visitor through the casemate provides a good opportunity for the guide to convey the experience of the living and working in the casemate's taxing conditions.The parks active volunteer organization could be of great help in this.

Notes for Chapter 4

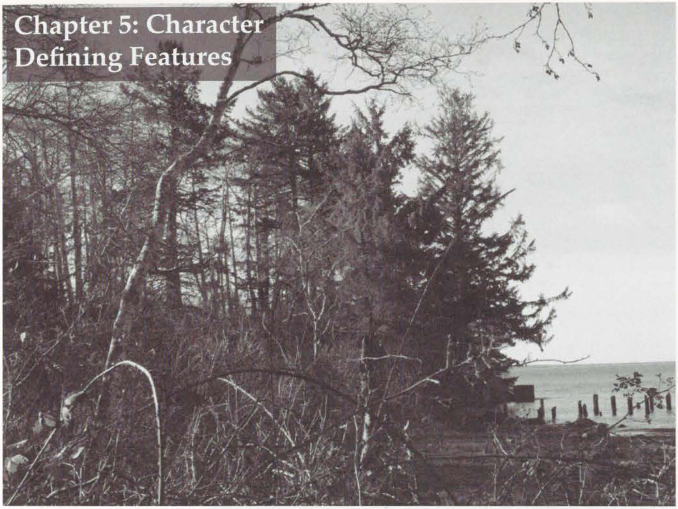
[1] This section and the specific recommendations on the method to be employed in carrying out the complete condition assessment is based on conversation with Paul Gaudette and a condition assessment performed by Mr. Gaudette and the author on the south wall of the plotting room in September 2008. The American Concrete Institute "Guide for Making a Condition Survey of Concrete in Service" gives detailed definitions and photographs. It is included as an appendix in Washington State Parks *Historic Fortification Preservation Manual* and is available from the American Concrete Institute.

[2] Martin Weaver, "Fighting Rust", APT Bulletin, Vol. 19, No. 1 (1987) Association for Preservation Technology International, pp. 16-18.

[3] Ibid.

[4] http://www.fertanamerica.com/data_sheet.htm

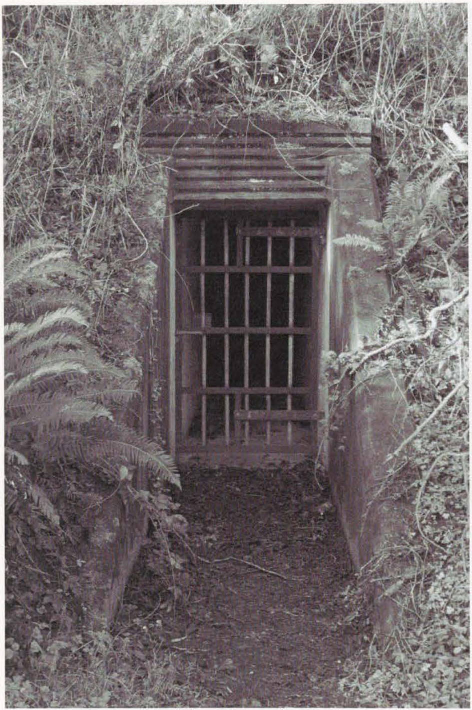
Chapter 5: Character Defining Features



Character Defining Features are defined by the National Park Service as "... those features or elements that give the building its visual character and that should be taken into account in order to preserve them to the maximum extent possible."[1] All buildings have such features, and Fort Columbia's new mine casemate is no exception, with its unique situation in the landscape and expressive use of materials. The following features are vital to the character of the casemate and must be protected in any preservation activity. These features are presented in the order they would be encountered by a visitor and not ranked by importance. Each is vital to the visual character of the casemate.

Relation to Chinook Point and the Columbia River as part of the landscape.

The situation of the casemate in close association with the river is vital to its function and its visual appearance. The casemate was carefully concealed from view from the river by its builders both by locating it behind the knoll of Chinook Point and by building the high-mounded earthwork that gives the casemate its distinctive appearance. The newly-built earthwork was landscaped with native plants in order to provide cover from observation. Though this landscape has changed over time, it represents intentional choices by the builders and must be protected.



Entry gateways with stripped classical details.

The casemate does not present itself with a conventional architectural facade. The only real clue that one is approaching a building are the gateways that penetrate the hill. These are very simple in execution, but are ornamented with a stripped classical entry that reminds one of Grecian Doric architecture in its evocation of raw strength.

Curved entry tunnels.

The elegantly curved entry tunnels form a striking counterpoint to the severe entry gates and create a strong sense of drama as the visitor passes from the outside to the operational portions of the casemate.

Doors and pipes of gas-proofing system

On turning the last corner into the casemate the gas doors immediately catch the eye. The arrangement of the gas-proofing pipes dominate the visual aspects of the air locks, gas-proofing room, and plotting room.

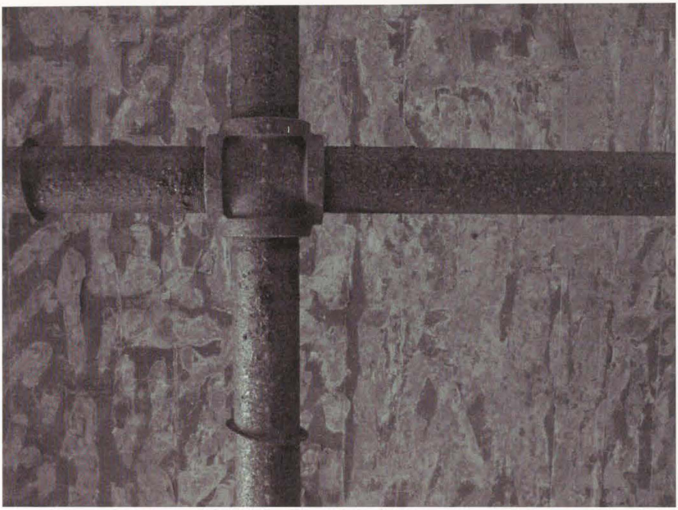
Contrasting surface treatments in different casemate areas

•Smooth plastered finish of tunnels and gas-proofing rooms.

The concrete walls of these spaces have been finished with a thin skim coat of plaster to fill construction voids in the concrete. These surfaces should be kept free of paint and other coatings, which would destroy the visual effect of the plastered finish.

•Plywood formboard finish in plotting room.

The contrast between the tunnels and the plotting room are a subtle clue to the



accumulative construction process of the casemate. As with the tunnels and gas-removing rooms this finish should be left intact.

- Dark wainscot level band in casemate proper.

The dark blue-black band on the lower portion of the casemate operations area walls should be preserved.

Asymmetrical plan

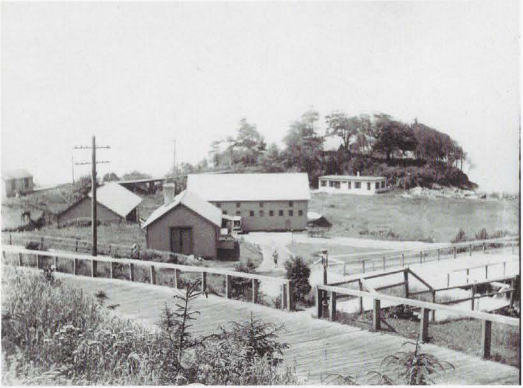
There is little symmetrical in the layout of the building, evidence of the organic development of the building over time.

Above: Gas-proofing pipes, plotting room ceiling. The gas-proof pipes and doors are character defining features.

Notes for Chapter 5:

[1] Lee Nelson, "Architectural Character: Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving Their Character," *Preservation Brief 17*, National Park Service, Washington, D.C. 1988.

Appendix A — Historic Photos



This photo dates from c. 1920. It is a distant view of the 1911 Sewell-type mine casemate that was replaced in 1921 by the first phase of the new mine casemate. Below is an enlarged detail. Washington State Parks Photo.

Above: Photo showing construction underway on one of the casemate additions, c.1942. Washington State Parks Photo.
Below: Newly finished casemate. C.1945. Washington State Parks Photo.

Appendix [illegible] Historic Photos

This photo [illegible] pieces [illegible]

[illegible]

[illegible]

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Appendix B — Glossary and Technical Information

Selections from *Seacoast Fortifications Preservation Handbook*, Golden Gate Recreation Area, San Francisco : National Park Service, 1999.

Glossary of Terms relating to Architecture, Fortifications and Preservation

Preservation of Metals

Annotated Bibliography

Paul Gaudette and Deborah Slaton, *Preservation Brief 15: Preservation of Historic Concrete*. Washington, D.C. : National Park Service. 2007.

Shawn Lingo, "Protecting reinforcing steel in concrete from corrosion". 2008.

Martin Weaver, "Fighting Rust", APT Bulletin, Vol. IX, No. 1, 1987.

Fertan Product Information

Appendix B — Glossary and Technical Information

Selections from *Seacoast Fortifications Preservation Handbook*, Golden Gate Recreation Area, San Francisco: National Park Service, 1999.

Glossary of Terms relating to Architecture, Fortifications and Preservation

Preservation Checklist

Annotated Bibliography

Paul Gaudette and Deborah Slaton, *Preservation Brief 15: Preservation of Historic Concrete*, Washington, D.C.: National Park Service, 2007.

Shawn Lingo, "Protecting reinforcing steel in concrete from corrosion", 2009.

Martin Weaver, "Fighting Rust", *APT Bulletin*, Vol. IX, No. 1, 1985.

Fortan Product Information

FROM: SEACOAST FORTIFICATIONS
PRESERVATION MANUAL
NATIONAL PARK SERVICE, 1999.

GLOSSARY OF TERMS

Architecture, Fortifications, and Preservation

active cracking	cracking showing recent movement
adaptive reuse	contemporary reuse for an existing historic structure, often with an updating of infrastructure and added amenities, and, typically with few sustained ties to the original historic function
adobe	sun-dried (unburnt), clay-soil brick; the clay was often mixed with chaff, straw, chopped weeds, tule reeds, or sometimes manure for historic adobe bricks in California, with the individual brick sizes approximately eleven by twenty-five inches and of two-to-five inches thickness; each brick weighed about sixty pounds; Spanish word derived from Arabic *atob* (mud)
aggregate	a constituent in cementitious mixes, usually sand or gravel
alkalinity	the presence of chemical base material such as hydroxides and carbonates of calcium, sodium, or potassium
alligatoring	a surface cracking pattern resembling alligator skin
ammunition hoist	a mechanical device for moving projectiles and powder from the magazine to the level of the gun
ancillary	a dependent structure, often but not always small in scale; associated hierarchically with a primary structure; often found in clusters with other dependent structures
angle iron	iron or steel cross section with two legs ninety degrees apart
architectonic	resembling architecture in manner and organization
area drain	a surface drainage inlet to convey and disperse water
artificial stone	varieties of cement-based, man-made imitations of naturally occurring rock, the latter typically quarried for building
asphalt (asphaltum)	various bituminous substances, both naturally occurring and resultant from petroleum processing; also a bituminous substance mixed with crushed rock for paving
asphalt emulsion paint	a surface coating containing emulsified asphalt for moisture protection
automatic cannon	rapid-fire, light-caliber guns in which the force of the recoil is used to load and fire the piece without the crew having to manually insert and fire each round
backer rod	a foam, tubular-shaped rod placed in a joint that is to receive a sealant to provide a solid base to receive and hold sealant
backfill	filling a previous excavation

balanced pillar mount	a mount for smaller caliber coast artillery, which raises the gun above the parapet into the firing position and lowers it below the parapet for loading using a telescoping cylinder
barbette carriage	a mount for seacoast artillery in which the gun remains above the parapet for loading and firing
base line	a pre-surveyed horizontal line used for accurate position-finding and fire control, with observation posts called base-end stations at either end
base-end station	observation station at either end of a base line, containing an azimuth instrument or depression position finder, used to supply position data for the indirect aiming of coast artillery weapons
battery	a defensive structure containing all features and appliances necessary to support and serve a number of cannon
battery parade	the area in the rear of a battery where troops take formation
Beaux-Arts	French term [*Ecole Nationale et Spéciale des Beaux-Arts*, Paris] meaning fine arts; label for an architectural movement and training program, and for its associated architects, 1865-1915; loosely, architecture as fine art, characterized by an emphasis on classical tradition; Beaux-Arts was sometimes used as an alternative term for Classical or Colonial Revival design in the United States during the late nineteenth and early twentieth centuries
benching	installing fill materials in lifts
bentonite panel	an organic clay sheeting (compressed and rolled) to provide a waterproof membrane
berm	a ledge, embankment, or shoulder, often man-made, and typically earthen; also, a narrow path between a fortification parapet and its surrounding ditch
beton agglomere	a French term for an artificial stone of cementitious materials in a matrix
binder	cementitious materials which chemically bind aggregates in a matrix
bitumen	rock largely consisting of hydrocarbons; naturally occurring asphalt
blackboard rack	a metal frame extending from the side of the data booth in a mortar battery to support a set of blackboards upon which firing data could be written
blast apron	a relatively thin paving of concrete in front of a gun emplacement that protects the ground from erosion, reduces dust, and helps control the possibility of fire
blind drain	a hidden drain
bombproof	a heavily built shelter, either a separate structure or a room within a battery, that can withstand the effects of bombardment

breast wall	a wall of breast height, typically used to provide a defensive position for infantry soldiers
breech-loading weapon	a weapon in which the round is loaded by opening a plug at the base of the gun tube
built environment	buildings, structures, and ancillaries comprising an inter-related man-made area, often architectural in character
bunker	an indistinct term that generally means a heavily built structure, usually a shelter against bombardment, that may or may not have provisions for defense; no specific meaning in coast defense; comes into popular use during WWI
butyl membrane	a rubberized sheet membrane utilizing butyl
caliber	the minimum diameter of the bore of a firearm, and therefore the diameter of the projectile it fires; also used to describe the length of a cannon, expressed as a multiple of its diameter
camouflage	the measures taken, or the material used, to conceal or misrepresent a military position
cantilever	to project horizontally with one end of the structure (beam or slab) anchored into a pier or wall; also, the term for such an extension or for a projecting bracket
caponier	a protrusion from the wall of a fortification, designed to allow grazing fire from within to sweep across the scarp walls adjacent to the parapet
carbonization	formation of carbon from organic matter under heat and compression
casemate	a chamber within a fortification built with overhead cover, and therefore resistant to bombs or high-angled shell fire
casement window	a window opening on hinges, which are generally attached to the sides of the window frame
castillo	the Spanish term for fortification
cast iron	a brittle iron cast from molten iron to a specific shape
ceiling trolley	a wheeled carriage running on, or in, tracks fastened to the ceiling, from which a projectile was suspended for movement
cement paint	a water-based paint containing Portland cement
cement-stabilization	to stay chemical activity in cement; to prevent further deterioration
chalking	paint deterioration caused by loss of paint binder, leaving dried pigments
chamfer	an oblique surface cut on the edge or corner of a board, usually sloping at forty-five degrees

character-defining / distinctive feature	features particular to a historic structure that distinguish and/or typify its character in terms of its original visual and structural design (and engineering), and in terms of its historic function or use
charette	a French term for a small, two-wheeled cart; at the *Ecole Nationale et Spéciale des Beaux-Arts* instructors collected students' drawings for assigned projects in a charette and the term came to be associated with the process of designing, and in particular with a work in progress by a group of architectural professionals
choke point	a constricted geographical area, easy to defend.
cold joint	a break in a construction installation; a stopping point
cold rolled steel	steel pressed and shaped without heat
columbiad	a large caliber, smoothbore, breech-loading cannon, designed to fire both shot and shell
common brick	utilitarian brick used for normal-load-bearing construction
compressive force	the tendency of a mass to bear on a surface by gravity
counter-scarp wall	in field fortification, the wall opposite the scarp; more directly, the side of a defensive ditch closest to the opposing force
crazing	random hairline surface cracking
cross fire	direct fire coming from two opposing directions at once
cultural landscape	the comprehensive (and linked) built and natural landscape defining a distinctive cultural-use area
curing	chemical process of dehydration by which cement and aggregate harden or set
cut and fill	efficient earthwork where cut materials are used to fill low spots adjacent to the cut
dado	the lower, broad part of an interior wall, finished in a painted or textured scheme different from that of the overall wall surface
damp course	a thru-wall membrane to resist rising damp
deflection	deformation of a structural element caused when loading exceeds resistance
deflector	a large stone placed within the mass of early concrete fortifications and intended to deflect a projectile that might strike it, thereby protecting interior spaces
delamination	deterioration in disconnected sheets or plates
dependent structure	ancillary structure

design parameters	variables of function, need, or usage that directly affect the design of a building, structure, or object
disappearing carriage	a gun mount designed to raise the gun to firing position above the parapet by means of a counterweight, and use the force of recoil to carry the gun back to its loading position below the parapet
dog	a metal connector or strap
dormant cracking	cracking that is not active
double-hung window	a sash-type window with the lower framework typically moving up and down vertically, and the upper framework fixed; single-paned or multi-paned in type
drip line	the line where water is shed from a surface
dynamite battery	an experimental, and impractical, pneumatic gun that fired dynamite, using compressed air rather than gun powder to propel the dynamite to the target
earthwork	a military construction formed chiefly of earth, used in both defensive and offensive operations
efflorescence	soluble salts forming on a surface
elastomeric membrane	a flexible sheet of rubberized material used for moisture protection
elevation	a scale drawing representing a structure or building as projected geometrically on a vertical plane parallel to the chief dimension
embrasure	a small opening in a fortification through which the weapon fires
emplacement	a subdivision of a battery that refers to a single gun and the provision of services necessary to its functioning; compare with *pit*
escutcheon plate	the door plate to which the handle is attached; or, the door plate protecting the keyhole or locking mechanism
esplanade	a level area of a fortification
Endicott	William C. Endicott, Secretary of War under the administration of President Grover Cleveland, associated with the program of modernization of American seacoast fortifications at the end of the nineteenth century
epoxy	a polymer-based substance where oxygen and carbon atoms bond in a unique way; used in paints and adhesives; usually a two-component paint system where the components are mixed to achieve the chemical reaction that results in a hard and durable finish
existing condition	the current condition, inclusive of advancing deterioration, of the physical fabric defining a site, structure, building, or object
expansion joint	a joint used to compensate for or isolate structural movement

fatigue	natural deterioration or loss of strength in a material
feature mapping	the accurate recording of all features in a structure, including the observable imperfections of fabric, as a base for future preservation work or measuring the rate of change in physical condition
field artillery	the light and medium artillery pieces, and their units, whose function is to support the army in mobile battles and campaigns, not emplaced permanently in one area
field density	field-measure density used to determine degree of compaction; expressed as a percentage
field review (inspection / reconnaissance)	the on-site, physical observation and analysis required to ascertain the current conditions present at a historic property; here, when accompanied by maintenance actions, using the Action Log (Appendix C)
fire control station	a structure housing the equipment and personnel necessary to accurately determine the location of targets or to command the fire of several batteries
first system of American seacoast fortification	open fortification works of earthen construction, dating to the 1790s, which represent the first American attempt at a seacoast fortification network
flag	a flat slab of stone, or artificial stone, used for paving
flash rust	immediate corrosion of bare ferrous metals due to exposure to moisture in the air
flashing	a mechanical device used to prevent moisture infiltration
flat trajectory fire	high velocity direct fire, in which the projectile travels in a relatively straight line to the target
fog base	a base line system positioned at low elevation, to act as an alternate base line in case the view from the primary base-end stations was obscured by fog
footing	the perimeter base (or bottom) beam of a structure
formwork	the temporary mold of timber or metal boards, or sheets, that is used to give concrete its desired form, and, to give it support until it has hardened sufficiently
French drain	an underground linear drain designed to intercept and disperse water
gallery	a long room or passage, typically enclosed
garrison	the troops permanently assigned to a military post
general management plan	the official master plan for a park, approved after a period of public comment

GPF gun	the U.S. 155mm gun, Model 1918 on field carriage, a large mobile artillery piece used to supplement the fixed seacoast defenses; GPF is the acronym for *Grand Puissance, Fillioux* or high-powered gun, named after its French designer
granolithic finish	a cement-based surface (or floor) finish for concrete resembling granite; often applied when the concrete is fresh (green) and sometimes augmented by a surface hardener based on sodium silicate
gravity / convection ventilation	ventilation using natural convection or air movement caused by differential pressure and air temperature
grazing fire	flat trajectory fire placed low along the ground or water
gritblast	high pressure air cleaning using sand or other grit
groin vault	a vault formed by the intersection of two or more barrel vaults, with the omission of all of those parts that would lie below each of the uppermost vault forms
groupment	an organization of firing batteries grouped together, irrespective of their permanent units, to provide the most effective command and control of an area's harbor defenses
grout	a thin, coarse mortar poured into the joints of masonry and brickwork; to fill such joints
gun	a cannon that fires a high velocity projectile on a flat trajectory
gun platform	that portion of a permanent battery upon which the cannon is emplaced
habitat	the kind of place where a particular animal or plant lives or grows naturally, or, thrives
harmonic movement	coordinated movement due to the effects of wind loading
historic architectural inventory	a systematic inventory recording the physical fabric and setting for historic properties; usually accompanied by photography; here, using the Coast Defense Resource Checklist (Appendix C)
historic structure / resource	generally, with respect to American preservation efforts , a building, structure, or object meeting the requirements of eligibility for the National Register of Historic Places
historic site	generally, with respect to American preservation efforts, a prehistoric or historic archeology site meeting the requirements of eligibility for the National Register of Historic Places
hopper window	a window opening outwards at an angle and having a bin-like appearance when open

horizontal crest	a coastal fortification term that refers to the desire of the designers to keep the highest part of a gun battery, particularly those for guns mounted on the disappearing carriage, flat and unmarked by any object that could be used to identify the location of the battery from the sea
hydrostatic pressure	variation in air pressure that causes moisture to rise vertically in a wall
I beam	a metal structural shape designed to withstand deflection and twisting forces; consists of flanges and web
infrastructure	the structural skeleton beneath the outer skin of a building; also, the comprehensive system underlying a cohesive group of buildings and structures
integrity	with respect to American preservation actions, a reference to the seven points of integrity—location, design, setting, materials, workmanship, feeling, and association—defined within the criteria for eligibility to the National Register of Historic Places
interpretive plan	a document that describes the themes and objectives of a park's public education program, and the means for reaching those objectives
jack	a mechanical device to lift
jamb	a vertical piece forming the side of a doorway or window opening
jig	template
joist	a simple timber, steel, or precast-concrete beam supporting floor boards or ceiling lath
laitance	a condition occurring when concrete is mixed too wet, causing cementitious materials to concentrate and leaving portions of the mix cement-poor
lamellar tearing	stress-related metal deterioration
lampblack	a carbon byproduct of burning hydrocarbons; used as a pigment in paint
lime mortar	a mortar of one part lime and three parts sand
lime wash	a thin lime mortar used as a paint
lintel	a horizontal supporting member above an opening such as a window or door
loam	a loose soil composed of clay, sand, and organic matter, often highly fertile
louver	a slanted board or slat in an opening, overlapping with other boards or slats, and arranged to admit air but to exclude rain
magazine	a room within a battery or an emplacement where munitions are kept; often used more narrowly to indicate a room for the storage of powder
maintenance	the ongoing efforts to clean and repair a structure in order to prevent or slow its deterioration

Mandary flue cap	a proprietary name for a type of clay flue cap manufactured by the Superior Clay Company in Ohio
maneuvering ring	an iron ring set into the interior wall of a gun pit to aid in moving or adjusting the position of the heavy weapons
microclimate	the distinctive climate of a restricted geographic area as defined within the more encompassing climate of a region
microcrystalline wax	a fine wax with the ability to fill microscopic pores in materials; a sacrificial coating and protection
mine casemate	a heavily protected room or building specially fitted out for the firing of submarine mines
moisture / damp-proof membrane	a surface coating that prevents moisture infiltration
monolithic	of one material
mortar (architecture)	a mixture, as of lime or cement, sand, and water, which hardens in the air and is used for binding together bricks or stones
mortar (fortification)	a cannon designed to fire projectiles in a high, arched trajectory to reach over line-of-sight obstacles
mortar joint	the area between individual bricks or stones, and between layers of such masonry, filled with binding material to create a compact mass
mortise	a rectangular cavity of considerable depth in a piece of wood for receiving a corresponding projection (tenon) of another piece of wood
muntin	a slender, vertical or horizontal, wood or metal piece separating individual window panes
muzzle-loading weapon	a weapon in which the projectile is loaded from the front, or muzzle, end of the gun tube
National Historic Landmark	nationally significant properties in American history and archeology; recognition established through the Historic Sites Act of 1935; official list maintained by the National Park Service on behalf of the U.S. Secretary of the Interior
National Historic Site	nationally significant sites in American history and archeology; program established through the Historic Sites Act of 1935; National Historic Sites are formally a part of the U.S. National Park system and are managed as physical property by the National Park Service

National Register of Historic Places	the official list of historically significant national, state, and local districts, sites, buildings, structures, and objects maintained by the National Park Service on behalf of the U.S. Secretary of the Interior; established through the National Historic Preservation Act of 1966
native vegetation	vegetation indigenous to a geographic area
neat cement	a mix of one part cement and one part sand without large aggregate
open space	relatively undeveloped land set aside for its recreational, habitat, or resource values
ordnance	artillery pieces and the equipment used to maintain and fire them
Panama mount	a permanently fixed open gun platform upon which a mobile artillery piece can be quickly placed for accurate fire and ease of traverse
parados	an earthen or concrete barrier that protects a battery from fire from the rear
paraffin paint	a paint containing petroleum-based wax
parapet	in coast defense, a wall of concrete or masonry that protects the cannon and those manning it
parging	coating masonry with a cement-rich wash
percolation	filtration of water through a material
pintle	a pin or bolt, especially one on which something turns, as in a hinge
pit	an emplacement containing two to four mortars and the provisions necessary for their service; compare with *emplacement*
plan	a drawing made to scale to represent the top view or a horizontal cut of a structure or building
planes of weakness	cold joints or planes susceptible to differential movement
plasticity index	a scale of relative value indicating swelling or the expansive characteristics of soil
plate	a thin, flat sheet of metal or other material of uniform thickness
plotting room	a room containing the men and equipment required to develop the necessary data to accurately aim a gun or a group of mortars
pneumatic gun	a gun that fires a projectile by the sudden release of highly compressed air
point	to apply a final layer of mortar to a joint

point loading	structural loading concentrated on a small cross-sectional area, as in the load of a beam transferred to a column
poultice	a material applied to a surface that absorbs a previous coating and draws it out
Portland cement	a hydraulic cement made by burning limestone and clay
preservation	an effort to sustain the remaining physical fabric of an historic structure, with attention to the seven points of integrity—location, design, setting, materials, workmanship, feeling, and association—as defined by the criteria of the National Register of Historic Places
presidio	the Spanish term for a fortified garrison
primary structure	the key building or structure defining a cluster of buildings and / or structures; or, the key building or structure supported by a group of ancillary (dependent) buildings and / or structures
prime	the first coat of a series of coats, usually paint
projectile	a generic term for the destructive missile thrown from a firearm
protection	to provide an historic site or property with a defensive system intended to inhibit further loss or deterioration of the existing physical fabric
punching shear	a point load acting on a horizontal plane, as in a column resting on a slab
rail	a horizontal timber or piece in a window framework, wainscot, or door paneling; paired with *stile*
rapid-fire gun	a gun that can be loaded and fired with great rapidity because of a single-motion breech mechanism; such guns also usually employ fixed ammunition, avoiding the need to load the propellant and the projectile separately
rebar	reinforcing steel bars used to provide a tensile component to compressive cement; various shapes: billeted, deformed, smooth, and twisted
redan	a small fortification consisting of two parapets forming a salient angle, with the rear face of the fortification open
rehabilitation	an effort that minimally alters the remaining physical fabric of an historic property, while sometimes adding features to allow efficient contemporary use; executed with an emphasis on the seven points of integrity—location, design, setting, materials, workmanship, feeling, and association—defined by the criteria of the National Register of Historic Places
repoint	replacement of masonry joint mortar
resource management zone	geographical areas defined in a park's general management plan that are managed according to distinct legislative and administrative requirements, resource values, and public preference

restoration	an effort to retain, preserve, or restore the complete physical fabric of an historic property appropriate to a researched temporal period, with close attention to the seven points of integrity—location, design, setting, materials, workmanship, feeling, and association—defined by the criteria of the National Register of Historic Places
retaining wall	a wall built to hold back a mass of earth; a revetment
rifled artillery	a large caliber, long-range weapon, with helical grooves cut in the bore to impart spin, and therefore stability and accuracy, to the projectile
riser	the vertical face of a stair step
rising damp	moisture rising in a wall due to hydrostatic pressure
Rosendale cement	a Portland-type cement found in New York state; naturally occurring
saddle	a structural implement or connector
salients	the portion of a fortification that projects towards the enemy
sally port	the protected entry way of a fortification
sash	a moveable framework in which planes of glass are set, as in a window
scab	a new piece of wood attached to an existing, deteriorated, or weakened member
scarp wall	in field fortification, the wall closest to the defenders in a ditch built as an obstruction
seacoast fortification	the fortification network designed and emplaced to protect naval bases, seaports and other important coastal waters from the intrusion of hostile warships
second system of American seacoast fortification	open batteries and masonry-faced forts constructed by the United States to protect strategic points on the Atlantic seaboard; predominantly prior to the War of 1812
section	a cross-sectional drawing made to scale representing a vertical cut through a building or structure
Sewell building	a frame building clad with cement stucco applied over an expanded metal lath, and referred to by the name of the army engineer officer who developed the technique, John Sewell
sheepsfoot roller	a heavy steel roller with individual protruding cleats in a shape associated with that of the feet of sheep; used for soil compaction
sheet lead	flat sheets of lead used for flashing
sheet metal	flat, thin metal, usually steel or steel alloy

shell	a hollow projectile, filled with explosives, designed to exercise destructive force by explosive energy
shoring	supporting posts, beams, and auxiliary members placed against the side of a building or structure; especially supports placed obliquely
shot	a solid projectile of dense metal, designed to exercise destructive force through penetration and kinetic energy
shot room	a room within a battery or an emplacement for the storage of projectiles
sloughing (soil)	the movement or partial collapse of an earthen slope
shuttering	overlapping or sheet materials to shed water; shingling
sidewalk concrete	concrete with a granolithic finish or with a finish of small stones imbedded in cement
significance	generally in American preservation efforts, defined through the four criteria (A, B, C, and D) of the National Register of Historic Places; summarized as significance associated with key historic events (A), the lives of important persons (B), established architectural or engineering merit (C), and, the potential to yield worthy new information in history or prehistory (D).
sill	a horizontal timber, block , or the like, serving as the foundation for a wall; the horizontal piece beneath a window, door, or other opening
smoothbore artillery	large caliber weapons with smooth, unrifled bores, designed to fire spherical shot or shell ("cannonballs")
soil grouting	injection of lime or cement into soil for stability
sonic meter	a device using sound waves to determine relative density
sounding hammer	a hammer used to strike concrete to determine consistency by the characteristics of the sound
spall	the flaking off of a material caused by expansion and contraction, or by material decomposition
speaking tube	a metal tube, either imbedded in the body of concrete or suspended from the ceiling, through which voice communication could be had between various parts of an emplacement or battery
splinterproof	a heavy concrete roof designed to protect against shell fragments
stabilization	to reestablish the structural equilibrium of an historic building or structure, or, to arrest further deterioration to an historic property or site, generally
stanchion	an upright bar, beam, post, or support, as in a window, stall, or compartment
stewardship	the management of a property, site, or historic resource

stile	a vertical member in a wainscot, window, paneled door, or other piece of framing; paired with *rail*
strategic	military art and science applied on the large scale to the employment of nations, their resources, armies and fleets
stud	a post or upright wood member in the wall of a building
stirrup	a shaped piece of reinforcing steel designed to tie two (top and bottom) horizontal rows of reinforcing
substrate	a raw, base material (wood substrate to paint); underlying layer
suction spotting	inconsistent absorption by a porous substrate caused by inconsistent surface preparation; volatile solvents evaporate at different rates
surface bonding	chemical or friction connection between a substrate and applied finish surface
tactical	military art and science applied to the employment of small scale units and capabilities of particular weapons
tamping	manipulation of concrete in a form to settle concrete and eliminate voids
Taylor-Raymond hoist	the most successful of several ammunition hoist designs, developed by Harry Taylor through a series of improvements upon an earlier design by Robert Raymond; Taylor and Raymond were both army engineer officers
telautograph booth	a free-standing concrete structure (but also a recess) that housed a telautograph, an electro-mechanical distance writing instrument
tensile force	force which seeks to pull materials apart
terreplein	a term that dates from much earlier fortification practice and meaning the area of a rampart where guns could be maneuvered; by the 1890s, it was used most often to indicate the ground level of a battery, but it soon fell out of use
thermal expansion / contraction	differential movement due to change in size caused by changes in temperature
third system of American seacoast fortification	a system of permanent masonry forts and supplementary batteries, designed between the War of 1812 and the Civil War, to improve upon the protection of strategic points along the Atlantic and Gulf coasts of the United States
tongue-and-groove joint	a common joint consisting of a projecting strip along the edge of a board and a matching groove on the edge of the next board
tramway	a light rail line upon which ammunition carts could be pushed or hauled by hand

transfer drawing	a detailed drawing made by U.S. Army engineers when a completed battery was transferred to the artillery service; it provided instructions about the use and care of all the equipment and facilities furnished with the battery
transit	an optical instrument used to set lines, grades, and elevations
traverse	in fortifications, the structure on either side of an emplacement that provides protection from flanking fire; when referring to a cannon and its carriage, it can also mean movement to the left or the right
treatment plan	a plan describing specific operations used in maintaining or preserving architectural properties
trench drain	a linear drain designed to convey, intercept, or trap water
turret mount	a weapon mounted in a rotating, armored enclosure
variable-burning powder	propellant charge consisting of various sized grains of powder, which will therefore burn at different rates; the effect will accelerate the projectile more gradually out the gun tube, providing increased ultimate velocity and less strain on the gun barrel
viewshed	the panoramic, or otherwise fully encompassing, view *from* an historic site or property
water battery	a gun battery placed to lay grazing fire across the water
whitewash	a mix a hydrated white lime, alum, water used as a surface coating
wythe	the width of a brick

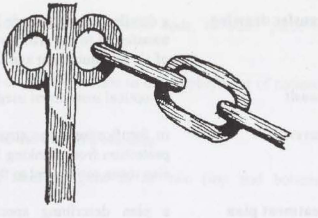
FROM [illegible]
PRESERVATION MANUAL,
NATIONAL PARK SERVIC

Metals: General

Metal items associated with the coastal fortifications around San Francisco Bay include iron and structural steel in the form of steel beams and other structural shapes, reinforcing steel in the form of twisted, billeted, and deformed bars, imbedded steel items and hardware, metal handrails, metal doors and windows, and anchors and connectors. The use of structural metal items changed with the development of concrete construction, particularly from the late nineteenth century to the beginning of World War I. Imbedded metal items and hardware such as maneuvering rings and anchoring plates changed little. Handrails evolved from small square bar rails and chain rails to pipe rails with threaded connections.

Causes of Deterioration:

1. Corrosion: Iron, steel and other metal may suffer from corrosion due to chemical and electrochemical reactions which cause the metal to oxidize or combine with chemicals such as carbonates or sulfides. The salt- and moisture-rich environment of the coastal fortifications is particularly hard on metals. Contact between dissimilar metals can also cause electrochemical reactions.
2. Fatigue: Structural iron and steel may be subject to metal fatigue due to excessive loading, repetitive movement due to wind loading, or stress from cyclical loading. Harmonic movement from wind loading and seismic movement can also cause fatigue.
3. Impact: Equipment and vehicles impacting structural metals can cause localized damage that can lead to further deterioration and failure.
4. Lamellar Tearing: Tearing at welded joints results from improper welding practices.
5. Loose Connections: Structural steel joints and connections may loosen due to impact, vibration, or stress on connectors and anchors such as bolts and nuts.



Detail. Iron stanchion and chain rail.

Identification:

The detection of metal deterioration is best accomplished by a structural engineer. However, many problems are visible through careful and systematic inspection. Whatever symptoms are found, professional evaluation is recommended. The signs of metal deterioration include:

1. Wearing away of metal surfaces.
2. Cracks, especially at points of maximum stress.
3. Localized distortion, twisting, or bending.
4. Paint or coating failure (an indication of underlying metal stress).
5. Misalignment.
6. Lack of plumb or level, sagging, or deflection.
7. Rusting or staining.
8. Loose bolts, rivets, or other connectors.
9. Broken welds.
10. Visible movement.

Inspection and Testing:

Inspection can identify deleterious conditions and distinguish among the various materials and conditions but testing and laboratory analysis may be required to identify hidden conditions, particularly those within masses of concrete. Such testing may be required where structural failure has occurred or where failure is eminent. This type of testing is best recommended by a corrosion or structural engineer. Testing methods include the use of ground-penetrating radar, x-ray analysis, and sonic penetration.

Metals: Structural Iron and Steel

Structural iron and steel items include I-beams, angles, channels, rails, bars, and smooth, twisted, deformed, or billeted reinforcing bars. Structural iron and steel, where exposed, should be inspected regularly and treated promptly to prevent further deterioration.

Replacement of Deteriorated or Damaged Members:

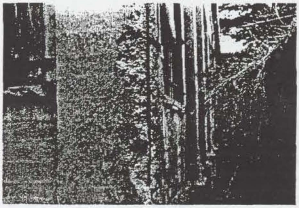
Replacement of structural items should be a last resort to prevent structural failure or damage to adjacent historic fabric. Replacement should be with similar materials if hidden and with matching materials if exposed.

Repair of Deteriorated or Damaged Members:

Repair of structural metal, in place, is preferable to removal and replacement. Surface patching and filling should be done with metal fillers such as automobile repair compounds.

Prevention of Corrosion:

Corrosion is prevented by removal to bare metal and the application of appropriate protective coatings. Sandblasting, or gritblasting, is the preferred method of removal of rust and corrosion from steel but may cause damage to wrought and cast iron. Gritblasting should be limited to specific areas of corrosion and adjacent areas protected with plywood. Where metal items such as doors can be removed, it is preferable to remove the item and gritblast and prime coat the item in protected shop conditions. After cleaning to bare metal, the metal surface should be wiped with a solvent and a primer should be immediately applied. Priming should be followed by finish painting with at least two coats of approved paint material applied according to the manufacturer's written instructions. A single manufacturer for the primer and top coats is recommended to insure compatibility. Specific painting and coating treatment is addressed in Finishes: Wood and Metal Coatings.



Battery Dynamite power plant. Spalled concrete and exposed rebar.

Relief from Excessive Loading:

Excessive loading of structural beams such as I-beams or reinforcing steel can be reduced by reducing the loading or by adding additional supports to transfer or redistribute the loading. Plant growth, vegetation, and trees, and trapped moisture can contribute to loads in overhead earthworks. Additional supports, in the form of support columns and plates can be useful is transferring loads. Additional supports should be designed by a structural engineer and carefully placed to avoid punching shear or point loading where bearing capacity is inadequate.

Connectors:

Bolts, nuts, rivets, anchoring plates, and other connectors should be inspected. All loose connectors should be tightened and monitored. Replace missing connectors.

Metals: Imbedded Hardware

Imbedded metal items include wrought iron maneuvering rings, brass hinges, window bars, and other miscellaneous fittings. These items are set into concrete or masonry either being cast-in-place or attached to cast-in-place anchors. Imbedded metal items can have corrosion problems that can affect the masonry or concrete into which they are set. Weakened planes can form around the imbedded item and can contribute to cracking and spalling.

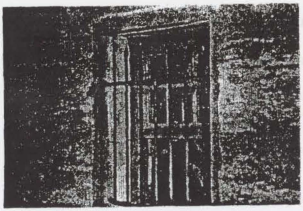
Wrought Iron Maneuvering Rings:

Wrought iron maneuvering rings are set in concrete on walls adjacent to fortification gun positions. The rings were designed to be used in the placement and setting of guns on their mounts. The rings are in good condition and require only regular inspection, cleaning, and protective coating.

Hinges:

Brass pivot hinges are set in concrete walls adjacent to masonry openings and support iron strap hinge assemblies attached to wood or metal doors. The brass hinge portion is in direct contact with the iron hinge portion and the electrochemical reaction causes corrosion and efflorescence. Treatment should be directed at isolating the two incompatible metals. For efficiency, treatment of the doors should be coordinated with isolating the metals.

1. Remove metal or wood doors from hinges.
2. Clean brass hinges free of efflorescence using an approved chemical cleaner and brass wool.
3. Install a solid neoprene gasket and sleeve over the brass hinge portion.
4. Rehang door. Treatment and repair of doors is covered in Doors and Windows: General; Treatment for Doors; and Hardware.



Battery Duncan. Double-hung window at traverse wall showing grill with decorative points.

Window Bars:

Hand-fabricated, wrought iron and steel bars are installed in some window openings. The openings are in masonry or concrete walls. The bars are simple vertical rods set on horizontal bar stock which is anchored into the concrete at the window jambs. The bars are flattened at the top ends to form a decorative "spear point" design. The bars have suffered vandalism in the form of bending and distortion. In some cases bars have been removed. Anchorage of the horizontal bars in jambs has become loose. Treatment involves removal of the bars, reworking in a metal shop, and reinstallation. Repair concrete and masonry jambs if required.

For restoration purposes, removal of window bars and other imbedded items may be required. When bars are loose, the metal may be heated sufficient to bend the metal, or cut for removal. Where inset metal has already caused spalling or masonry deterioration, break out additional material, repair metal, reinstall, and patch masonry.

Metals: Handrails and Guardrails

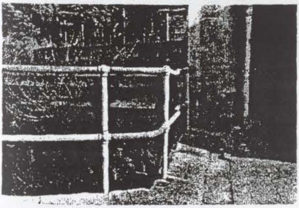
Handrails at the fortifications are of three types: Solid square wrought iron bars, chain rails, and pipe rails. Few of the early square section bar rails and chain rails from the Endicott and Taft periods are extant, although many examples of pipe rails remain intact. Retention of existing original metal railings and installation of new railings to replace missing elements is important for safety and as character-defining features. The square-section railings are set in sleeved holes cast into the concrete. The risers for the rails are set in cement or molten sulfur grout. Pipe rails are set in escutcheon plates bolted to risers at the concrete. In some cases, piperail uprights are screwed into escutcheon plates bolted to concrete. Rails are connected by four-ways, elbows, and Ts. The joints are threaded. Original pipe rails were primed and painted.

Treatment:

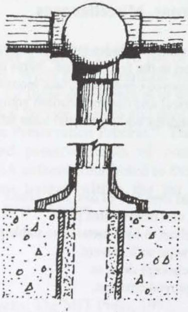
Railings should be repaired or replaced to meet standards that require railings to resist a lateral load of 200 pounds at any point along the rail.

Existing Railings:

1. Tighten all joints at screwed or bolted connections. Replace bent or severely deteriorated components to match original materials. Verify secure anchorage.
2. Gritblast metal railings and wipe down with solvent to remove residue and flash'corrosion.
3. Prime immediately and paint.
4. Wrought iron bar rails and chain rails require solvent cleaning and waxing.



Battery Kirby. Handrails.



Typical pipe rail detail.

New Railings:

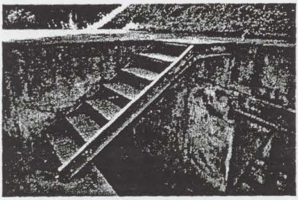
1. Design new railings to match existing original railings. Pipe railings are typically two-inch outer diameter, thick-walled, black iron piping with cast ornamental ball joint connectors. Railings are anchored into pipe sleeves cast or drilled into the concrete and grouted in place. The joint between the pipe and concrete is covered with an escutcheon plate and screwed in place.
2. Fabricate railings as specified from pipe of the proper diameter. Ball joint connectors may require special casting. Rails are to be shop primed.
3. Install new railings. Clean out existing sleeves and set railings plumb and level. Grout in place using a non-shrink metallic grout. Install escutcheons.
4. Fabricate wrought iron bar rails and stanchions for chain rails from mild steel to match original construction.

Metals: Ferrous, Miscellaneous

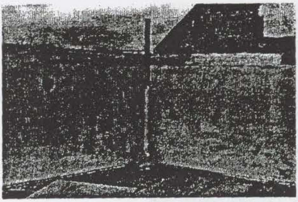
Miscellaneous metals includes military hardware attached to or set in the fortifications. Items include gun mounts, armored conduits, surface mounted boxes for electrical and communications equipment, ammunition handling equipment and other items.

Treatment:

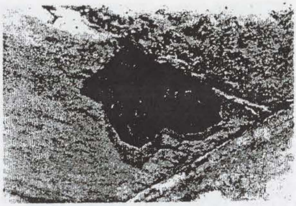
1. Clean metal item free of dirt, oils, debris, corrosion, and deteriorated paint.
2. Brush or clean to bare metal or to stable paint level and wipe with solvent.
3. Secure anchorage devices.
4. Apply approved coatings.



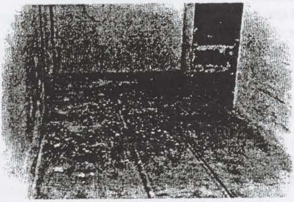
Battery Marcus Miller. Steps leading from loading platform to working platform.



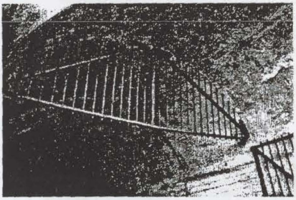
Battery Crosby. Emplacement one, support for camouflage, corner of loading platform. Note also, ventilator opening to left; heavy asphalt coating on floor.



Battery Marcus Miller. Counterweight cable pulley for ammunition hoist doors.



Battery Stotsenburg-McKinnon. Ammunition supply tramway and turntable in central corridor between pits.



Battery Construction #129. Emplacement two, grill above entry gates.

Annotated Bibliography

The annotated bibliography provided below is not intended to offer a comprehensive list of references used in compiling the *Seacoast Fortifications Preservation Manual*. While the materials do include some references used in the preparation of the text, the fullest citations for these documents is in the endnotes following each chapter. Also not included here are the National Park Service sources and general advised archives mentioned in Chapter 4, "Standards and Guidelines for the Preservation Process." The materials discussed herein are intended to guide future researchers and preservationists of coast defense fortifications, both in San Francisco and generally. Each of the KEA authors contributed to the annotated bibliography, with an emphasis on professional specialty. **Items bolded within the list are those essential to work on the San Francisco coast defenses and their preservation.**

Books

Elliott, Cecil D. *Technics and Architecture*. Cambridge, Massachusetts: The MIT Press, 1992.

> A useful reference organized by materials and techniques tracing the origins and development of steel, concrete, glass, plumbing, and other items.

Floyd, Dale E. *Defending America's Coasts, 1775 - 1950: A Bibliography.* Alexandria, Virginia: Office of History, U.S. Army Corps of Engineers, 1997.

> **A comprehensive and useful aid to any research project dealing with coast fortifications. Floyd's familiarity with the subject and thoroughness of approach makes this work a standard. The bibliography is oriented toward historical sources rather than preservation and maintenance—however, these subjects may be touched upon in some of the references.**

Gillmore, Quincy Adams. *Beton Agglomere*. Professional Papers, No. 10, U.S. Army Corps of Engineers. Washington, D.C.: Government Printing Office, 1871.

> An extremely rare analysis of a French construction technique that utilized cement reinforced with iron. Includes diagrams and illustrations of bridges and aqueducts under construction.

Gillmore, Quincy Adams. *Limes, Hydraulic Cements & Mortars*. Practical Treatise No. 9. New York: D. Van Nostrand, 1863.

> A very rare publication by the U.S. Army's expert in cement and mortars during the last half of the nineteenth century. Includes early references to American and European cement manufacture and applications to military construction. Includes diagrams of early kilns and cement manufacturing equipment.

Graf, Don. *Basic Building Data, 10,000 Timeless Construction Facts*. New York: Van Nostrand Reinholt Company, 1949.

A compilation of fundamental building information (materials and techniques) current in 1949, with useful illustrations and clear text.

Hughes, Quentin. *Military Architecture.* New York: St. Martin's Press, 1974.

An overview of European examples through the nineteenth century, and useful as an introduction to fortification forms that would have been familiar to the builders of the San Francisco defenses.

Mallory, Keith and Arvid Ottar. *The Architecture of War.* New York: Pantheon Books, 1973.

This older volume remains useful for the breadth of its inquiry into the subject, as well as for its portrayal of the contributions of military design to more conventional building types.

Ramsey, Charles George and Harold Reeve Sleeper. *Architectural Graphic Standards*. New York: John Wiley & Sons, Inc., 1936. Second edition.

A useful desktop reference for the historic architect, with many materials and techniques from the period, such as metal pipe handrails and clay drainage tile shapes and sizes.

Texas Historical Commission. *Handbook of Maintenance Techniques*. Austin: Texas Historical Commission, 1984.

A maintenance manual prepared for the historic buildings in Galveston, Texas, with excellent references on the causes of masonry deterioration and moisture related deterioration.

Turner, C.A.P. *Concrete Steel Construction*. Minneapolis: Farnham Printing & Stationary Company, 1909.

An early, and rare, technical manual for reinforced concrete (called concrete-steel construction at the time). Includes structural calculations, design of reinforcing steel and concrete mix design. Includes examples from the period.

Winslow, Eben Eveleth. *Notes on Seacoast Fortification Construction.* Number 61 in the Occasional Papers of the Engineer School. Washington: Government Printing Office, 1920.

> **The basic treatise on the design and construction of coastal fortifications in the United States. Winslow's contribution, aside from his own considerable insights into the subject, was in the organization and interpretation of the engineering mimeographs that formed the core of his work. The mimeographs are now difficult to locate, and *Notes* too was considered rare until republished by the Coast Defense Study Group. This reproduced reference consists of two parts, a hardcover volume of text and a softcover volume containing the referenced plates.**

Government Documents

Brown, Moraig and Paul Pattison. *Beacon Hill Fort.* Cambridge: RCHM England, 1997.

> An example of an attractively produced survey and inventory of a coastal fortification with extant features from the 1890s to World War II. The emphasis on detailed physical descriptions is not always useful, but it is a successful demonstration of how a survey may be presented to the public.

Fort Glanville Conservation Park Management Plan. National Parks and Wildlife Service, Department of Environment and Planning, South Australia, 1988.

> A detailed and comprehensive study of Fort Glanville, a small coastal fortification in South Australia. The approach is a familiar one, beginning with an historical overview, presentation of significance, and description of significance; followed by a careful description of existing features, and concluding with recommendations for treatment and implementation.

Lonnquest, John C. and David F. Winkler. *To Defend and Deter: The Legacy of the United States Cold War Missile Program*, USACERL [U.S. Army Construction and Engineering Laboratory] Special Report 97/01. Rock Island, Illinois: Defense Publishing Service, November 1996.

> **Conducted as a research effort under the Department of Defense Legacy Resource Management Program, the 600-page volume addresses the complete American missile program of the Cold War years, from 1945 through 1989. The Nike program, inclusive of its precursors, is handled in several chapters. Part I of the study offers a history of the U.S. Cold War missile program; Part II, system profiles for the weapons systems; and, Part III, a state-by-state listing of deployment sites.**

Look, David, AIA, and Dirk H. R. Spennemann, PhD. *For Future Use: A Management Conservation Plan for the World War II Sites in the Republic of the Marshall Islands.* San Francisco and Albury, NSW: the National Park Service and Charles Sturt University, 1993.

> Particularly helpful for its coverage of treatment techniques for ordnance and other military objects of metal, but may be limited in non-tropical areas.

Martini, John A. and Stephen A. Haller. *What We Have We Shall Defend: An Interim History and Preservation Plan for Nike Site SF-88L, Fort Barry, California.* San Francisco: National Park Service, Golden Gate National Recreation Area, 1998.

> **The Martini and Haller study offers a thorough look at the Nike antiaircraft program in the San Francisco Bay Area, with a focus on the installation known as Nike Site SF-88L. The continuing preservation interpretations efforts undertaken at SF-88L offer a model for such Cold War sites, nationwide. The Department of Defense Legacy project, *To Defend and Deter*, completed in 1996, offers an excellent companion volume to this study.**

Thompson, Erwin N. *Historic Resource Study Seacoast Fortifications San Francisco Harbor Golden Gate National Recreation Area California.* Denver: National Park Service, Historic Preservation Team, May 1979.

> **Thompson's 650-page study provides the definitive research for the coast defense fortifications of the San Francisco Bay to date. Although Thompson does not discuss historic materials in his work, the research and citations offered here will continue to guide future historians of the fortifications—and indeed, will provide signposts to all those attempting the preservation of the coast defense sites for many years to come. Especially useful are references to archival materials held in Washington, D.C.**

U.S. Army, Chief of Engineers, *Annual Report of the Chief of Engineers, U.S. Army, to the Secretary of War*. Washington, D.C.: 1869-1903.

> **Covering a long range of years, the *Annual Report* offers the starting point for detailed information on historic materials and practices at the San Francisco batteries, as well as at a number of the ancillaries. The Army did not name the batteries until 1902, and hence a researcher using the *Annual Reports* must be familiar with the historic emplacement numbering and gun sizes for the batteries being sought in order to decipher the information. The *Annual Reports* require close and repeated reading to glean facts, often necessitating a back-and-forth approach to understanding the work proceeding at single batteries. Information is typically not given in a linear or strictly chronological way, but is extremely useful.**

Periodicals: History

Two currently published English-language periodicals concentrate on fortifications. *FORT* is published annually by the Fortress Study Group of Great Britain, and covers fortifications of all types throughout the world. It is a refereed academic journal and the quality of its articles is high. The *Coast Defense Study Group Journal* is published quarterly by the Coast Defense Study Group, an organization based in the United States. It has as its focus the defense built by the United States; the articles are edited but not refereed, and they tend to concentrate on the technology of the defenses.

> *FORT* and the *Coast Defense Study Group Journal* seldom contain articles discussing the maintenance or preservation of fortifications--however they are excellent sources of historical and interpretive information.

A third journal, *Fortress,* is no longer published, although it is still easily available at the time of this writing. It presented articles of defensive structure from all periods, prehistoric to modern. The emphasis was on historical summary and description of works, and often addressed fortifications that were open to the public. Diversity is the message to be gained from *Fortress*, both in the geography covered and the fortifications presented.

Also of interest are several foreign-language periodicals. They are noted here chiefly as an indication of the growing interest in fortifications as a class of historic properties.

> *DAWA* (*Deutsches Atlantik Wall Archiv*) *Nachrichten* – The title is a little misleading. While the central theme is often the defense of the Atlantic Wall, there are many articles about the defenses of other periods and locations. German language articles.
>
> *IBA* (*Interessengemeinschaft für Befestigungsanlagen beider Weltkriege*) *Informationen* – The coverage is of European subjects and emphasizes technical description over matters of preservation or interpretation. German language articles.
>
> *Forteca* – A glossy quarterly magazine that includes a great many unusual fortifications from eastern Europe, often with indications of present use. Of the periodicals mentioned here, *Forteca* is the only one that devotes regular coverage to the designers and builders of fortifications. The Polish language articles are accompanied by brief summaries in English.
>
> *Fortifications & Patrimoine* – Similar to *Forteca*, but with more color and better reproduction. The geographic extent of the French-language journal is Europe and Scandinavia, spanning the period from the 1870s to post-World War II; there is little coverage of preservation-related subjects.

Periodicals: Architecture

The researcher of San Francisco coast defense fortifications is also advised to review the historic California architectural journals, most especially *California Architect and Building News* for the late nineteenth century, and, *Architect and Engineer of California* for the twentieth century after 1906. In addition, small, limited-run architectural periodicals will yield substantial information on historic practices and materials pertinent to the batteries. Such journals may be held at the San Francisco Public Library; the Bancroft Library at the University of California, Berkeley; the Environmental Design (Architecture) Library at the University of California, Berkeley; and, in the California Room of the California State Library, Sacramento. Examples include *The Architect and Pacific Coast Architect* (both of San Francisco).

Those seeking information on historic engineering practices are also recommended to review national engineering journals, particularly *Engineering News-Record and Civil Engineering.*

A final recommendation, not yet reviewed for its usefulness to coast defense fortifications, are the journals and publications associated with the American Portland Cement Manufacturers Association. This association had a major impact on the concrete industry and is historically, and currently, headquartered in Detroit, with a research library. The key journal series begins with the title *Concrete Engineering*, becoming sequentially *Cement Age*, *Concrete-Cement Age*, and *Concrete*, over a period spanning from the turn of the twentieth century into the 1960s. The journal run, although changing titles over the decades, is very well illustrated, with significant discussions of experimentation with reinforced concrete and associated cement-based surfacing applications. Complete runs of this journal sequence are rare, but partial runs are often found in major university engineering libraries and special collections. Also very useful for excellent discussions of advances in the design and engineering of reinforced concrete structures from the 1920s forward is the *Journal of the American Concrete Institute*.

15 PRESERVATION BRIEFS

Preservation of Historic Concrete

Paul Gaudette and Deborah Slaton

National Park Service
U.S. Department of the Interior

Heritage Preservation Services

Introduction to Historic Concrete

Concrete is an extraordinarily versatile building material used for utilitarian, ornamental, and monumental structures since ancient times. Composed of a mixture of sand, gravel, crushed stone, or other coarse material, bound together with lime or cement, concrete undergoes a chemical reaction and hardens when water is added. Inserting reinforcement adds tensile strength to structural concrete elements. The use of reinforcement contributes significantly to the range and size of building and structure types that can be constructed with concrete.

While early twentieth century proponents of modern concrete often considered it to be permanent, it is, like all materials, subject to deterioration. This Brief provides an overview of the history of concrete and its popularization in the United States, surveys the principal causes and modes of concrete deterioration, and outlines approaches to repair and protection that are appropriate to historic concrete. In the context of this Brief, historic concrete is considered to be concrete used in construction of structures of historical, architectural, or engineering interest, whether those structures are old or relatively new.

Brief History of Use and Manufacture

The ancient Romans found that a mixture of lime putty and pozzolana, a fine volcanic ash, would harden under water. The resulting hydraulic cement became a major feature of Roman building practice, and was used in many buildings and engineering projects such as bridges and aqueducts. Concrete technology was kept alive during the Middle Ages in Spain and Africa. The Spanish introduced a form of concrete to the New World in the first decades of the sixteenth century, referred to as "tapia" or "tabby." This material, a mixture of lime, sand, and shell or stone aggregate mixed with water, was placed between wooden forms, tamped, and allowed to dry in successive layers. Tabby was later used by the English settlers in the coastal southeastern United States.

The early history of concrete was fragmented, with developments in materials and construction techniques occurring on different continents and in various countries. In the United States, concrete was slow in achieving widespread acceptance in building construction and did not begin to gain popularity until the late nineteenth century. It was more readily accepted for use in transportation and infrastructure systems.

The Erie Canal in New York is an example of the early use of concrete in transportation in the United States. The natural hydraulic cement used in the canal construction was processed from a deposit of limestone found in 1818 near Chittenango, southeast of Syracuse. The use of concrete in residential construction was

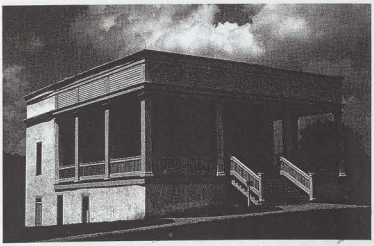


Figure 1. The Sebastopol House in Seguin, Texas, is an 1856 Greek Revival-style house constructed of lime concrete. Lime concrete or "limecrete" was a popular construction material, as it could be made inexpensively from local materials. By 1900, the town had approximately ninety limecrete structures, twenty of which remain. Photo: Texas Parks and Wildlife Department.

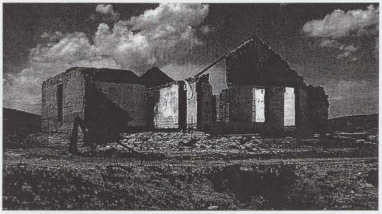


Figure 2. Chatterton House was the home of the post trader at Fort Fred Steel in Wyoming, one of several forts established in the 1860s to protect the Union Pacific Railroad. The walls of the post trader's house were built using stone aggregate and lime, without cement. The use of this material presents special preservation challenges.

publicized in the second edition of Orson S. Fowler's *A Home for All* (1853) which described the advantages of "gravel wall" construction to a wide audience. The town of Seguin, Texas, thirty-five miles east of San Antonio, already had a number of concrete buildings by the 1850s and came to be called "The Mother of Concrete Cities," with approximately ninety concrete buildings made from local "lime water" and gravel (Fig. 1).

Impressed by the economic advantages of poured gravel wall or "lime-grout" construction, the Quartermaster General's Office of the War Department embarked on a campaign to improve the quality of building for frontier military posts. As a result, lime-grout structures were constructed at several western posts soon after the Civil War, including Fort Fred Steele and Fort Laramie, both in Wyoming (Fig. 2). By the 1880s, sufficient experience had been gained with unreinforced concrete to permit construction of much larger buildings. A notable example from this period is the Ponce de Leon Hotel in St. Augustine, Florida.

Extensive construction in concrete also occurred thr the system of coastal fortifications commissioned by federal government in the 1890s for the Atlantic, Pac and Gulf coasts. Unlike most concrete construction to that time, the special requirements of coastal fortifications called for concrete walls as much as 20 thick, often at sites that were difficult to access. Majo structures in the coastal defenses of the 1890s were b of mass concrete with no internal reinforcing, a pract that was replaced by the use of reinforcing bars in fortifications constructed after about 1905.

The use of reinforced concrete in the United States da from 1860, when S.T. Fowler obtained a patent for a reinforced concrete wall. In the early 1870s, William Ward built his own house in Port Chester, New York, using concrete reinforced with iron rods for all struct elements. Despite these developments, such construc remained a novelty until after 1880, when innovation introduced by Ernest L. Ransome made the use of reinforced concrete more practicable. Ransome made many contributions to the development of concrete construction technology, including the use of twisted reinforcing bars to improve bond between the concre and the steel, which he patented in 1884. Two years la Ransome introduced the rotary kiln to United States cement production. The new kiln had greater capacit and burned more thoroughly and uniformly, allowin development of a less expensive, more uniform, and more reliable manufactured cement. Improvements i concrete production initiated by Ransom led to a muc greater acceptance of concrete after 1900.

The Lincoln Highway Association, incorporated in 1913, promoted the use of concrete in construction of coast-to-coast roadway system. The goal of the Lincol Highway Association and highway advocate Henry B. Joy was to educate the country in the need for good roads made of concrete, with an improved Lincoln

Figure 3. The Lincoln Highway Association promoted construction of a high quality continuous hard surface roadway across the country. The Boys Scouts of America installed concrete road markers along the Lincoln Highway in 1928.

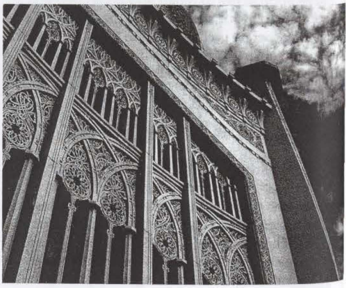


Figure 4. The highly ornamental concrete panels on the exterior facade of the Baha'i House of Worship in Wilmette, Illinois, illust the work of fabricator John J. Earley, known as "the man who ma concrete beautiful."

Figure 5. Following World War II, architects and engineers took advantage of improvements in concrete production, quality control, and advances in precast concrete to design structures such as the Police Headquarters building in Philadelphia, Pennsylvania, constructed in 1961. Photo: Courtesy of the Philadelphia Police Department.

Highway as an example. Concrete "seedling miles" were constructed in remote areas to emphasize the superiority of concrete over unimproved dirt. The Association believed that as people learned about concrete, they would press the government to construct good roads throughout their states. Americans' enthusiasm for good roads led to the involvement of the federal government in road-building and the creation of numbered U.S. routes in the 1920s (Fig. 3).

During the early twentieth century, Ernest Ransome in Beverly, Massachusetts, Albert Kahn in Detroit, and Richard E. Schmidt in Chicago, promoted concrete for use in "Factory Style" utilitarian buildings with an exposed concrete frame infilled with expanses of glass. Thomas Edison's cast-in-place reinforced concrete homes in Union Township, New Jersey (1908), proclaimed a similarly functional emphasis in residential construction. From the 1920s onward, concrete began to be used with spectacular design results: examples include John J. Earley's Meridian Hill Park in Washington, D.C.; Louis Bourgeois' exuberant, graceful Baha'i Temple in Wilmette, Illinois (1920–1953), for which Earley fabricated the concrete (Fig. 4); and Frank Lloyd Wright's Fallingwater near Bear Run, Pennsylvania (1934). Continuing improvements in quality control and development of innovative fabrication processes, such as the Shockbeton method for precast concrete, provided increasing opportunities for architects and engineers. Wright's Guggenheim Museum in New York City (1959); Geddes Brecher Qualls & Cunningham's Police Headquarters building in Philadelphia, Pennsylvania (1961); and Eero Saarinen's soaring terminal building at Dulles International Airport outside Washington, D.C., and the TWA terminal at Kennedy Airport in New York (1962), exemplify the masterful use of concrete achieved in the modern era (Fig. 5).

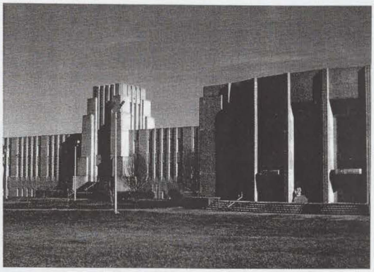


Figure 6. The Bailey Magnet School in Jackson, Mississippi, was designed as the Jackson Junior High School by the firm of N.W. Overstreet & Town in 1936. The streamlined building exemplifies the applicability of concrete to creating a modern architectural aesthetic. Photo: Bill Burris, Burris/Wagnon Architects, P.A.

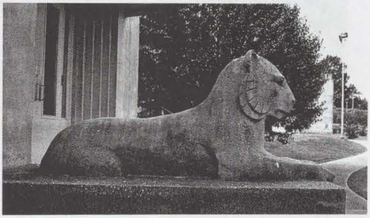


Figure 7. Detailed bas reliefs as well as sculptures, such as this lion at the Bailey Magnet School, could be used as ornamentation on concrete buildings. Sculptural concrete elements were typically cast in molds.

Throughout the twentieth century, a wide range of architectural and engineering structures were built using concrete as a practical and cost-effective choice—and concrete also became valued for its aesthetic qualities. Cast in place and precast concrete were readily adapted to the Streamlined Moderne style, as exemplified by the Bailey Magnet School in Jackson, Mississippi, designed as the Jackson Junior High School by N.W. Overstreet & Town in 1936 (Figs. 6 and 7). The school is one of many concrete buildings designed and constructed under the auspices of the Public Works Administration. Recreational structures and landscape features also utilized the structural range and unique character of exposed concrete to advantage, as seen in Chicago's Lincoln Park Chess Pavilion, designed by Morris Webster in 1956 (Fig. 8), and the Ira C. Keller Fountain in Portland Oregon, designed by Lawrence Halprin in 1969 (Fig. 9). Concrete was also popular for building interiors, with ornamental features and exposed structural elements recognized as part of the design aesthetic (See Figs. 10 and 11 in sidebar).

Historic Interiors

The expanded use of concrete provided new opportunities to create dramatic spaces and ornate architectural detail on the interiors of buildings, at a significant cost savings over traditional construction practices. The architectural design of the Berkeley City Club in Berkeley, California, expressed Moorish and Gothic elements in concrete on the interior of the building (Fig. 10). Used as a woman's social club, the building was designed by noted California architect Julia Morgan and constructed in 1929. The vaulted ceilings, columns, and ornamental capitals of the lobby and the ornamental arches and beamed ceiling of the "plunge" are all constructed of concrete.

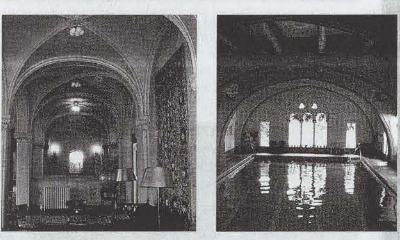


Figure 10. The Berkeley City Club has significant interior spaces and features of concrete construction, including the lobby and pool. Photos: Una Gilmartin (left) and Brian Kehoe (right), Wiss, Janney, Elstner Associates, Inc.

The historic character of a building's interior can also be conveyed in a more utilitarian manner in terms of concrete features and finishes (Fig. 11). The exposed concrete structure—columns, capitals, and drop panels—is an integral part of the character of this old commercial building in Minneapolis. In concrete warehouse and factory buildings of the early twentieth century, exposed concrete columns and formboard finish concrete slab ceilings are common features as seen in this warehouse, now converted for use as a parking garage and shops.

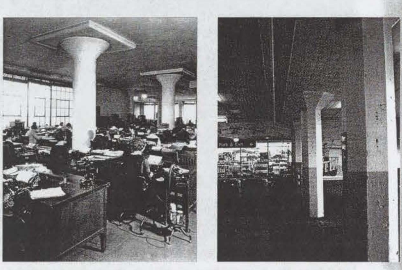


Figure 11. Whether in a circa 1925 office (left) or in a parking garage and retail facility (right), exposed concrete structures help characterize these building interiors. Photo: Minnesota Historical Society (left).

Concrete Characteristics

Concrete is composed of fine (sand) and coarse (crushed stone or gravel) aggregates and paste made of portland cement and water The predominant material in terms of bulk is the aggregate. Portland cement is the binder most commonly used in modern concrete. It is commercially manufactured by blending limestone or chalk with clays that contain alumina, silica, lime, iron oxide and magnesia and heating the compounds together to high temperatures. The hydration process that occurs between the portland cement and wate results in formation of an alkali paste that surrounds and binds the aggregate together a a solid mass.

The quality of the concrete is dependent on the ratio of water to the binder; binder content sound, durable, and well-graded aggregates; compaction during placement; and proper curing. The amount of water used in the mix affects the concrete permeability and strength. The use of excess water beyond that required in the hydration process results in more permeable concrete, which is more susceptible to weathering and deterioration. Admixtures are commonly added to concrete to adjust concrete properties such as setting or hardenin time, requirements for water, workability, and other characteristics. For example, the advent of air entraining agents in the 1930s provided enhanced durability for concrete.

During the twentieth century, there was a steady rise in the strength of ordinary concrete as chemical processes became better understood and quality control measures improved. In addition, the need to protect embedded reinforcement against corrosion was acknowledged. Requirements for concrete cover over reinforcing steel, increased cement content, decreased water-cement ratio, and air entrainment all contributed to greater concrete strength and improved durability.

Mechanisms and Modes of Deterioration

Causes of Deterioration

Concrete deterioration occurs primarily becau of corrosion of the embedded steel, degradatio of the concrete itself, use of improper techniqu or materials in construction, or structural problems. The causes of concrete deterioration must be understood in order to select an appropriate repair and protection system.

While reinforcing steel has played a pivotal role in expanding the applications of concrete in twentieth century architecture, corrosion of this steel has also caused deterioration in many historic structures. Reinforcing steel embedded in the concrete is normally surrounded by a passivating oxide layer that, when present, protects the steel from corrosion and aids in bonding the steel and concrete. When the concrete's normal alkaline environment (above a pH of 10) is compromised and the steel is exposed to water, water vapor, or high relative humidity, corrosion of the steel reinforcing takes place. A reduction in alkalinity results from carbonation, a process that occurs when the carbon dioxide in the atmosphere reacts with calcium hydroxide and moisture in the concrete. Carbonation starts at the concrete's exposed surface but may extend to the reinforcing steel over time. When carbonation reaches the metal reinforcement, the concrete no longer protects the steel from corrosion.

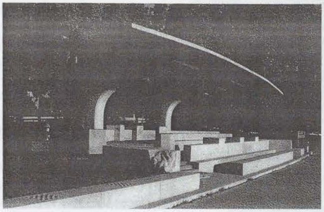


Figure 8. The Chess Pavilion in Chicago's Lincoln Park was designed by architect Morris Webster and constructed in 1956. The pavilion is a distinctive landscape feature, with its reinforced concrete cantilevered slab that provides cover for chess players.

Corrosion of embedded reinforcing steel may be initiated and accelerated if calcium chloride was added to the concrete as a set accelerator during original construction to promote more rapid curing. It may also take place if the concrete is later exposed to deicing salts, as may occur during the winter in northern climates. Seawater or other marine environments can also provide large amounts of chloride, either from inadequately washed original aggregate or from exposure of the concrete to seawater.

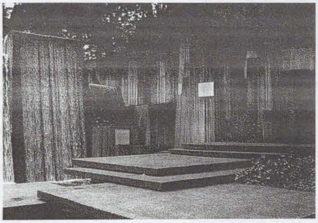


Figure 9. The Ira C. Keller Fountain in Portland, Oregon, was designed by Lawrence Halprin and constructed in 1969. The fountain is constructed primarily of concrete pillars with formboard textures and surrounding elements, patterned with geometric lines, which facilitate the path of water. Photo: Anita Washko, Wiss, Janney, Elstner Associates, Inc.

Corrosion-related damage to reinforced concrete is the result of rust, a product of the corrosion process of steel, which expands and thus requires more space in the concrete than the steel did at the time of installation. This change in volume of the steel results in expansive forces, which cause cracking and spalling of the adjacent concrete (Fig. 12). Other signs of corrosion of embedded steel include delamination of the concrete (planar separations parallel to the surface) and rust staining (often a precursor to spalling) on the concrete near the steel.

Lack of proper maintenance of building elements such as roofs and drainage systems can contribute to water-related deterioration of the adjacent concrete, particularly when concrete is saturated with water and then exposed to freezing temperatures. As water within the concrete freezes, it expands and exerts forces on the adjacent concrete. Repeated freezing and thawing can result in the concrete cracking and delaminating. Such damage appears as surface degradation, including severe scaling and micro-cracking that extends into the concrete. The condition is most often observed near the surface of the concrete but can also eventually occur deep within the concrete. This type of deterioration is usually most severe at joints, architectural details, and other areas with more surface exposure to weather. In the second half of the twentieth century, concrete has utilized entrained air (the incorporation of microscopic air bubbles) to provide enhanced protection against damage due to cyclic freezing of saturated concrete.

The use of certain aggregates can also result in deterioration of the concrete. Alkali-aggregate reactions—in some cases alkali-silica reaction (ASR)—occur when alkalis normally present in cement react with certain aggregates, leading to the development of an expansive crystalline gel. When this gel is exposed to moisture, it expands and causes cracking of the aggregate and concrete matrix. Deleterious aggregates are typically found only in certain areas of the country and can be detected through analysis by an experienced petrographer. Low-alkali cements as well as fly ash are used today in new construction to prevent such reactions where this problem may occur.

Problems Specifically Encountered with Historic Concrete

Materials and workmanship used in the construction of historic concrete structures, particularly those built before the First World War, sometimes present potential sources of problems. For example, where the aggregate consisted of cinder from burned coal or crushed brick,

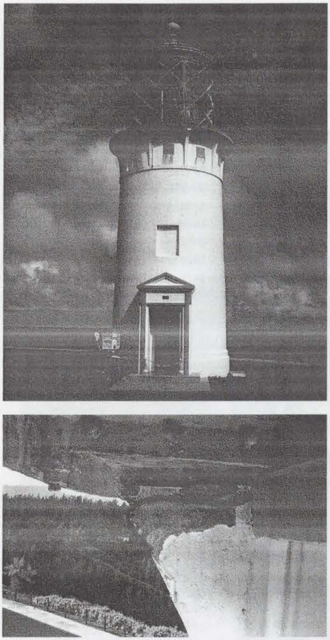


Figure 12. The concrete lighthouse at the Kilauea Point Light Station, Kilauea, Kauai, Hawaii, was constructed circa 1913. The concrete, which was a good quality, high strength mix for its day, is in good condition after almost one hundred years in service. Deterioration in the form of spalling related to corrosion of embedded reinforcing steel has occurred primarily in areas of higher ornamentation such as projecting bands and brackets (see close-up photo).

the concrete tends to be weak and porous because these aggregates absorb water. Some of these aggregates can be extremely susceptible to deterioration when exposed to moisture and cyclic freezing and thawing. Concrete was sometimes compromised by inclusion of seawater or beach sand that was not thoroughly washed with fresh water, a condition more common with coastal fortifications built prior to [illegible] ıe sodium chloride present in seawater [illegible] each sand accelerates the rate of corrosion of the reinforced concrete.

Another problem encountered with historic concrete is related to poor consolidation of the concrete during its placement in forms, or in molds in the cas of precasting. This problem is especially prevalent in highly ornamental units. Early twentieth century concrete was often tamped or rodded into place, similar to techniques used in forming cast stone. Poorly consolidated concrete often contai voids ("bugholes" or "honeycombs"), which can reduce the protective concrete cover over the embedded reinforcing bars, entrap water, and, if sufficiently large and strategically numerous, reduce localized concrete strength. Vibration technology has improved over time and flowability agents ar also used today to address this problem.

A common type of deterioration observed in concrete is the effect of weathering from exposure to wind, rain, snow, and salt water or spray. Weathering appears as erosion of the cement paste, a condition more prevalent in northern regions where precipitation can be highly acidic. This results in the exposure of the aggregate particles on the exposed concrete surface. Variations may occur in the aggregate exposure due to differential erosion or dissolution of exposed cement paste. Erosion can also be caused by the mechanical action of water channeled over concrete, such as by the lack of drip grooves belt courses and sills, and by inadequate drainage. In additio high-pressure water when used for cleaning can also erode t concrete surface.

In concrete structures built prior to the First World War, concrete was often placed into forms in relatively short vertical lifts due to limitations in lifting and pouring techniques available at the time. Joints between different concrete placements (often termed cold joints or lift lines) ma sometimes be considered an important part of the character a concrete element (Fig. 13). However, wide joints may perm water to infiltrate the concrete, resulting in more rapid paste erosion or freeze-thaw deterioration of adjacent concrete in cold climates.

In the early twentieth century, concrete was sometimes place in several layers parallel to the exterior surface. A base concr was first created with formwork and then a more cement ric mortar layer was applied to the exposed vertical face of the

Figure 13. Fort Casey on Admiralty Head, Fort Casey, Washington, was constructed in 1898. The lift lines from placement of concrete are clearly visible on the exterior walls and characterize the finished appearance.

base concrete. The higher cement content in the facing concrete provided a more water-resistant outer layer and finished surface. The application of a cement-rich top layer, referred to in some early concrete publications as "waterproofing," was also used on top surfaces of concrete walls, or as the top layer in sidewalks. With this type of concrete construction, deterioration can occur over time as a result of debonding between layers, and can proceed very rapidly once the protective cement-rich layer begins to break down.

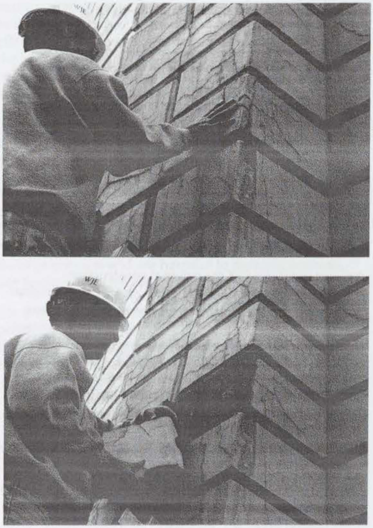
It is common for historic concrete to have a highly variable appearance, including color and finish texture. Different levels of aggregate exposure due to paste erosion are often found in exposed aggregate concrete. This variability in the appearance of historic concrete increases the level of difficulty in assessing and repairing weathered concrete.

Signs of Distress and Deterioration

Characteristic signs of failure in concrete include cracking, spalling, staining, and deflection. Cracking occurs in most concrete but will vary in depth, width, direction, pattern, and location, and can be either active or dormant (inactive). Active cracks can widen, deepen, or migrate through the concrete, while dormant cracks remain relatively unchanged in size. Some dormant cracks, such as those caused by early age shrinkage of the concrete during curing, are not a structural concern but when left unrepaired, can provide convenient channels for moisture penetration and subsequent damage. Random surface cracks, also called map cracks due to their resemblance to lines on a map, are usually related to early-age shrinkage but may also indicate other types of deterioration such as alkali-silica reaction.

Structural cracks can be caused by temporary or continued overloads, uneven foundation settling, seismic forces, or original design inadequacies. Structural cracks are active if excessive loads are applied to a structure, if the overload is continuing, or if settlement is ongoing. These cracks are dormant if the temporary overloads have been removed or if differential settlement has stabilized. Thermally-induced cracks result from stresses produced by the expansion and contraction of the concrete during temperature changes. These cracks frequently occur at the ends or re-entrant corners of older concrete structures that were built without expansion joints to relieve such stress.

Spalling (the loss of surface material) is often associated with freezing and thawing as well as cracking and delamination of the concrete cover over embedded reinforcing steel. Spalling occurs when reinforcing bars corrode and the corrosion by-products expand, creating high stresses on the adjacent concrete, which cracks and is displaced. Spalling can also occur when water absorbed by the concrete freezes and thaws (Fig. 14). In addition, surface spalling or scaling may result from the improper finishing, forming, or other surface phenomena when water-rich cement paste (laitance) rises to the surface. The resulting weak material is vulnerable to spalling of thin layers, or scaling. In some cases, spalling of the concrete can diminish the load-carrying capacity of the structure.



Figures 14. Layers of architectural concrete that have debonded (spalled) from the surface were removed from a historic water tank during the investigation performed to assess existing conditions. Photos: Anita Washko, Wiss, Janney, Elstner Associates, Inc.

Deflection is the bending or sagging of structural beams, joists, or slabs, and can be an indication of deficiencies in the strength and structural soundness of concrete. This condition can be produced by overloading, corrosion of embedded reinforcing, or inadequate design or construction, such as use of low-strength concrete or undersized reinforcing bars.

Staining of the concrete surface can be related to soiling from atmospheric pollutants or other contaminants, dirt accumulation, and the presence of organic growth. However, stains can also indicate more serious underlying problems, such as corrosion of embedded reinforcing steel, improper previous surface treatments, alkali-aggregate reaction, or efflorescence, the deposition of soluble salts on the surface of the concrete as a result of water migration (Fig. 15).

Planning for Concrete Preservation

The significance of a historic concrete building or structure—including whether it is important for its architectural or engineering design, for its materials and construction techniques, or both—guides decision making about repair and, if needed, replacement methods. Determining the causes of deterioration is also central to the development of a conservation and repair plan. With historic concrete buildings, one of the more difficult challenges is allowing for sufficient time during the planning phase to analyze the concrete, develop mixes, and provide time for adequate aging of mock-ups for matching to the original concrete.

An understanding of the original construction techniques (cement characteristics, mix design, original intent of assembly, type of placement, precast versus cast in place, etc.) and previous repair work performed on the concrete is important in determining causes of existing deterioration and the susceptibility of the structure to potential other types of deterioration. For example, concrete placed in short lifts (individual concrete placements) or constructed in precast segments will have numerous joints that can provide entry points for water infiltration. Inappropriate prior repairs, such as installation of patches using an incompatible material, can affect the future performance of the concrete. Such prior repairs may require corrective work.

As with other preservation projects, three primary approaches are usually considered for historic concrete structures: ***maintenance*, *repair*,** or ***replacement***. Maintenance and repair best achieve the preservation goal of minimal intervention and the greatest retention of existing historic fabric. However, where elements of the building are severely deteriorated or where inherent problems with the material lead to ongoing failures, replacement may be necessary.

During planning, information is gathered through research, visual survey, inspection openings, and laboratory studies. The material should then be reviewed by professionals experienced in concrete deterioration to help evaluate the nature and causes of the concrete problems, to assess both the short-term and long-term effects of the deterioration, and to formulate proper repair approaches.

Condition Assessment

A condition assessment of a concrete building or structure should begin with a review of all available documents related to original construction and prior repairs. While plans and specifications for older concrete buildings are not always available, they can be an invaluable resource and every attempt should be made to find them. They may provide information on the composition of the concrete mix or on the type and location of reinforcing bars. If available, documents related to past repairs should also be reviewed to understand how the repairs were made and to help evaluate their anticipated performance and service life. Archival photographs can also provide a valuable sourc of information about original construction.

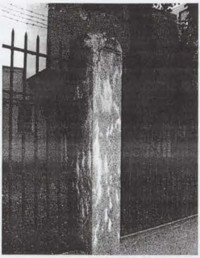


Figure 15. Evidence of moisture movement throu concrete is apparent in the form of mineral deposits on the concrete surface. Cyclic freezing and thawing of entrapped moisture, and corrosion o embedded reinforcement, have also contributed to deterioration of the concre column on this fence at Crocker Field in Fitchburg Massachusetts, designed b the Olmsted Brothers.

A visual condition survey will help identify and evaluate the extent, types, and patterns of distress and deterioration. The American Concrete Institute offers several useful guides on how to perform a visual condition survey of concrete. Generally, the condition assessment begins with an overall visual survey, followed by a close-up investigation of representative areas to obtain more detailed information about modes of deterioration.

A number of nondestructive testing methods can be used in the field to evaluate concealed conditions. Basic techniques include sounding with a hand-held hammer (or for horizontal surfaces, a chain) to help identify area of delamination. More sophisticated techniques include impact-echo testing (Fig. 16), ground penetrating radar, pulse velocity, and other methods that characterize concrete thickness and locate voids or delaminations. Magnetic detection instruments are used to locate embedded reinforcing steel and can be calibrated to identify the size and depth of reinforcement. Corrosion measurements can be taken using copper-copper sulfate half-cell tests or linear polarization techniques t determine the probability or rate of active corrosion of the reinforcing steel.

To further evaluate the condition of the concrete, samples may be removed for laboratory study to determine material components and composition, and causes of deterioration. Samples need to be representative of existing conditions but should be tak from unobtrusive locations. Laboratory studies of the concrete may include petrographic evaluation followin ASTM C856, *Practice for Petrographic Examination of Hardened Concrete*. Petrographic examination, consisting of microscopical studies performed by a geologist specializing in the evaluation of construction materials, is performed to determine air content, wate cement ratio, cement content, and general aggregate characteristics. Laboratory studies can also include chemical analyses to determine chloride content, sulfate content, and alkali levels of the concrete; identification of deleterious aggregates; and determination of depth of carbonation. Compressive strength studies can be conducted to evaluate the strength of the existing concrete and provide information for repair work. The laboratory studies provide a general identification of the original concrete's components and aggregates, and evidence of damage due to various mechanisms including cyclic freezing and thawing, alkali-aggregate reactivity, or sulfate attack. Information gathered through laboratory studies can also be used to help develop a mix design for the repair concrete.

Cleaning

As with other historic structures, concrete structures are cleaned for several reasons: to improve the appearance of the concrete, as a cyclical maintenance measure, or in preparation for repairs. Consideration should first be given to whether the historic concrete structure needs to be cleaned at all. If cleaning is required, then the gentlest system that will be effective should be selected.

Three primary methods are used for cleaning concrete: water methods, abrasive surface treatments, and chemical surface treatments. Low-pressure water (less than 200 psi) or steam cleaning can effectively remove surface soiling from sound concrete; however, care is required on fragile or deteriorated surfaces. In addition, water and steam methods are typically not effective in removing staining or severe soiling. Power washing with high-pressure water is sometimes used to clean or remove coatings from sound, high-strength concrete, but high-pressure water washing is generally damaging to and not appropriate for concrete on historic structures.

When used with proper controls and at very low pressures (typically 35 to 75 psi), microabrasive surface treatments using very fine particulates, such as dolomitic limestone powder, can sometimes clean effectively. However, microabrasive cleaning may alter the texture and surface reflectivity of concrete. Some concrete can be damaged even by fine particulates applied at very low pressures.

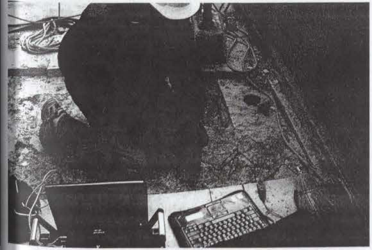


Figure 16. Impact echo testing is performed on a concrete structural slab to help determine depth of deterioration. In this method, a short pulse of energy is introduced into the structure and a transducer mounted on the impacted surface of the structure receives the reflected input waves or echoes. These waves are analyzed to help identify flaws and deterioration within the concrete.

Chemical surface treatments can clean effectively but may also alter the appearance of the concrete by bleaching the concrete, removing the paste, etching the aggregate, or otherwise altering the surface. Detergent cleaners or mild, diluted acid cleaners may be appropriate for removal of staining or severe soiling. Cleaning products that contain strong acids such as hydrochloric (muriatic) or hydrofluoric acid, which will damage concrete and are harmful to persons, animals, site features, and the environment, should not be used.

For any cleaning process, trial samples should be performed prior to full-scale implementation. The intent of the cleaning program should not be to return the structure to a like new appearance. Concrete can age gracefully, and as long as soiling is not severe or deleterious, many structures can still be appreciated without extensive cleaning.

Methods of Maintenance and Repair

The maintenance of historic concrete often is thought of in terms of appropriate cleaning to remove unattractive dirt or soiling materials. However, the implementation of an overall maintenance plan for a historic structure is the most effective way to help protect historic concrete. For examples, the lack of maintenance to roofs and drainage systems can promote water related damage to adjacent concrete features. The repeated use of deicing salts in winter climates can pit the surface of old concrete and also may promote decay in embedded steel reinforcements. Inadequate protection of concrete walls adjacent to driveways and parking areas can result in the need for repair work later on.

The maintenance of historic concrete involves the regular inspection of concrete to establish baseline conditions and identify needed repairs. Inspection tasks involve monitoring protection systems, including sealant joints, expansion joints, and protective coatings; reviewing existing conditions for development of distress such as cracking and delaminations; documenting conditions observed; and developing and implementing a cyclical repair program.

Sealants are an important part of maintenance of historic concrete structures. Elastomeric sealants, which have replaced traditional oil-resin based caulks for many applications, are used to seal cracks and joints to keep out moisture and reduce air infiltration. Sealants are commonly used at windows and door perimeters, at interfaces between concrete and other materials, and at attachments to or through walls or roofs, such as with lamps, signs, or exterior plumbing fixtures.

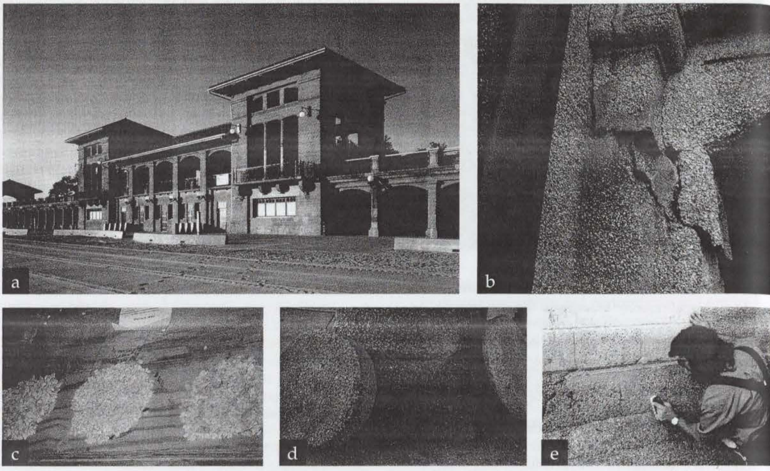


Figure 17. (a) The 63rd Street Beach House was constructed on the shoreline of Chicago in 1919. The highly exposed aggregate concrete of the exterior walls of the beach house was used for many buildings in the Chicago parks as an alternative to more expensive stone construction. Photo: Leslie Schwartz Photography. (b) Concrete deterioration included cracking, spalling, and delamination caused by corrosion of embedded reinforcin steel and concrete damage due to cyclic freezing and thawing. (c) Various sizes and types of aggregates were reviewed for matching to the original concrete materials. (d) Mock-ups of the concrete repair mix were prepared for comparison to the original concrete. Considerations included aggreg type and size, cement color, proportions, aggregate exposure, and surface finish. (e) The craftsman finished the surface to replicate the original appearance in a mock-up on the structure. Here, he used a nylon bristle brush to remove loose paste and expose the aggregate, creating a variable surface to match the adjacent original concrete.

Where used for crack repairs on historic facades, the finished appearance of the sealant application must be considered, as it may be visually intrusive. In some cases, sand can be broadcast onto the surface of the sealant to help conceal the repair.

Urethane and polyurethane sealants are often used to seal joints and cracks in concrete structures, paving, and walkways; these sealants provide a service life of up to ten years. High-performance silicone sealants also are often used with concrete, as they provide a range of movement capabilities and a service life of twenty years or more. Some silicone sealants may stain adjacent materials, which may be a problem with more porous concrete, and may also tend to accumulate dust and dirt. The effectiveness of sealants for sealing joints and cracks depends on numerous factors including proper surface preparation and application. Sealants should be examined as part of routine maintenance inspections, as these materials deteriorate faster than their substrates and must be replaced periodically as a part of cyclical maintenance.

Repair of historic concrete may be required to address deterioration because the original design and construction did not provide for long-term durability, or to facilitate a change in use of the structure. Examples include increasing concrete cover to protect reinforcing steel and reducing water infiltration into th structure by repair of joints. Any such improvements must be thoroughly evaluated for compatibility with the original design and appearance. Care is required i all aspects of historic concrete repair, including surfac preparation; installation of formwork; development of the concrete mix design; and concrete placement, consolidation, and curing.

An appropriate repair program addresses existing distress and reduces the rate of future deterioration, which in many cases involves moisture-related issues. The repair program should incorporate materials and methods that are sympathetic to the existing materials in character and appearance, and which provide good long-term performance. In addition, repair materials should age and weather similarly to the original materials. In order to best achieve these goals, concret repair projects should be divided into three phases: development of trial repair procedures, trial repairs an evaluation, and production repair work.

For any concrete repair project, the process of investigation, laboratory analysis, trial samples, mock-ups, and full-scale repairs allows ongoing refinement of the repair work as well as implementation of quality-control measures. The trial repair process provides an opportunity for the owner, architect, engineer, and contractor to evaluate the concrete mix design and the installation and finishing techniques for the repairs from both technical and aesthetic standpoints. The final repair materials and procedures should match the original concrete in appearance while meeting the established criteria for durability. Information gathered through trial repairs and mock-ups is invaluable in refining the construction documents prior to the start of the overall repair project (Fig. 17).

Surface Preparation

In undertaking surface preparation for historic concrete repair, care must be taken to limit removal of existing material while still providing an appropriate substrate for repairs. This is particularly important where ornamentation and fine details are involved. Preparation for localized repairs usually begins with removal of the loose concrete to determine the general extent of the repair, followed by saw-cutting the perimeter of the repair area. The repair area should extend beyond the area of concrete deterioration to a sufficient extent to provide a sound substrate. When repairing concrete with an exposed aggregate or other special surface texture, a sawcut edge may be too visually evident. To hide the repair edge, techniques such as lightly hand-chipping the edge of the patch may be used to conceal the joint between the original concrete and the new repair material. The depth to which the concrete needs to be removed may be difficult to determine without invasive probing in the repair area. Removal of concrete should typically extend beyond the level of the reinforcing steel, if present, so that the patch encapsulates the reinforcing steel, which provides mechanical attachment for the repair.

If the concrete was originally of lower strength and quality, the assessment of present soundness is more difficult. Deteriorated and unsound concrete is typically removed using pneumatic chipping hammers. Removal of concrete in historic structures is better controlled by using smaller chipping hammers or hand tools. The area of the concrete to be repaired and the exposed reinforcing steel are then cleaned, usually by careful sandblast and air blast procedures applied only within the repair area. Adjacent original concrete surfaces should be protected during this work. In some cases, project constraints such as dust control may limit the ability to thoroughly clean the concrete and steel. For example, it may be necessary to use needle scaling (a small pneumatic impact device) and wire brushing instead of sandblasting.

Supplemental steel may be needed when existing reinforcing steel is severely deteriorated, or if reinforcing steel is not present in repair areas. Exposed existing reinforcing and other embedded steel elements can be cleaned, primed, and painted with a corrosion-inhibiting coating. The patching material should be reinforced and mechanically attached to the existing concrete. Reinforcement materials used in repairs most often include mild steel, epoxy-coated steel, or stainless steel, depending on existing conditions.

Formwork and Molds

Special formwork is needed to recreate ornamental concrete features—which may be complex, in high relief, or architecturally detailed—and to provide special surface finishes such as wood form board textures. Construction of the formwork itself requires particular skill and craftsmanship. Reusable forms can be used for concrete ornamentation that is repeated across a building facade, or precast concrete elements may be used to replace missing or unrepairable architectural features. Formwork for ornamental concrete is often created using a four-step process: a casting of the original concrete is taken; a plaster replica of the unit is prepared; a mold or form is made from the plaster replica; and a new concrete unit is cast. Custom formwork and molds are often the work of specialty companies, such as precasters and cast stone fabricators.

The process of forming architectural features or special surface textures is particularly challenging if early age stripping (removal of formwork early in the concrete curing process) is needed to perform surface treatment on the concrete. Timing for formwork removal is related to strength gain, which in turn is partly dependent on temperature and weather conditions. Early age removal of formwork in highly detailed concrete can lead to damage of the new concrete that has not yet gained sufficient strength through curing.

Selection of Repair Materials and Mix Design

Selection and design of proper repair materials is a critical component of the repair project. This process requires evaluation of the performance, characteristics, and limitations of the repair materials, and may involve laboratory testing of proposed materials and trial repairs. The materials should be selected to address the specific type of repair required and to be compatible with special characteristics of the original concrete. Some modern repair materials are designed to have a high compressive strength and to be impermeable. Even though inherently durable, these newer materials may not be appropriate for use in repairing a low strength historic concrete.

The concrete's durability, or resistance to deterioration, and the materials and methods selected for repair depend on its composition, design, and quality of workmanship. In most cases, a mix design for durable replacement concrete should use materials similar to those of the original concrete mix. Prepackaged materials are often not appropriate for repair of historic concrete. The concrete patching material can be air entrained or polymer-modified if subject to exterior exposure, and should incorporate an appropriate selection of aggregate and cement type, and proper water content and water

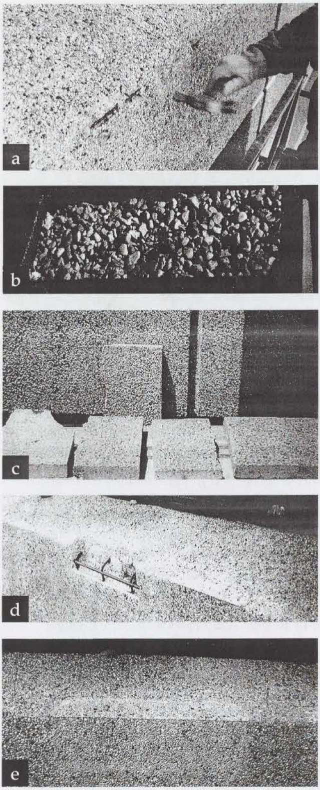


Figure 18. (a) Exposed aggregate precast concrete is sounded with a hammer to detect areas of deterioration. Corrosion of the exposed reinforcing steel bar has led to spalling of the adjacent concrete. (b) Samples of aggregate considered for use in repair concrete are compared to the original concrete materials in terms of size, color, texture, and reflectance. (c) Various sample panels are made using the selected concrete repair mix design for comparison to the original concrete on the building, and the mix design is adjusted based on review of the samples. (d) After removal of the spall, the concrete surface is prepared for installation of a formed patch. (e) Prior to placement of the concrete, a retarding agent is brush-applied to the inside face of the formwork to slow curing at the surface. After the concrete is partially cured, the forms are removed and the surface of the concrete is rubbed to remove some of the paste and expose the aggregate to match the original concrete.

to cement ratio. Some admixtures, including polymer modifiers, may change the appearance of the concrete mix. Design of the concrete patching material should address characteristics requir for durability, workability, strength gain, compressive strength, and other performance attributes. During installation of the repair, skilled workmanship is required to ensure proper mixing procedures, placement, consolidation, and curing.

Matching and Repair Techniques for Historic Concrete

Repair measures should be selected that retain as much of the original material as possible, while providing for removal of an adequate amount of deteriorated concrete to provide a sound substrate for a durable repair. The installed repair must visually match the existing concrete as closely as possible and should be similar in other aspects such as compressive strength, permeabil and other characteristics important in the mix design of the concrete (Fig. 18).

Understanding the original construction techniques often provid opportunities in the design of repairs. For example, joints betwe the new and old concrete can be hidden in changes in surface profile and cold joints. The required patching mix for the concre to be used in the repair will likely need to be specially designed to replicate the appearance of the adjacent historic concrete. A high level of craftsmanship is required for finishing of historic concrete, in particular to create the sometimes inconsistent finish and variation in the original concrete in contrast to the more eve appearance required for most non-historic repairs.

To match the various characteristics of the original concrete, trial mixes should be developed. These mixes need to take into accou the types and colors of aggregates and paste present in the origin concrete. Different mixes may be needed because of variations in the appearance and composition of the historic concrete. The trials should utilize different forming and finishing techniques to achieve the best possible match to the original concrete. Initial trials should first take place on site but off the structure. The mix designs providing the best match are then installed as trial repair on the structure, and assessed after they have cured.

Achieving compatibility between repair work and original concrete may be difficult, especially given the variability often present in historic concrete materials and finishes. Formed rather than trowel-applied patch repairs are recommended for durabili as forming permits better ranges of mix ingredients (such as coar aggregates) and improved consolidation as compared to trowel-applied repairs. Parge coatings usually are not recommended as they do not provide as durable repair as formed concrete. However, in some cases parge coatings may be appropriate to match an original parged surface treatment. Proper placement and finishing of the repair are important to obtain a match with the original concrete. To minimize problems associated with rapi curing of concrete, such as surface cracking, it is important to use proper curing methods and to allow for sufficient time.

Hairline cracks that show no sign of increasing in size may often be left unrepaired. The width of the crack and the amount of movement usually limits the selection of crack repair techniques that are available. Although it is difficult to determine whether cracks are moving or non-moving, and therefore most cracks should be assumed to be moving, it is possible to repair non-moving cracks by installation of a cementitious repair mortar matching the adjacent concrete. It is generally desirable not to widen cracks prior to the mortar application. Repair mortar containing sand in the mix may be used for wider cracks; unsanded repair mortar may be used for narrower cracks.

When it is desirable to re-establish the structural integrity of a concrete structure involving dormant cracks, epoxy injection repair has proven to be an effective procedure. Such a repair is made by first sealing the crack on both sides of a wall or structural member with epoxy, polyester, wax, tape, or cement slurry, and then injecting epoxy through small holes or ports drilled in the concrete. Once the epoxy in the crack has hardened, the surface sealing material may be removed; however, this type of repair is usually quite apparent. Although it may be possible to inject epoxy without leaving noticeable residue, this process is difficult and, in general, the use of epoxy repairs in visible areas of concrete on historic structures is not recommended.

Active structural cracks (which move as loads are added or removed) and thermal cracks (which move as temperatures fluctuate) must be repaired in a manner that will accommodate the anticipated movement. In some more extreme cases, expansion joints may have to be introduced before crack repairs are undertaken. Active cracks may be filled with sealants that will adhere to the sides of the cracks and will compress or expand during crack movement. The design, detailing, and execution of sealant repairs require considerable attention, or they will detract from the appearance of the historic building. The routing and cleaning of a crack, and installation of an elastomeric sealant to prevent water penetration, is used to address cracks where movement is anticipated. However, unless located in a concealed area of the concrete, this technique is often not acceptable for historic structures because the repair will be visually intrusive (Fig. 19). Other approaches, such as installation of a cementitious crack repair, may need to be considered even though this type of repair may be less effective or have a shorter service life than a sealant repair.

Replacement

If specific components of historic concrete structures are beyond repair, replacement components can be cast to match historic ones. Replacement of original concrete should be carefully considered and viewed as a method of last resort. In some cases, such as for repeated ornamental units, it may be more cost-effective to fabricate precast concrete units to replace missing elements. The forms created for precast or cast-in-place units can then be used again during future repair projects.

Careful mix formulation, placement, and finishing are required to ensure that replacement concrete units will match the historic concrete. There is often a tendency to make replacement concrete more consistent in appearance than the original concrete. The consistency can be in stark contrast with the variability of the original concrete due to original construction techniques, architectural design, or differential exposure to weather. Trial repairs and mock-ups are used to evaluate the proposed replacement concrete work and to refine construction techniques (Fig 20).

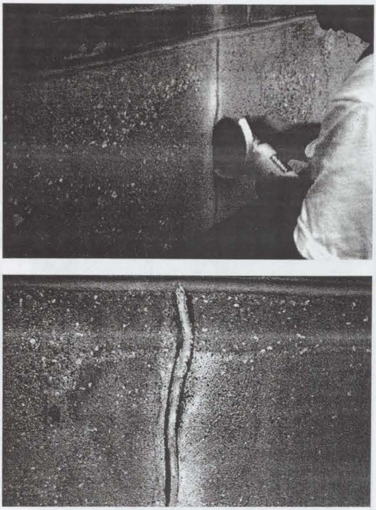


Figure 19. A high-speed grinder ia used to widen a crack in preparation for installation of a sealant. This process is called "routing." After the crack is prepared, the sealant is installed to prevent moisture infiltration through the crack. Although sealant repairs can provide a durable, watertight repair for moving cracks, they tend to be very visible.

Protection Systems

Coatings and Penetrating Sealers. Protection systems such as a penetrating sealers or film forming coating are often used with non-historic structures to protect the concrete and increase the length of the service life of concrete repairs. However, film-forming coatings are often inappropriate for use on a historic structure, unless the structure was coated historically. Film-forming coatings will often change the color and appearance of a surface, and higher build coatings can also mask architectural finishes and ornamental details. For example, the application of a coating on concrete having a formboard finish may hide the wood texture of the surface. Pigmented film-forming coatings are also typically not appropriate for use over exposed aggregate concrete, where the uncoated exposed surface contributes significantly to the historic character of

Figure 20. (a) The Jefferson Davis Memorial in Fairview, Kentucky, constructed from 1917–1924, is 351 feet tall and constructed of unreinforced concrete. The walls of the memorial are 8 feet thick at the base and 2 feet thick at the top of the wall. Access to the monument for investigation was provided by rappelling techniques, while ground supported and suspended scaffolding was used to access the exterior during repairs. (b) The concrete was severely deteriorated at isolated locations, with spalling and damage from cyclic freezing and thawing of entrapped water. In addition, previous repairs were at the end of their service life and removal of deteriorated concrete and failed previous repairs was required. Light duty chipping hammers were used to avoid damage to adjacent material when removing deteriorated concrete to the level of sound concrete. (c) Field samples were performed to match the color, finish, and texture of the original concrete. A challenge in matching of historic concrete is achieving variability of appearance. (d) The completed surface after repairs exhibits intentional variability of the concrete surface to match the appearance of the original concrete. Some formwork imperfections that would normally be removed by finishing were intentionally left in place, to replicate the highly variable finish of the original concrete. (e) The Jefferson Davis Memorial after completion of repairs in 2004. Photo e: Joseph Lenzi, Senler, Campbell & Associates, Inc.

concrete. In cases where the color of a substrate needs to be changed, such as to modify the appearance of existing repairs, an alternative to pigmented film-forming coatings is the use of pigmented stains.

Many proprietary clear, penetrating sealers are currently available to protect concrete substrates. These products render fine cracks and pores within the concrete hydrophobic; however, they do not bridge or fill cracks. Clear sealers may change the appearance of the concrete in that treated areas become more visible after rain in contrast to the more absorptive areas of original concrete. Once applied, penetrating sealers cannot be effectively removed and are therefore considered irreversible. They should not be used on historic concrete without thorough prior consideration. However, clear penetrating sealers provide an important means of protection for historic concrete that is not of good quality and can help to avoid more extensive future repairs or replacement. Thus they are sometimes appropriate for use on historic concrete. Once applied, these sealers will require periodic re-application.

Waterproofing membranes are systems used to protect concrete surfaces such as roofs, terraces, plazas, or balconies, as well as surfaces below grade. Systems range from coal tar pitch membranes used on older buildings, to asphalt or urethane-based systems. On historic buildings, membrane systems are typically used only on surfaces that were originally protected by a similar system and surfaces that are not visible from grade. Waterproofing membranes may be covered by roofing, paving, or other architectural finishes.

Laboratory and field testing is recommended prior to application of a protection system or treatment on any concrete structure; testing is even more critical for historic structures because many such treatments are not reversible. As with other repairs, trial samples are important to evaluate the effectiveness of the treatment and to determine whether it will harm the concrete or affect its appearance.

Cathodic Protection. Corrosion is an electrochemical process in which electrons flow between cathodic (positively charged) and anodic (negatively charged) areas on a metal surface; corrosion occurs at the anodes. Cathodic protection is a technique used to control the corrosion of metal by making the whole metal surface the cathode of an electrochemical cell. This technique is used to protect metal structures from corrosion and is also sometimes used to protect steel reinforcement embedded in concrete. For reinforced concrete, cathodic protection is typically accomplished by connecting an auxiliary anode to the reinforcing so that the entire reinforcing bar becomes a cathode. In sacrificial anode (passive) systems, current flows naturally by galvanic action between the less noble anode (such as zinc) and the cathode. In impressed-current (active) systems, current is impressed between an inert anode (such as titanium) and the cathode. Cathodic protection is intended to reduce the rate of corrosion of embedded steel in concrete, which in turn reduces overall deterioration. Protecting embedded steel from corrosion helps to prevent concrete cracking and spalling.

Impressed-current cathodic protection is the most effective means of mitigating steel corrosion and has been used in practical structural applications since the 1970s. However, impressed-current cathodic protection systems are typically the most costly to install and require substantial ongoing monitoring, adjustment, and maintenance to ensure a proper voltage output (protection current) over time. Sacrificial anode cathodic protection dates back to the 1800s, when the hulls of ships were protected using this technology. Today many industries utilize the concept of sacrificial anode cathodic protection for the protection of steel exposed to corrosive environments. It is less costly than an impressed-current system, but is somewhat less effective and requires reapplication of the anode when it becomes depleted.

Re-alkalization. Another technique currently available to protect concrete is realkalization, which is a process to restore the alkalinity of carbonated concrete. The treatment involves soaking the concrete with an alkaline solution, in some cases forcing it into the concrete to the level of the reinforcing steel by passage of direct current. These actions increase the alkalinity of the concrete around the reinforcement, thus restoring the protective alkaline environment for the reinforcement. Like impressed-current cathodic protection methods, it is costly. Other corrosion methods are also available but have a somewhat shorter history of use.

Careful evaluation of existing conditions, the causes and nature of distress, and environmental factors is essential before a protection method is selected and implemented. Not every protection system will be effective on each structure. In addition, the level of intrusion caused by the protection system must be carefully evaluated before it is used on a historic concrete structure.

Summary

In the United States, concrete has been a popular construction material since the late nineteenth century and recently has gained greater recognition as a historic material. Preservation of historic concrete requires a thorough understanding of the causes and types of deterioration, as well as of repair and replacement materials and methods. It is important that adequate time is allotted during the planning phase of a project to provide for trial repairs and mock-ups in order to evaluate the effectiveness and aesthetics of the repairs. Careful design is essential and, as with other preservation efforts, the skill of those performing the work is critical to the success of the repairs. The successful repair of many historic concrete structures in recent years demonstrates that the techniques and materials now available can extend the life of such structures and help ensure their preservation.

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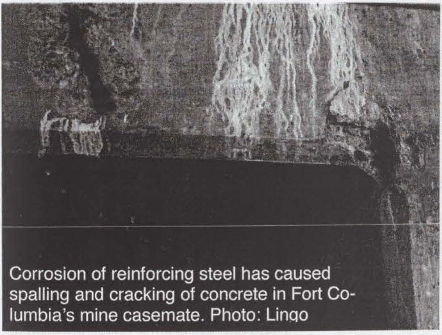
Protecting reinforcing steel in concrete from corrosion

Shawn Lingo

The strength and stability of reinforced concrete depends to a large extent upon the steel bars encased in the body of the structure. However, the same bars that give this strength can prove an avenue for weakness and structural degradation. A variety of chemical and mechanical forces are capable of breaking down the single unit formed by the concrete and the reinforcing steel.



Corrosion of reinforcing steel has caused spalling and cracking of concrete in Fort Columbia's mine casemate. Photo: Lingo

The original quality of the concrete is a determining factor in the process of reinforcing steel corrosion.[1] If the original mix is contaminated with chloride (most commonly in the from of salt) then the stage is set for the chemical reactions that cause the embedded steel to rust. Once the steel begins to rust, it expands significantly in volume, and the resulting phenomenon, known as "steel jacking" causes the concrete to crack and spall.[2] The cracks caused by this process provide a route for penetration by moisture (and in a marine environment, further salt infiltration). The problem is then self-amplifying.

Although the preservationist can do nothing about the builder's choice of materials, the quality and composition of the original mix is a deciding factor for preservation treatment. These considerations particularly come into play in the preservation of coastal military fortifications, where due to the early application of reinforced concrete as a building material such systemic problems are common. Structures of the Endicott period of-

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[1] Marcela Vasquez, et. al. "Corrosion of Construction Steel in Concrete", in *Topics in Electrochemistry Research*, Nova Science Publishing, 2006. pp. 47-84.

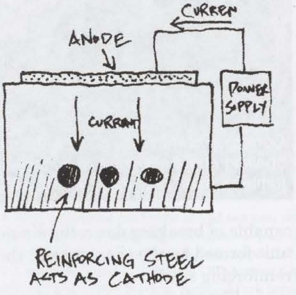
[2] Arne P. Johnson and Seung Kyoung Lee, "Soldier Field Stadium: Corrosion Mitigation for Historic COncrete," APT Bulletin, Vol. 35 , No. 2/3. (2003), pp. 67-75.

ten exhibit a range of variation in the mix of cement and aggregate, as well as inconsistency in workmanship.[3] The workmanship evident in the batteries and other concrete structures at Fort Columbia appears to be of good quality, however, the same processes are at work.

Upon first reflection it would seem impossible to apply preservation treatments to steel that lies encased in several feet of concrete. But such treatments are available. All treatments rely on the concept that concrete is never quite a solid, that although it is set up and solidified it retains some characteristics of a liquid.

Application of **migrating corrosion inhibitors** is the simplest of these treatments, and the least costly in terms of initial expense. These chemicals are either mixed into the concrete during repairs and patching, or are applied to the concrete surface and absorbed into the mass. These compounds are easily applied and require no maintenance, and taken with their low cost this makes them attractive solutions for concrete preservation problems. The main drawback of corrosion inhibitors is the general disagreement over whether they are effective means of controlling corrosion. Some studies have shown that most of the chemicals applied never reach the reinforcing metal inside the concrete.[4]

In current preservation practice some form of **galvanic cathodic protection** is likely to be a viable consideration. The scientific concept involved is well understood, and the first practical application was made by Humphry Davy. In 1824 the scientist attached pieces of iron to the copper clad hulls of Royal Navy vessels in order to protect the copper sheathing from interaction with sea water. The iron acted as a sacrificial anode, in other words it was used up in the chemical reaction with the copper, thus protecting the copper.[5]



from Lee and Johnson, p. 72. redrawn S. Lingo, 3/08

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[3] Gary Scott, "Historic Concrete Preservation Problems at Fort Washington, Maryland", *Bulletin of the Association for Preservation Technology*, Vol. 10, No. 2. (1978), pp. 122-131.

[4] Johnson and Lee, p. 70.

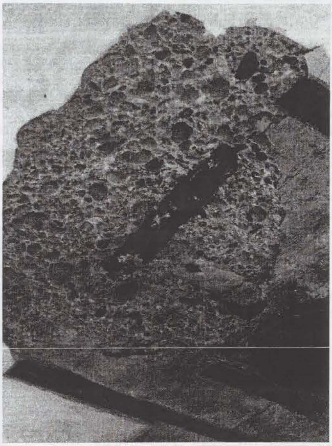
[5] http://ocw.mit.edu/NR/rdonlyres/Materials-Science-and-Engineering/-014Fall-2006/5B99DD6C-3068-43A1-8FD3-A4E161EEFDA9/0/w3_b2.pdf, accessed 03/17/08.

More recently galvanic protection has been used very successfully to preserve Oregon's coastal bridges by important designer-engineer Conde McCullough. The bridges were arc-coated with a zinc film, which by introduction of a low-voltage current into the rebar framework is gradually drawn into the concrete and forms a protective coating over the metal from the inside.[6]

Cathodic protection systems have been used effectively in hundred of highways bridges in the United States and Canada. In the late 1980s English heritage management agencies began seriously considering modern concrete buildings for listing. CP has been used in a wide variety of buildings in the UK.[7]

Cathodic protection has many important advantages. It is a very effective method of stopping the corrosive processes that preservationists must deal with in reinforced concrete structures. The anodes can be inserted or positioned within the structure with minimal visual impact or damage. The anodes can be distributed so as to account for the complex shapes and volumes of many historic buildings. With current advances in technology the anode systems are viable for an estimated 100 years, making lifetime system costs very low.[8]

Advances in monitoring and control systems mean that the cathodic protection can continuously self-adjust to account for variances in moisture and chemical composition in the concrete.[9]



Embedded metal has caused spalling in the ceiling of Fort Columbia's mine casemate. Feb. 2008.

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[6] http://www.pwri.go.jp/eng/ujnr/tc/g/pdf/21/21-8-2johnson.pdf "Management of Coastal Bridges Using Cathodic Protection and Stainless Steel Reinforcing Bars" Frank Nelson and Bruce Johnson

[7] Paul Noyce and Gina Crevello, "Electrochemical Treatments on Historic Steel Frame Buildings", American Institute of Architects, http://www.aia.org/hrc_a_200803_Electrochemical

[8] Ibid.

[9] Johnson and Lee, pp. 72, 74.

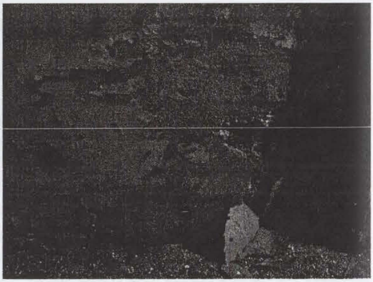
Cathodic protection systems are also reversible. The cables and anodes are easily removable if other preservation measures become available.[10]

Drawbacks for the use of cathodic protection include the complex engineering required to effectively set up systems, and the ongoing adjustment, monitoring, and maintenance required.

Chloride extraction and **re-alkalization** are two other electrochemical processes available to the preservationist. They use the same techniques as cathodic protection — the application of an anode and use of electrical current to alter the chemical composition of the concrete. In chloride extraction a strong electrical current is applied, causing the chloride ions to move away from the reinforcing steel and toward the anode. this technique has several drawbacks, especially the difficulty of applying the special electrolyte coating, and the tendency to stain the concrete.[11]

Re-alkalization uses principles of cathodic protection to raise the pH of the concrete around the reinforcing steel. The process was invented in Norway to deal with bridge problems and has been used more frequently in Europe than in the United States. Rudolph Steiner's Goetheanum in Switzerland served as an early trial project demonstrating the effectiveness of the technique.[12] In re-alkalization, a high voltage current is applied to an alkali anode, driving the chemical into the concrete. The increased pH restores the protective environment.

These technological fixes provide a promising approach to problems involving historic concrete. They allow a greater retention of historic fabric and more systematic for repair. They do not, however, restore structural integrity, and should not be considered an alternative, but rather a complement, to traditional patching and repair of concrete in order to protect the reinforcing steel.[13]



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[10] John P. Broomfield, "The application of impressed current cathodic protection to historic listed reinforced concrete and steel frame structures", *Journal of Corrosion Science and Engineering*, Vol. 9, No. 15. 2004. p. 13

[11] Johnson and Lee, p. 70.

[12] Wessel de Jonge, "Concrete Repair and Material Authenticity: Electrochemical Preservation Techniques", *APT Bulletin*, Vol. 28, No. 4. (1997) pp. 51-57.

[13] Ibid., pp. 56-57.

Fighting Rust

FROM APT BULLETIN, VOL. IX, NO. 1, 1987

Martin Weaver

What is the connection between the wreck of the Royal Navy's first submarine and a 16th-century wrought-iron "Armada Chest" lying in an Ottawa garden? The answer to this curious question is *Fertan* — a British product which will shortly be available in Canada. The story of the connection and subsequent developments is one which should be told.

In 1984 I read an article in *American Heritage* (April/May issue) entitled "The Holland Surfaces" which told of the Royal Navy Submarine Museum's successful quest leading to the location and salvage of His Majesty's Submarine *No. 1*, more often known after her launch in 1901 as *"Holland 1"*.

A brief reference in that article to "Fertan, a compound with the alchemical powers to transform rust into a material as strong as the original steel" was enough to set me on a track which led to delightful correspondence with Commander Richard Compton Hall M.B.E. R.N. (Retd.), Director of the Royal Navy Submarine Museum, H.M.S. *Dolphin*, Gosport, Hampshire, U.K., and eventually at Christmas 1984 to a very productive meeting which later developed into a pretty wild party with Tony Munroe, Director of Fertan Ltd. and his staff just outside London, England.

I had asked Commander Compton Hall if he felt that the Fertan treatment had worked well in the case of *"Holland 1"* which is exhibited out-of-doors at his museum close to the sea. I added that if it had, I foresaw that in Canada, Fertan could be the answer to corrosion prevention, removal or inhibition treatments on a number of historic or heritage vessels and structures of iron and steel.

His answer was very positive, that he was a satisfied customer and that the application of the product was simple, quick and inexpensive.

The *"Holland 1"* had been located by sonar in April 1981 by the mine hunter H.M.S. *Bossington*. The submarine lay at a depth of 63 metres, about 2.5 kilometres off the Eddystone Lighthouse in the English Channel. In August 1982, a team of Navy divers, which included two from the Canadian Armed Forces, reached and entered the submarine. This was the first time anyone had been on her decks since 1913, when she accidentally sank with nobody on board.

In September 1982 *"Holland 1"* was successfully raised and transported in underwater slings to Davenport Dockyard. The great No. 12 dock was pumped dry, and as the waters receded, the long submerged,weed-encrusted,iron and steel hull surfaced at last after 69 years. Almost at once a crew set-to with high-powered water jets to remove the marine growth and encrustations, and then, working non-stop through the night, they sprayed on the dark brown liquid Fertan which converted the dripping rusty unstable corrosion products into a hard, stable, black iron-tannate compound. The notoriously problematic and unstable iron and steel corrosion products from her long rest in salt water were almost miraculously stabilized, and *"Holland 1"* stands by the sea to this day with her plates in remarkably sound condition at Gosport, the Edwardian base from which she long ago operated.

Since then, Fertan has been used on a wealth of heritage resources, ranging from the iron of the S.S. *Great Britain* (Brunel's great composite ship of 1842) to World War I tanks at the British Army's Bovington Tank Museum; a D-Day vintage Sherman tank found in the English Channel; vintage aircraft hanger doors; a World War II midget submarine; and even great Victorian cast-iron underground sewer pipes near London's Parliament Buildings.

Having personally examined stabilized iron and steel on *"Holland 1"* and on a World War II midget sub raised from the sea off the English Coast, I enthusiastically brought samples of Fertan to Canada to experiment on heritage iron and steel exposed out-of-doors to the violence of Canadian winters and the stress of acid rain and other forms of atmospheric pollution.

At home in Ottawa I have a damaged and heavily corroded wrought-iron 16th-century strong box of the type known as an Armada Chest. Popular tradition in England has it that at the time of the Spanish Armada's threat to England in the 1580's, many people purchased such iron chests to safeguard their treasures. With continuing threats from civil war, highwaymen, and burglars, the chests remained popular well into the 19th century.

In April 1985 I donated my large but damaged wrought-iron chest to science and started the first of a series of applications of Fertan and a related product to the venerable but rusty iron. The chest has stood out in the snow, rain, fog, wind and sunshine ever since. With no further treatment the Fertan-stabilized iron stood up well to its first year of exposure to this tough test and is now, at the time of writing, nearly three months into its second year. A careful and continuous record has been kept with colour slide photography.

What is Fertan, and what makes it such an improvement over other products and methods for treating rusting or corroding iron and steel? It has been known for many years that vegetable tannins possess useful anti-corrosion properties for the treatment of rusting or corroding iron and steel. In the 1950's, research into tannin technology took place in the U.S.S.R. and progressed in Europe during the 60's and 70's. Chemical formulations like Fertan which are based on tannin derivatives, phosphoric

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acid, and wetting agents have the capacity to convert unstable iron oxides or rust to a stable ferric tannate. The latter is a blue-black insoluble complex organic compound. Such products are called rust converters as opposed to rust removers.

To understand what actually happens in this process we must first understand a little about the nature of rust. What is rust? In the more than 2,000 years that people have been using iron and watching it rust, the question may seem to have an obvious answer. Surprisingly, it has to be admitted that even researchers who have dedicated their lives to answering this question still do not have such clear answers as we might at first assume.

Essentially the making of iron from ore and its subsequent corrosion are parts of a circular process. We find iron ore in many forms, typically as mineral compounds such as haematite and various other types of iron oxide. If we subject these minerals to great heat — about 1600°C — the iron within is reduced to a pure metal in a liquid state. This process is known as smelting and involves a huge input of energy.

Corrosion, which can be described as the chemical reaction of a metal with oxygen and other substances, then takes place as the metallic iron is exposed to the atmosphere, moisture, and other chemical compounds. Thus commences the slow but almost inexorable reversion again to a mineral compound like the natural ore.

The metamorphosis also involves energy exchange. If a sheet of iron lies in acidic or salt water with metals such as bronze, gun metal, copper, brass or chromium, the iron will suffer from electrochemical corrosion. Energy will be generated and, as the electrical current flows, the iron will corrode preferentially, protecting the "more noble" metal in the process.

Metals can be arranged in a series, like the steps of a ladder, ascending from the so-called base metals such as calcium, magnesium, aluminum, zinc and iron up the ladder to the so-called noble metals of silver, platinum, and gold. This is called the electromotive series. Metals at the bottom of the ladder are highly reactive and have a strong tendency to ionize — lose positively charged ions. The more positively charged ions which are lost, the more negatively charged the metal becomes. A negativelly charged area of metal is called an anode. A positively charged area of metal is called a cathode and tends to be protected in any reaction. Thus, we also refer to anodic corrosion and cathodic protection.

Electrochemical corrosion, also known as galvanic corrosion, occurs if differences in electrical potential exist between two metals or on a metallic surface; if there is contact so that electrons can flow; and if there is an electrolyte (water plus salts) so that ions can go into solution and travel from one area of metal to another.

Minute differences of exposure to the air, water, various chemical compounds or degrees of acidity can make the surface of even a single piece of iron or steel an actively changing series of areas with negative or positive charges.

This will result in continuous corrosion losses in the anodic areas as they move around the surface. The process is typically uneven and leads to heavier corrosion, or even deep pitting in some areas.

To eliminate corrosion we have a number of things we can do. First, we must prevent any reaction from taking place between iron or steel and water and oxygen. This means that air and water must not even contact the surface of the metal. Second we must stop any active corrosion process currently in progress.

Sandblasting, grinding, and wire brushing are typically inefficient processes which seek to stop active corrosion by physically tearing off corrosion products. If the metal remains exposed to air and water it will simply start to corrode again immediately. In some environments this process can commence in minutes and is termed "flash rusting".

Protecting the surface of the iron with oil, grease, paint or thin layers of other metals is only good for as long as the protective layers remain intact and impenetrable to air and moisture or even water vapor or tiny amounts of oxygen.

In our polluted urban environments and with acidic precipitation (acid rain, snow, and fog) protective layers may have disastrously shortened lives. Paint films and other coatings become permeable and may actually admit oxygen and water vapor to the metal surface, allowing corrosion to commence while at the same time, the imperfect coating actually holds the moisture in and creates conditions which cause more corrosion rather than preventing it.

The more complex the surface of the iron, the more difficult it is to remove unstable corrosion products. Typically difficult iron objects to treat are iron cannons, antique mortar shells, and iron ships found under the sea. All have complex forms with inaccessible areas and may even have active corrosion occurring deep down in pits and fissures in the very metal itself. Obviously, a sunken submarine made of different metals and with many chambers has just about the worst collection of corrosion problems one could find. The complete removal of all the corrosion products and the subsequent protection of the metal is virtually impossible by traditional means. This is what made the success of the treatment of "*Holland 1*" so interesting and important.

The secret of Fertan's success lies in

the fact that you don't have to remove all the corrosion to beat speedy "flash rusting". Fertan reacts *with* the corrosion products and converts them to a passive insoluble organometallic compound. All you have to do is thoroughly wet the surface — even with acid rain — and apply the Fertan with a brush, a paint roller, or an airless sprayer. The conversion process starts virtually before your eyes, and in a matter of 24 to 48 hours the reaction is complete.

Interestingly enough, there are problems associated with Fertan's very efficiency. Scientists still cannot explain every aspect of the complex chemical reactions which occur, but Cmdr. Compton Hall put one potential problem very clearly. In a 1984 letter to Vice Admiral Sir Patrick Bayly of the Maritime Trust concerning the potential use of Fertan in salvaging the famous U.S.S. *Monitor*, he wrote, "The only word of warning is, perhaps, obvious: it (Fertan) really does turn rusty and corroded parts into something as hard as the original metal, and it is important to avoid treating ragged spikes in the way that I did on some parts of "*Holland 1*". Such spikes subsequently become a metal-grinding job if it is desired to smooth them down! . . it works, one might say, all too well on all surfaces . . ."

There are other products which are based partly on tannins; but, unlike Fertan, they also contain a synthetic resin. These resins tend to undermine the effectiveness of total passivation and function only as a primer.

In order for the passivation or corrosion-product conversion process to be completed, oxygen must continue to reach the surface. Resin and solvent-based "converters" tend to form a skin, excluding oxygen and preventing completion of the conversion. Because of their formulae and solids' content, the resin-based products do not penetrate as effectively as Fertan, which is based on water. Some resin-based products cannot be used on heavy rust, wet rust, or soluble rust.

Resin-based products may also have limited shelf life and pot life (i.e. they deteriorate in their containers before use and after partial use). Some may also be toxic and flammable.

If it is found that a treatment has not resulted in complete rust conversion, Fertan may be reapplied *ad infinitum*, but with the resin-based products the skin or film formed makes reapplication impossible.

In these days of an increasing consciousness of the importance of preventing pollution and of reducing the toxicity of chemical products, it is also refreshing to learn that tests carried out in 1983 showed that Fertan is of very low toxicity even to such sensitive species as plaice and brown shrimp.

For the practically minded, Fertan has a coverage of 8-10 m^2/litre, and for small quantities, costs in North America very roughly equal $6.00 per litre.

Once the total rusted surface has become black and is completely dry, one simply removes all residual black dust and then paints over the black with a complete normal paint system.

Having seen the results, one could almost believe in "alchemical miracles", but this rust fighter is a real ally for us in the war on rust.

OPINION, *(cont'd from p.3)*

With the renewed support and funding from Congress in 1987, the Service is continuing the inventory of historic maritime resources. Inventories will be completed for the remaining categories of resources with the exception of the intangibles. In addition, standards and guidelines for the preservation treatment and maintenance of historic vessels will be completed.

Standards and guidelines for recording and documenting historic vessels and shipwrecks will be prepared as part of the manual for the documentation of historic maritime resources. The HABS/HAER documentation of the 1886 steel-hulled square-rigged ship *Balclutha* (at the National Maritime Museum, San Francisco) and the 1776 gundelo *Philadelphia* (at the National Museum of American History in Washington, D.C.) will provide the final model for drafting these standards and guidelines. The Service will also prepare standards and guidelines for documenting historic shipwrecks.

Standards and guidelines for restoration, preservation treatment, and maintenance of historic vessels are being prepared under the direction of Service professionals. This document will be similar to the Service's own standards document, NPS-28. Advice and assistance in preparing this document is being sought from the maritime preservation community. The preparation of the Historic Structure Report on the National Historic Landmark vessel *Wapama* and the Condition Surveys for the other ships in the National Maritime Museum's collection are also providing needed data and experience in developing ship-preservation standards.

Working advisory committees for other categories of maritime resources, such as that established to begin the evaluation of preserved historic vessels, will be established by the Trust to review and advise on preservation priorities, standards, and guidelines. The Trust will continue to facilitate the involvement of the maritime preservation community and to cooperate with the Service on a variety of issues.

With the development of the inventories of historic maritime resources, the public awareness and understanding of the nation's maritime heritage will be enhanced. In this way too, Congress can respond with understanding to the requests for funding the "real" work of maritime preservation.

Although much remains to be done, identifying the needs and developing uniform standards for meeting those needs will be a major achievement. Above all, we have learned we are not alone in our needs, our concerns, and our caring. We look forward to getting on with the challenge.

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Product Description Sheet

The information in this document is for reference only.

For specific application queries please contact us.

Maintenance & Repair Operations

Fertan® Rust converter and remover

US patent 4,293,349, Euro patent 87113303.9

German patent 387259-6-08

PRODUCT DESCRIPTION

Fertan® Rust converter is brown aromatic liquid (sg 1.18) that is applied to metal to remove rust,
protect the surface and act as a primer for any finish coat.

TYPICAL APPLICATIONS

All steel and iron including:

Ship maintenance
Cranes
Fencing, railing, gratings
Trucks, trailers, cars
Storage tanks, pipe-work
Bridges
Structural steel
Agricultural equipment
inter-machining coat

TYPICAL PROPERTIES OF UNCURED MATERIAL

Appearance: Glossy brown
Odour: Aromatic
Specific Gravity: 1.18
Viscosity: water like
Flash Point: None
Coverage: 1 litre - 12 sq. metre

AGING

Shelf life in excess of 15 years when closed

TYPICAL ENVIRONMENTAL RESISTANCE

Fertan® Rust Converter is designed to be the best converter and remover of rust to provide a surface suitable for overcoating. Depending on the environment Fertan® will provide resistance to further rust for up to 6 months without painting (environment dependent).

APPLICATION AND USE

Surface Preparation

Old Steel:
Loose rust and scale should be removed. Firmly bonded rust is welcome.
Fat, oil, silicon and dirt should be removed.
Loose rust, mill scale and oil paint may be removed by any appropriate method (manua or power wirebrushing, chipping, ehpwj, peening) followed by rinsing with water to remove residues.

Fat etc. may be removed by detergent or degreaser and the surface should be rinsed.

Rust Conversion Time and Surface change:

One coat of Fertan® Rust converter is recommended. The metal surface should be damp prior to application.
Over a period of 12 hours the rust on the surface will become black.

Directions for Use

1. Remove loose rust and grease as described above.
2. Dampen metal surface
3. Mixing is not required as Fertan® does not suffer from sedimentation.
4. If applying by brush or sponge pour Fertan® into a suitable clean container.
5. Use of gloves is recommended.
6. Apply liberally by brush or sponge or airless spray
7. All rusted areas will turn black over the next 12 - 24 hours (moisture & temp dependent).
8. In dry conditions the surface should be dampened with a light water mist after an hour to maximise effectiveness
9. If any rust has not converted apply more Fertan® at any time.
10. The reaction continues for 36 hours. This provides the maximum performance. **Important**. Wipe down or wash surface with low pressure water to remove the loose black dust that will be present. This is rust too loose to bond.
11. When the surface is dry paint/coat as normal.
12. Brushes, sponges and spray equipment should be cleaned with water, preferabl within a few hours.

Hints and Precautions for Use

Loose rust and scale should be removed. Firmly bonded rust is welcome.
Loose rust, mill scale and oil paint may be removed by any appropriate method (manua or power wirebrushing, chipping, ehpwj, peening) followed by rinsing with water to

remove residues.

Fat, oil, silicon and dirt should be removed by detergent or degreaser and the surface should be rinsed.

The metal surface should be damp before application and, on hot dry days, should be dampened again after an hour

Application Conditions

Fertan® Rust Converter should be applied when the air and surface temperature is above 1ºC and below 30ºC. The reaction will continue for up to 48 hours at lower temperatures. In high temperatures and low humidity ensure the surface stays damp.

Fertan® may be applied in fog, mist or light rain.

Equipment and methods

Fertan® may be applied by brush, sponge, roller or spray. Spray application is recommended for large areas. Airless spray equipment is fast and provides more effective conversion due to improved surface penetration. Conventional air-spray equipment may be used.

Fertan® may be thinned with 5%-10% water to alter spray characteristics.

Cleaning up.

Wash brushes and equipment with water. Rinse adjacent painted surfaces with water. Some light coloured paints may take a stain from Fertan so it is easiest to remove it promptly.
Wash hands and skin with soap and water. We do recommend gloves.

Fertan will stain clothing. Prompt washing in large quantities of cold water and mild detergent may remove the marking.

Fertan® spilled into the environment should be washed down with water.

Resistance to Moisture Solvents & Chemicals

Once Fertan® has converted the rust the converted rust is tannated iron that will not rust. If the surface is to be in contact with anything other than the normal atmosphere of air and moisture we recommend that the surface should be overcoated with appropriate paint systems.

Fertan® has always worked well with **all** surfacing products. It is responsible to recommend that a trial area should be tested.

Container Sizes

30ml car scratch repair
250ml handspray, household/restoration
1 litre
5 litre general maintenance
20 litre
50kgs
1000kgs

Storage
Store material in original container. Store between 1ºc to 30ºC (34º to 90ºF). Protect from freezing. When stored under these conditions, a shelf life exceeding 15 years ma be expected.

Note
The data contained herein are furnished for information only and are believed to be reliable. We cannot assume responsibility for the results obtained by others over whos methods we have no control. It is the user's responsibility to determine suitability for th user's purpose of any production methods mentioned herein and to adopt such precautions as may be advisable for the protection of property and of persons against any hazards that may be involved in the handling and use thereof.

Appendix C — Reports of Completed Works, Harbor Defense Maps.

U.S. Army Corps of Engineers Reports of Completed Works.

- Old Mine Casemate (1911). June 30, 1921.
- New Mine Casemate (1921). June 30, 1921.
- Supplemental Report, Gas Proofing Addition. May 10, 1943.
- Supplemental Report, Cable Gallery. October 15, 1944.
- Supplemental Report, Plotting Room Addition. September 1, 1945.

New Mine Casemate - Fort Columbia. General Plan View. Drawing, Lee Guidry, Coast Defense Study Group, 1994.

United States Coast Artillery Corps. Harbor Defenses of the Columbia River. Maps.

- Fort Columbia, Edition of April 26, 1921.
- Oregon - Washington Regional Map, edition of May 1, 1946.
- Fort Columbia Detail Map. May 1, 1946.

Appendix C — Reports of Completed Works, Harbor Defense Maps

U.S. Army Corps of Engineers Reports of Completed Works

- Old Mine Casemate [illegible]
- New Mine Casemate [illegible]
- [illegible] Control Station [illegible]
- [illegible]
- [illegible]

New Mine Casemate—Fort Columbia. General Plan [illegible] Drawing, [illegible], Coast Defense Study Group, [illegible]

United States Coast Artillery Corps: Harbor Defenses of the Columbia River Maps:

- Fort Columbia, [illegible]
- Oregon–Washington Regional Map [illegible]
- Fort Columbia Detail Map [illegible]

Obsolete

REPORT OF COMPLETED WORKS - SEACOAST FORTIFICATIONS.
(Fire control or Torpedo Structures)

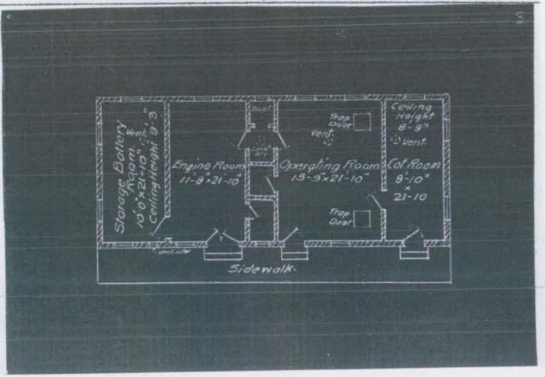
COAST DEFENSES OF...THE COLUMBIA..............
FORT. COLUMBIA, WASHINGTON,...................
STRUCTURE..OLD MINING CASEMATE (1911).........
(Abandoned)

Form 2. Corrected to June 30, 1921.

Location	Behind Rock Knoll, Chinook Point.
Date of transfer	March 30, 1911.
Cost to that date	$5,005.00
Type of construction	Sewell type.
(a) Roof	Wood, asphalt, paper & gravel
(b) Remainder of bld	Wood, plaster & expanded metal.
How concealed	Behind rock knoll.
How protected	Rock knoll.
Height above concealment	None.
Height above protection	None.
Conspicuous at.........yards	Visible from above and rear only.
Source of electric current	Central Power Plant.
Kilowatts required	1.0 kw.
Type of lighting fixtures	Ceiling & wall, common commercial.
How heated	Stove.
Connected to water mains	Yes.
Connected to sewer	Yes.
Type of latrine	Syphon.
Permanent or temporary installation	Permanent; replaced with new structure in 1921.
Present condition	About 14' above M.L.L.W.
Reference of site	
Reference of instrumental axis	
Type of observing inst.	
Type of plotting board	
Type and capacity of crane	
Max. dimensions of reel handled	

See Form 2, corrected to June 30, 1921, Structure, New Mining Casemate (1921)

Type of data transmission	
Date of transfer	
Cost of data transmission equipment	
For tide stations give description of tide gauge	
For datum points give Forts from which visible	
For dormitories give stations served	
For cable hut give S. C. type	



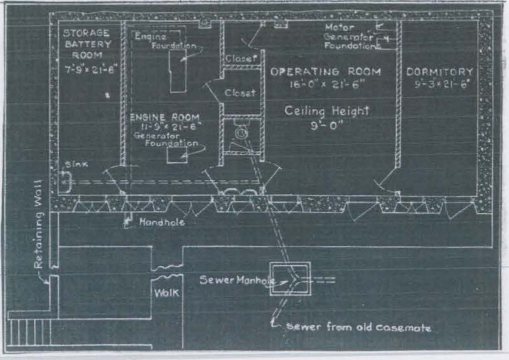
REPORT OF COMPLETED WORKS - SEACOAST FORTIFICATIONS.
(Fire control or Torpedo Structures)

COAST DEFENSES OF..THE COLUMBIA.............
FORT. COLUMBIA, WASHINGTON,..................
STRUCTURE. NEW MINING CASEMATE (1921),........

Form 2. Corrected to June 30, 1921.

Location	Behind rock knoll, Chinook Point.
Date of transfer	February 5, 1921.
Cost to that date	$17,213.79.
Type of construction	Bombproof.
(a) Roof	Reinforced concrete.
(b) Remainder of bld	Plain concrete.
How concealed	Dug into rear of rock knoll, with earth cover.
How protected	Rock knoll in front & on sides; reinforced concrete roof with earth cover.
Height above concealment	None.
Height above protection	None.
Conspicuous at.........yards	Rear visible from above; also about 500 yds. from rear.
Source of electric current	Central Power Plant.
Kilowatts required	1.2 kw.
Type of lighting fixtures	E.D. Standard.
How heated	Stoves.
Connected to water mains	Yes.
Connected to sewer	Yes.
Type of latrine	Syphon.
Permanent or temporary installation	Permanent.
Present condition	Good.
Reference of site	About 14' above M.L.L.W.
Reference of instrumental axis	
Type of observing inst.	
Type of plotting board	
Type and capacity of crane	
Max. dimensions of reel handled	

Type of data transmission	
Date of transfer	
Cost of data transmission equipment	
For tide stations give description of tide gauge	
For datum points give Forts from which visible	
For dormitories give stations served	
For cable hut give S. C. type	



Superseded
See supplemental form 2 corrected to 5/10/43

662 (Col. River) CM 44125

REPORT OF COMPLETED WORKS - SEACOAST FORTIFICATIONS
(Fire Control Structures)

Form 2. Corrected to May 10, 1943

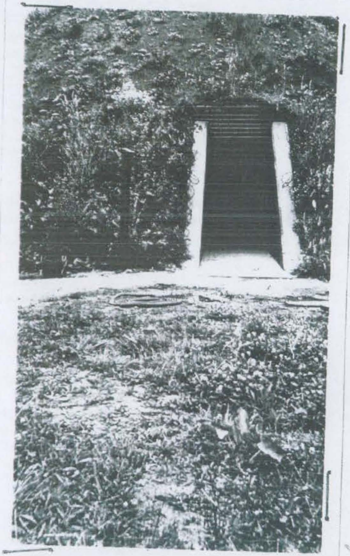
SECRET

HARBOR DEFENSES OF THE COLUMBIA,
FORT COLUMBIA, WASHINGTON.
MINE CASEMATE
(Supplemental Report)

44125

STRUCTURE:

Location	Within U.S. Military Reservation of Fort Columbia, Washington.
Date of transfer	March 31, 1943.
Cost to date of transfer . . .	Of supplemental work: $29,957.12. Original cost $17,213.79
Construction work	This supplemental work consisted of gasproofing and bombproofing of the Mine Casemate at Fort Columbia, Wash.
Gasproofing	To house the gasproofing equip ment, air locks etc. an addition with access tunnels were constructed to the original Mine Casemate. This addition was constructed of reinforced concrete of a 1:2:4 mix. The interior dimensions are 10'-0" x 50'-0" x a ceiling height of 10'-0". The interior walls are 12" thick, the exterior walls are 3'-0" thick and the roof is 5'-0" thick. Air intakes, ventilators etc. are provided for the gasproofing system. The gas-proof doors are fabricated of steel. The access tunnels are constructed of reinforced concrete of a 1:2:4 mix, are 4'-0" wide and have a clearance of 7'-0"; the walls and roof are 12" in thickness. Grill gates are used to close the tunnels.



Info. by TT PADPO 10-61, Dated 3 Oct 44
Electric lts, grinders, drills & other electrical equipment installed by troops. Load requirements as follows:
Lights equip etc 4 KW & 2.5 KW Gasproofing equip on Utility equipment on #210 circuit 4.5 KW

Proj Card 11

SECRET

REPORT OF COMPLETED WORKS - SEACOAST FORTIFICATIONS
(Fire Control Structures)

SECRET

HARBOR DEFENSES OF THE COLUMBIA,
FORT COLUMBIA, WASHINGTON.
MINE CASEMATE
(Supplemental Report)

Form 2. Corrected to May 10, 1943

Bombproofing	In addition to the 5 foot reinforced concrete roofs of the addition and the original structure an embankment of earth was placed over the entire structure. This embankment is 10 feet in depth over the roofs. On this embankment was placed a burster course of concrete. This burster course is 2 feet in thickness and extends over the entire area covered by the casemate. On this burster course was placed 3 feet more of earth embankment for concealment advantages.
Concealment	The entire structure is covered with earth embankment, the slopes of which were finished off in irregular plan. The embankment was planted with grass, sod and brush to conform to the surrounding area.
ELECTRIC CURRENT:	
Source of	Power for lighting of the addition was obtained by extending the circuits of the original structure. Commercial power for Fort Columbia is purchased from P.U.D. No. 2 of Pacific County, Washington.
Kilowatts required	For the additional lighting amounts to 1.8 kw.
Type of lighting fixtures	Are incandescent lamps in porcelain lamp receptacles.
HEAT, WATER & SEWER	No additional facilities were provided in connection with this supplemental work.
REMARKS	This supplemental work on the Mine Casemate was accomplished by Government forces with funds from P/A, Eng.-341 P 14 A 1204-12 and from P/A, Eng.-184 P 14 A 1205-N. Construction work was started November 1, 1941 and was completed, in-so-far as the Engineer work is concerned, on January 31, 1943. For construction details see plans DMCR 938.1, 938.2 and 960.

SECRET

WAR DEPARTMENT

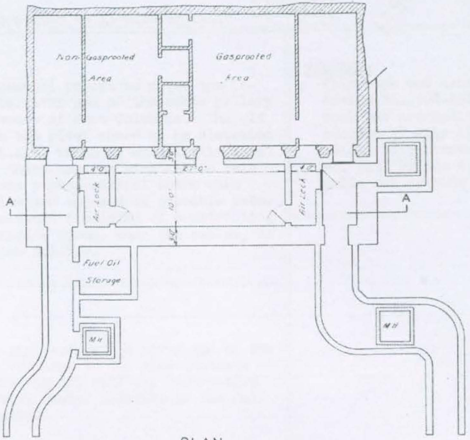
CORPS OF ENGINEERS, U. S. ARMY

HARBOR DEFENSES OF THE COLUMBIA
MINE CASEMATE
FORT COLUMBIA, WASH.
MAY. 1942
SCALE 1/16"=1'-0"

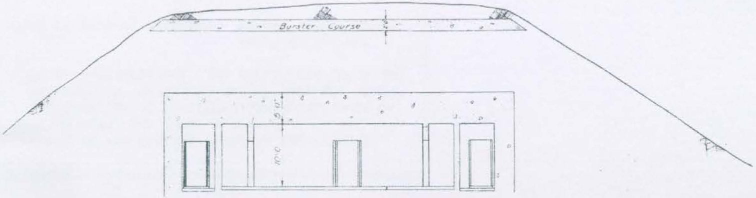
U. S. ENGINEER OFFICE, PORTLAND, OREGON, DISTRICT
Submitted — Senior Engineer
Recommended: — Principal Engineer
Approved May 20, 1942 — Lt Col., Corps of Engineers
Drawn WFH
Traced WFH

FOR DETAILED PLANS SEE DMCR 9381-9382-960

SECRET



PLAN



SECTION A-A

SECRET

600.914 (Col Riv) 119662

REPORT OF COMPLETED WORKS - SEACOAST FORTIFICATIONS

Part II   Corrected to 15 October 1944

SECRET

119662

HARBOR DEFENSES OF THE COLUMBIA
FORT COLUMBIA, WASHINGTON
MINE CASEMATE
(Supplemental Report)

Control Approval Symbol SPEKM-1

GENERAL:

This is a supplemental report to cover the improvements to the river end of the cable gallery to the Mine Casemate at Fort Columbia. The old gallery ended on the river shore at an elevation of + 4 feet, M.L.L.W. which is at a little less than half tide; therefore the mine cables laid on the river shore rocks, several hours each tide, in full view and exposed to possible sabotage. The improvement consisted of constructing a protective concrete apron, over the cables, to an elevation below M.L.L.W.

STRUCTURE:

Location: This work was on the river end of the cable gallery entrance to the Mine Casemate which is located in the Military Reservation of Fort Columbia, Harbor Defenses of The Columbia, Washington.

Date of transfer: Of this supplemental work, 22 September 1944.

Cost to date of transfer: Of the supplemental work, $2,197.80.

Type of construction: The protective apron and the manhole, providing access into the apron, are constructed of reinforced concrete of a 1:2:4 mix. For construction details and dimensions see drawing numbered DMCR-1182.1.

Incl 1

ED Form A-162B
16 Sept. 1943

ESD

REMARKS:

This work was constructed with funds having Advise No. 508-1341 P 220 A 0905-25 (GF). The work was accomplished by Government forces; was started 17 July 1944 and was completed 19 Aug. 1944. This construction was designated Project No. 3153 by the W.D.C. For construction details see drawing numbered DMCR-1182.1.

SECRET

Control Approval Symbol SPEKM-1

STRUCTURE:

General: This supplemental report is made to cover the construction of a second addition to the Mine Casemate; this second addition is a mine Plotting Room. Enough of the earth embankment was removed from over/and in front of the casemate to permit the construction of the plotting room as an addition to the casemate. In view of the possibility of a switch board room being built on, as still yet another addition, the reinforcing of the footings, walls, and roof of the plotting room were left protruding to act as dowels; also on the roof a 12" ledge was left on which to rest the roof of a future construction. After completion of the addition the earth embankment was replaced to its original shape.

Location: Is within the U.S. Military Reservation of Fort Columbia, Washington.

Date of transfer: Of this supplemental project, 28 July 1945.

Cost to date of transfer: Of this supplement project, was $14,698.79.

Type of construction:
- Roof: Is constructed of reinforced concrete of a 1:2:4 mix and is 4'-0" in thickness.
- Remainder of addition: Is constructed of reinforced concrete of 1:2:4 mix. The walls are 3'-0" and the floor is 10" in thickness. The walls are set on reinforced concrete footings 7'-0" wide by 1'-6" thick. The interior dimensions of this plotting room are 20'-0" x 23'-6" with a ceiling height of 10'-0". The gasproofing of this room was accomplished by extending the decontamination system from the original structure.

Concealment: The entire structure is covered with earth embankment, the slopes of which were finished off in irregular plan. The embankment was planted with grass, sod and brush to conform to the surrounding area.

UTILITIES:

Electric power:
- Source: Power for the addition was obtained by extending the circuits of the original structure. Commercial power for Fort Columbia is purchased from P.U.D. No. 2 of Pacific County, Washington.
- Characteristics: Voltage of 110 or 220 Ac, 3 phase.
- Kilowatts required: For the additional installations, 5.0 KW.
- Type of lighting fixtures: Four fixtures of 4-48" fluorescent lights.

Heat: Heat for the plotting room is provided by 2, 2000 watt, 220 volt, electric, wall-type heaters.

Water and sewer: No additional facilities were provided in connection with this supplemental work.

ED Form A-162B
16 Sept. 1943

INSTRUMENTS & EQUIPMENT:

Type of plotting board: Submarine Mine Plotting Board M9F.

DATA TRANSMISSION:

Type: By telephones, furnished and installed the Signal Corps.

REMARKS:

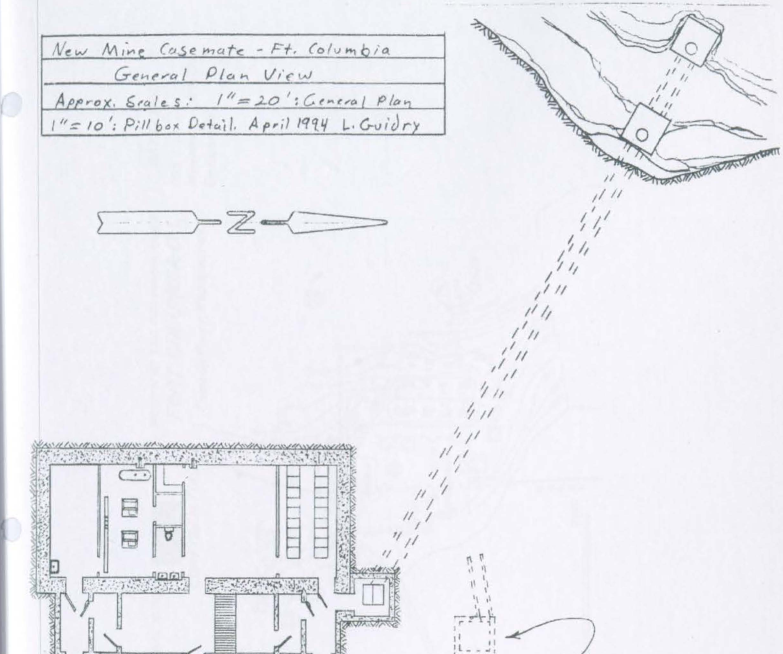
This supplemental work on the Mine Casemate was accomplished by Government forces with funds having advise numbers of 508-2015 P 270 A 212/51204 (SM) and 608-3810 P 270 A 212/61204 (SM). Construction work was started on 12 January 1945 and was completed on 16 July 1945. The work was designated Job No. Ft. Columbia FS-4 by Directive Consecutive Number FS-1594. For construction detail plans see plans numbered DMCR-1188.1 and DMCR-1188.2.

New Mine Casemate - Ft. Columbia

General Plan View

Approx. Scales: 1" = 20': General Plan

1" = 10': Pillbox Detail. April 1994 L. Guidry



LEGEND

1. ADMINISTRATION BLDG.
2.
3 OFFICER'S QUARTERS.
3a SURGEON'S
4. HOSPITAL.
5. " STWD'S. QRS.
6 N.C. OFFICERS QRS.
7 BARRACKS.
8 GUARD HOUSE.
9 POST EXCHANGE.
10. OLD POST EXCHANGE.
11 GYMNASIUM.
12 FIRE APPARATUS HO.
13 RESERVOIR.
14 BAKERY.
15 LAUNDRY.
16 OIL HOUSE.
17 COAL SHED.
18 SHOP.
19 STOREHOUSE.
100 TEAMSTER'S HOUSE.
101. STABLE.
102 WAGON SHED.
103 DEPOT.
104 FORMER SW. BD. ROOM.
105. DORMITORY.
31. ORDNANCE ST. HO.

EDITION OF APR. 26, 1921.

SERIAL NUMBER 124/

CONFIDENTIAL

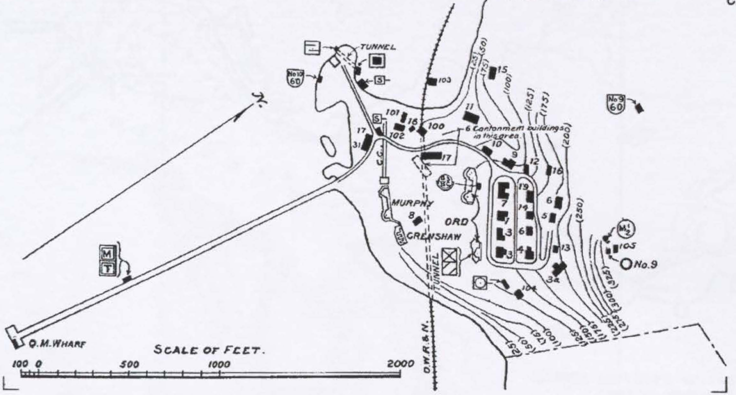
MOUTH OF THE COLUMBIA RIVER

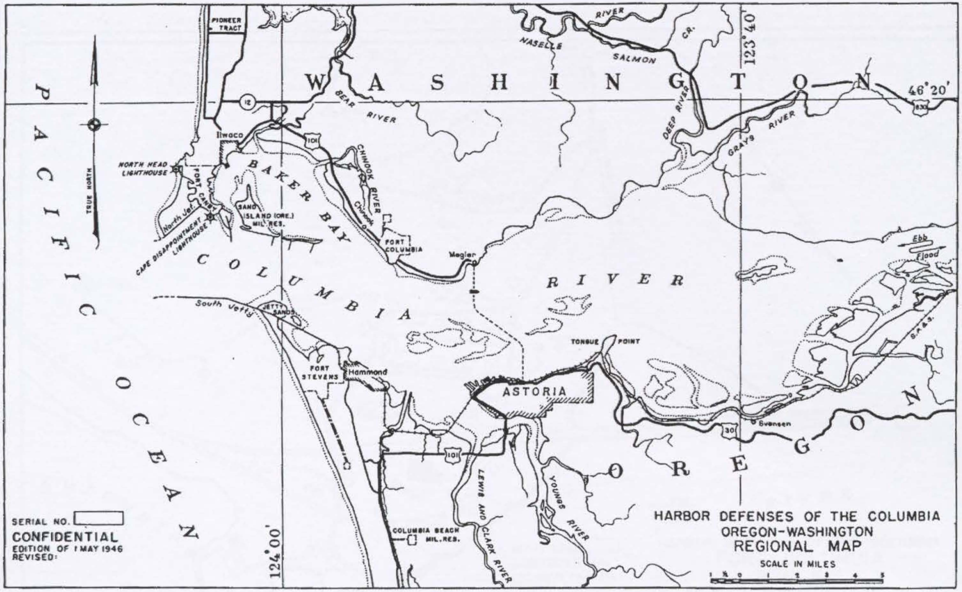
FORT COLUMBIA-D-1.

CHINOOK POINT, WASHINGTON.

BATTERIES

ORD. ....
MURPHY....... 2-6" Dis.
CRENSHAW....



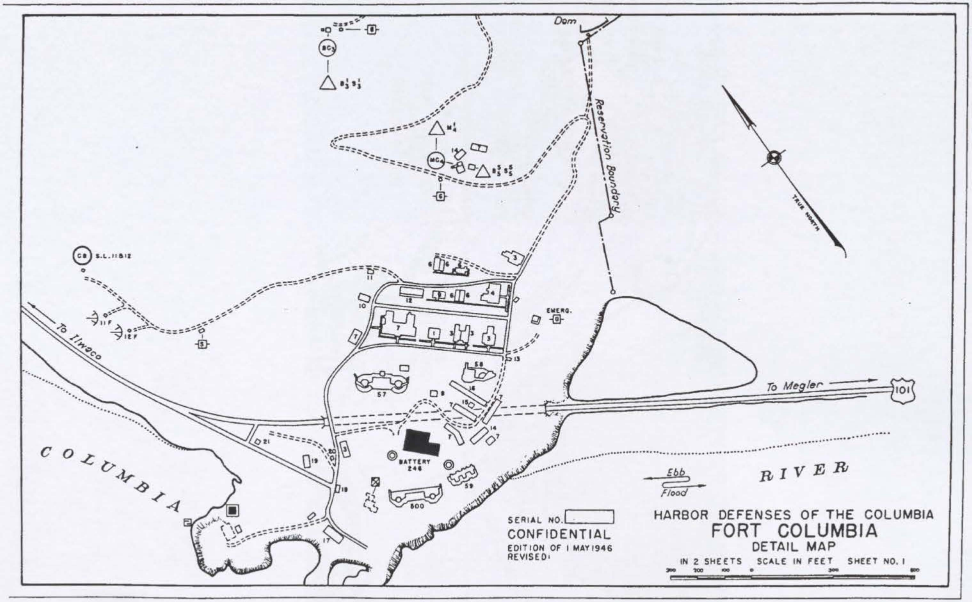


HARBOR DEFENSES OF THE COLUMBIA
OREGON-WASHINGTON
REGIONAL MAP

SERIAL NO. ☐

CONFIDENTIAL

EDITION OF 1 MAY 1946
REVISED:

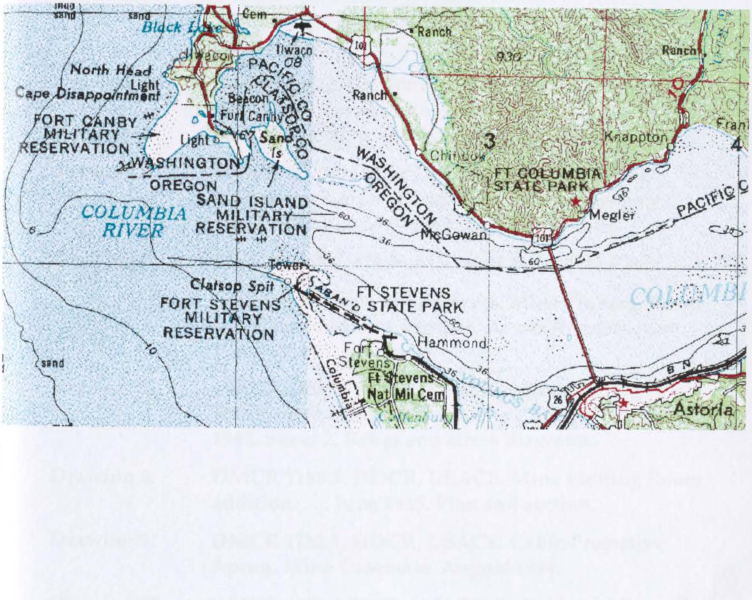


SERIAL NO.

CONFIDENTIAL

EDITION OF 1 MAY 1946
REVISED:

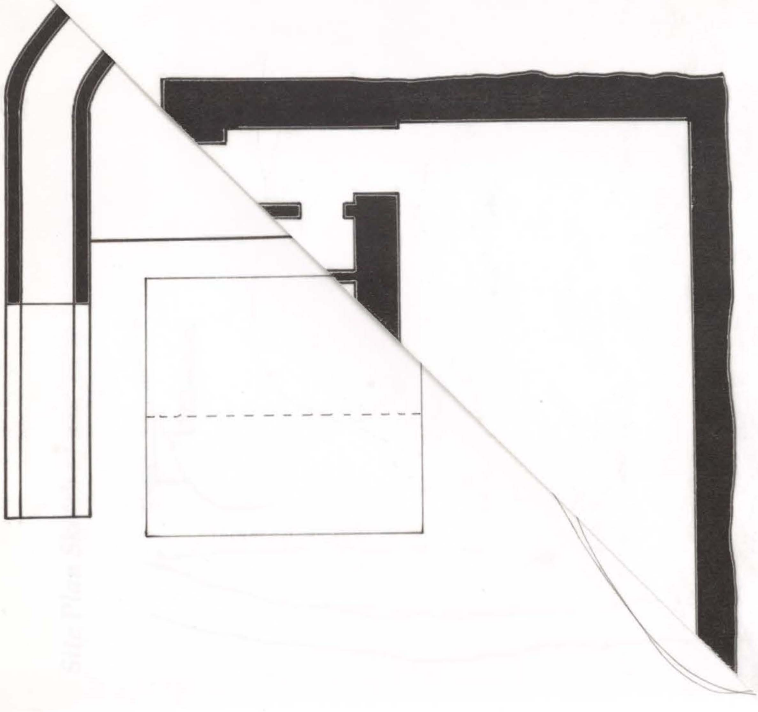
HARBOR DEFENSES OF THE COLUMBIA
FORT COLUMBIA
DETAIL MAP
IN 2 SHEETS SCALE IN FEET SHEET NO. 1


Black Lake
Cem
Ranch
Ilwaco
PACIFIC CO
CLATSOP CO
North Head Light
Cape Disappointment
Beacon
Fort Canby
FORT CANBY MILITARY RESERVATION
Light
Sand Is
WASHINGTON
OREGON
COLUMBIA RIVER
SAND ISLAND MILITARY RESERVATION
101
Ranch
930
Ranch
Knappton
3
4
Chinook
WASHINGTON
OREGON
FT COLUMBIA STATE PARK
Megler
PACIFIC C
McGowan
101
Tower
Clatsop Spit
FORT STEVENS MILITARY RESERVATION
FT STEVENS STATE PARK
Hammond
Fort Stevens
Ft Stevens Nat Mil Cem
Columbia
COLUMBI
B N
26
Astoria
sand
10

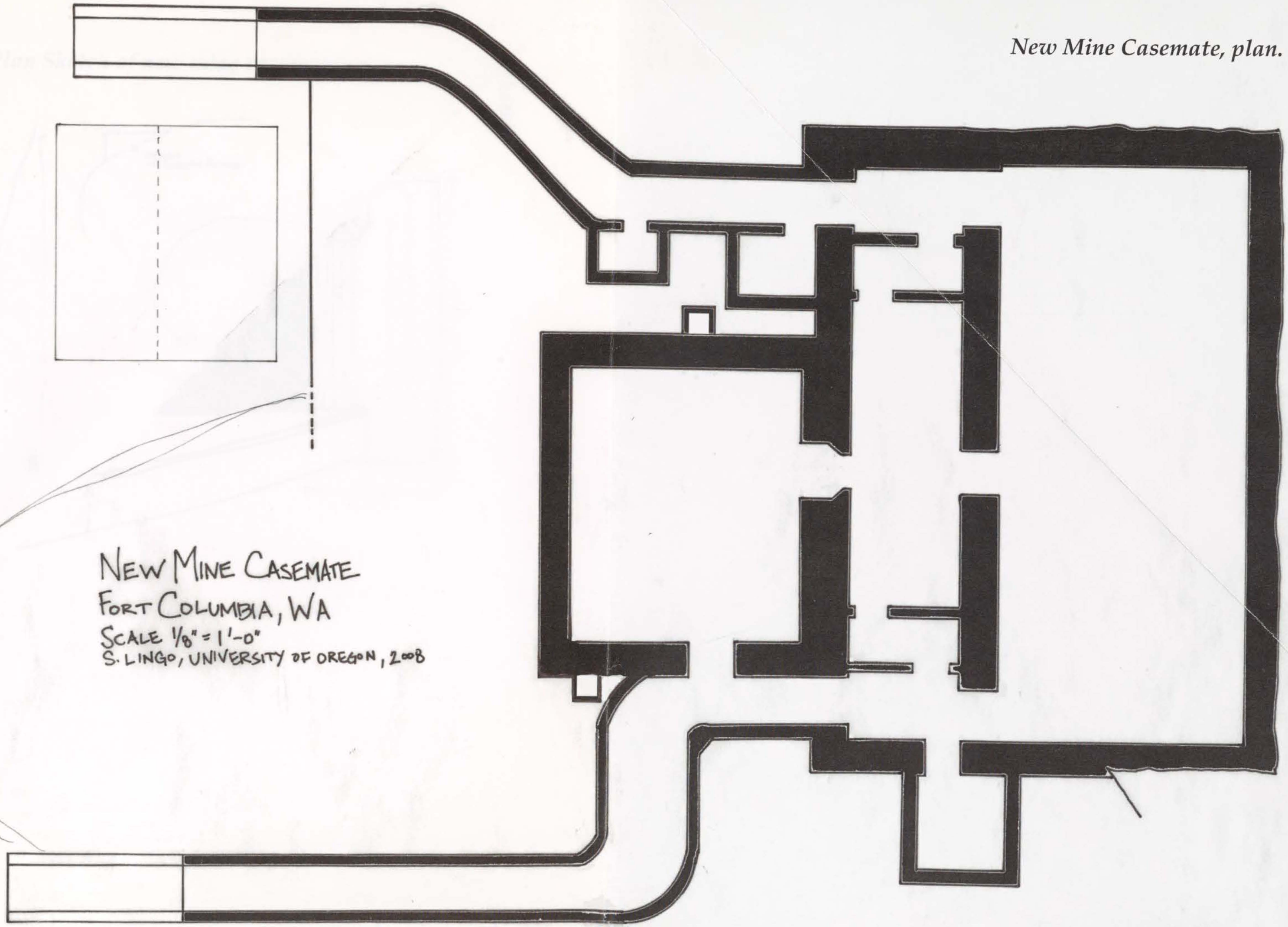
Appendix D - Drawings

Drawing 1.	New Mine Casemate, Fort Columbia, WA. Plan. 1/8″ = 1′-0″. Shawn Lingo, 2008.
Drawing 2.	(Left) Site Plan Sketch. Not to scale. S. Lingo, 2008. (Right) West Gate measured sketch. S. Lingo, Mary Lingo. 2008
Drawing 3.	DMCR 920. Harbor Defense Columbia River, U.S. Army Corps of Engineers. April 1941. Casemate plan and section.
Drawing 4.	DMCR 938.2. Harbor Defense Columbia River, U.S. Army Corps of Engineers. July 1941. Revised plan and section with gas-proofing details.
Drawing 5.	DMCR 1027. Harbor Defense Columbia River, U. S. Army Corps of Engineers. Mine Casemate, Fort Columbia. May 1942. Plan and section.
Drawing 6.	DMCR 1188.1. Harbor Defense Columbia River, U.S. Army Corps of Engineers. Mine Plotting Room Addition to Mine Casemate. As constructed. June 1945. Sheet 1. Electrical.
Drawing 7.	DMCR 1188.2. HDCR, USACE. Mine Plotting Room Addition to Mine Casemate. As Constructed. June 1945. Sheet 2. Rebar and stress diagrams.
Drawing 8.	DMCR 1188.3. HDCR, USACE. Mine Plotting Room addition. . . . June 1945. Plan and section.
Drawing 9.	DMCR 1182.1. HDCR, USACE. Cable Protective Apron. Mine Casemate. August 1944.
Drawing 10.	DMCR 1190. HDCR, USACE. Switchboard Room Addition to Mine Casemate. April 1945.

New Mine Casemate, plan.

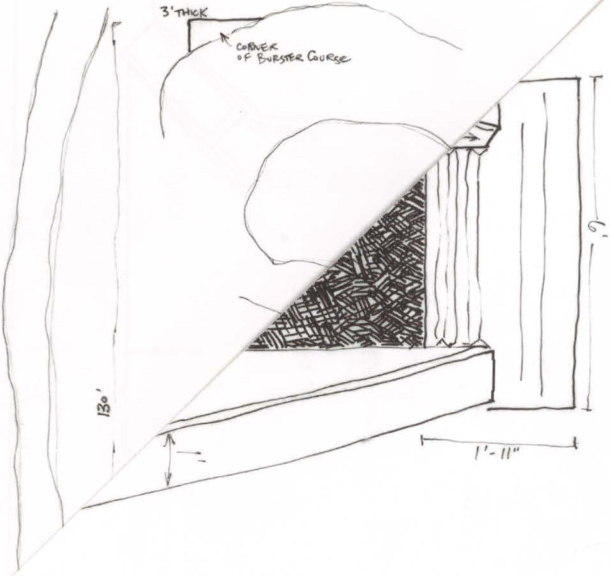


New Mine Casemate, plan.



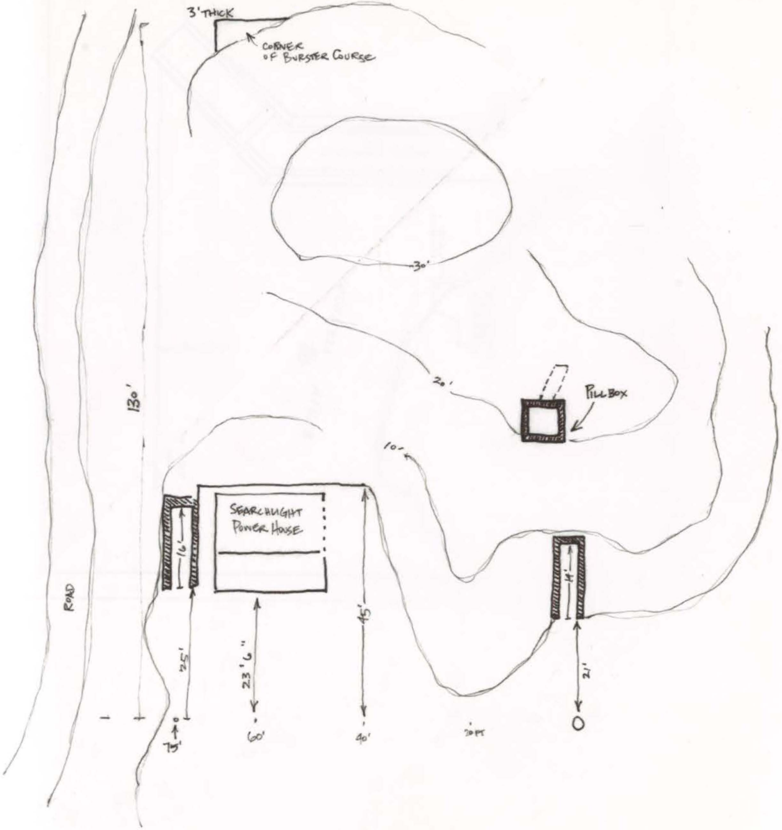
New Plan Geometries
Hans Cedermark, MA
[illegible]
[illegible]

Site Plan Sketch of new mine casemate area.

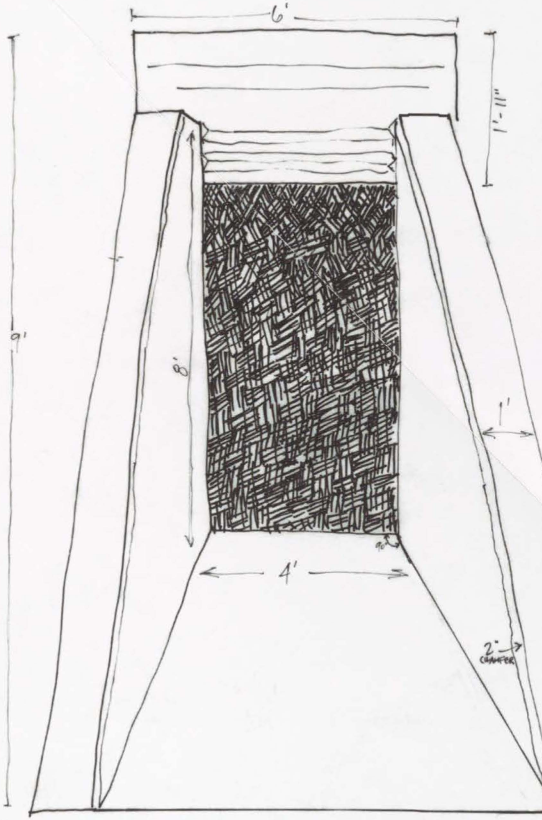


sketch.

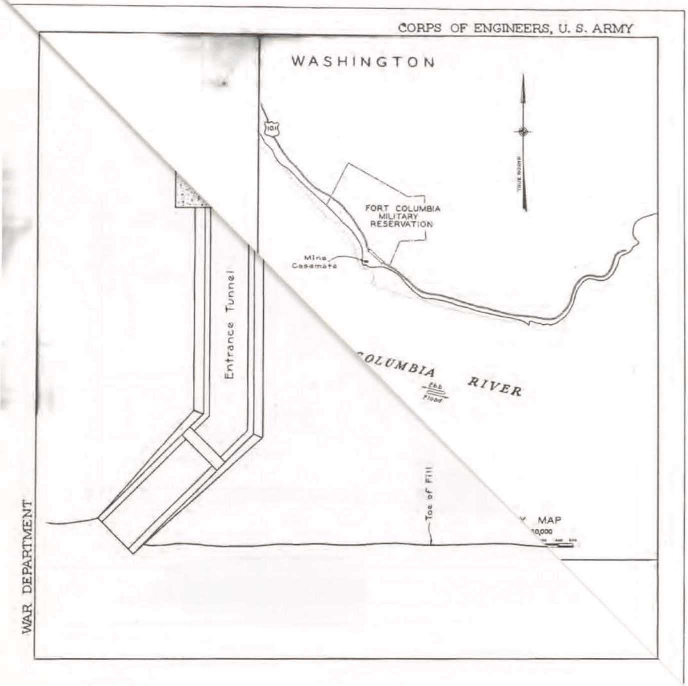
Site Plan Sketch of new mine casemate area.



West gate sketch.

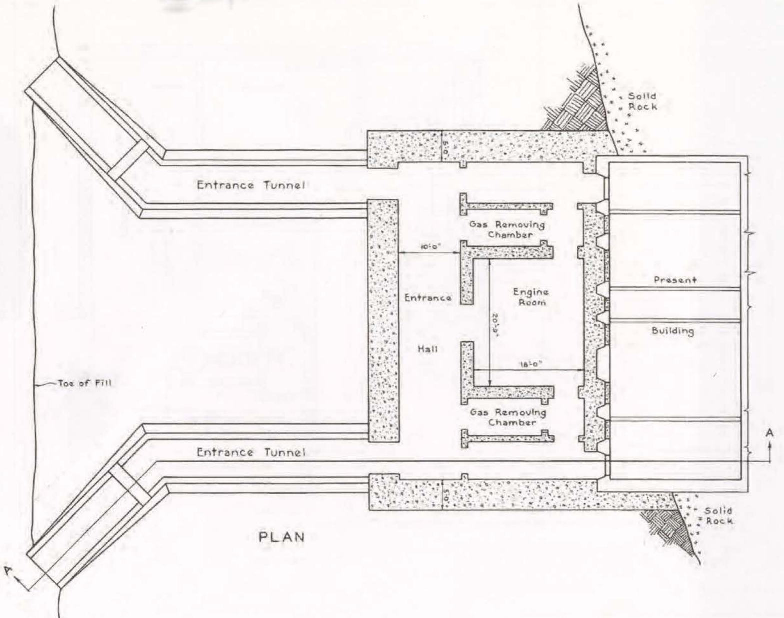


Traced by S. Lingo from Sketch by Mary Lingo. Measurements, S. Lingo

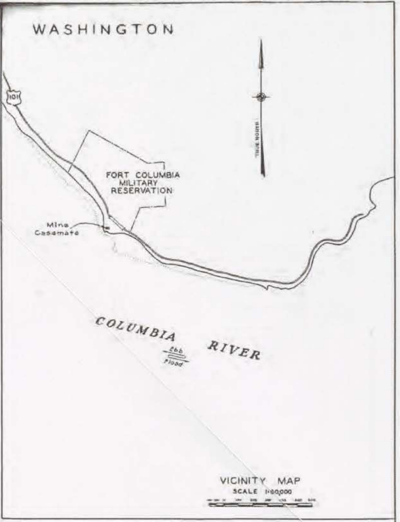

CORPS OF ENGINEERS, U. S. ARMY
WAR DEPARTMENT
WASHINGTON
101
TRUE NORTH
FORT COLUMBIA
MILITARY
RESERVATION
Mine
Casemate
Entrance Tunnel
COLUMBIA
RIVER
Ebb
Flood
Toe of Fill
MAP
10,000

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

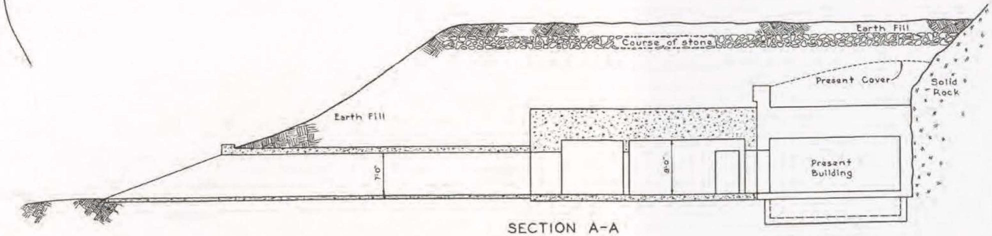


PLAN



VICINITY MAP
SCALE 1:60,000

Note:
Reinforcing is not shown on this drawing.



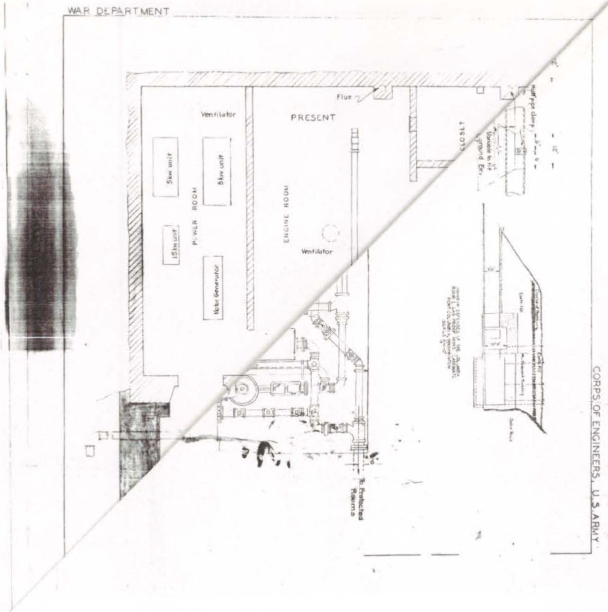
SECTION A-A

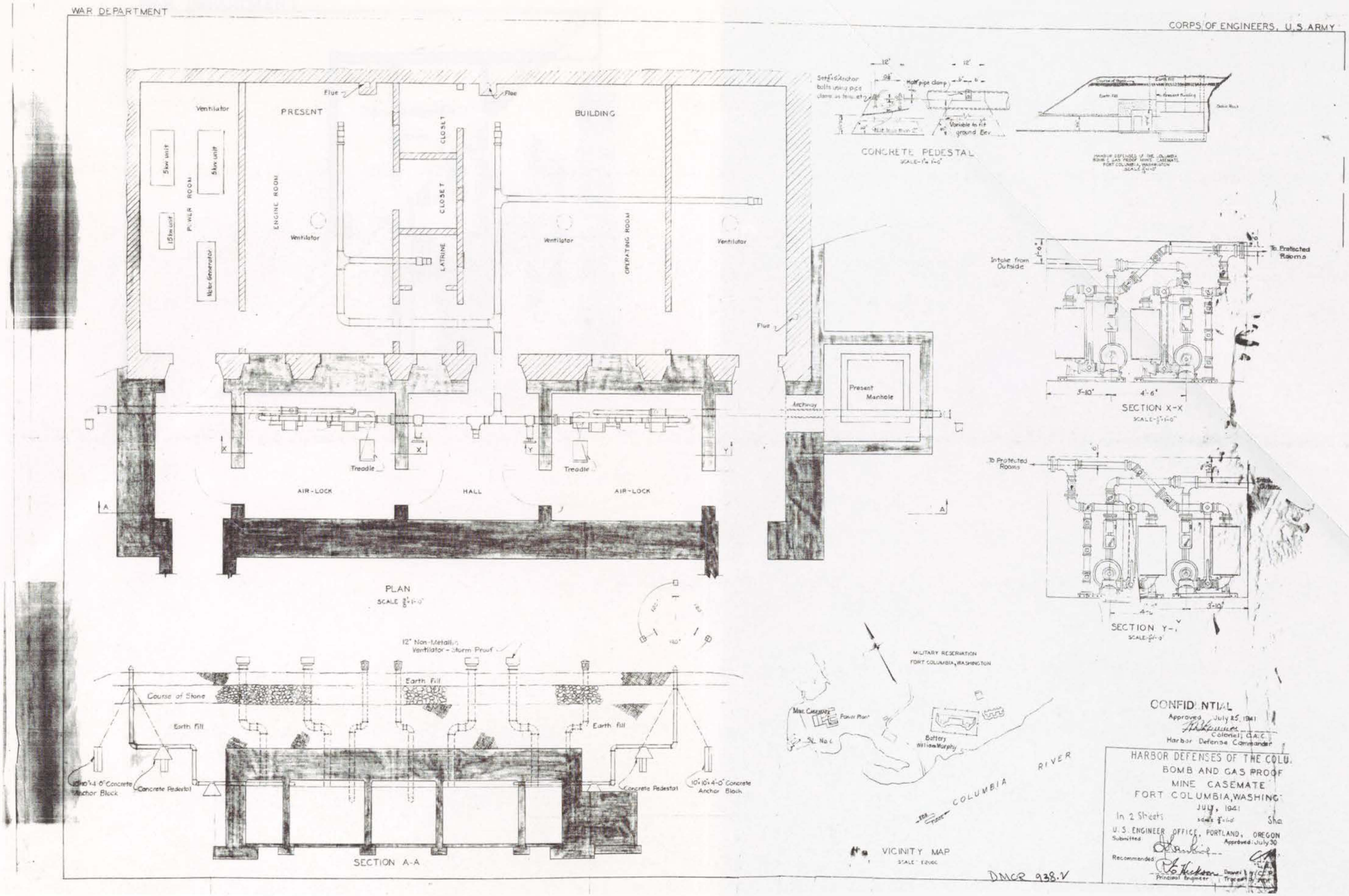
HARBOR DEFENSES OF THE COLUMBIA
BOMB & GASPROOF MINE CASEMATE
AND POWER PLANT FOR S.L. NO. 6
FORT COLUMBIA, WASHINGTON
APRIL 1941
SCALE 1/16"=1'-0"

U.S. ENGINEER OFFICE, PORTLAND, OREGON, DISTRICT
Submitted:
Engineer
Recommended:
Principal Engineer
Approved April 24, 1941
Lt. Col., Corps of Engineers
Drawn by D.L.H.
Traced by W.T.H. Checked

DMCR 920


[illegible] OF THE COLUMN


WAR DEPARTMENT
CORPS OF ENGINEERS, U.S. ARMY
PRESENT
POWER ROOM
ENGINE ROOM
Ventilator
Ventilator
5kw unit
5kw unit
15kw unit
Motor Generator
Flue
CLOSET
Half pipe clamp
To Protected Rooms



CONFIDENTIAL

Approved July 25, 1941

Colonel, C.A.C.
Harbor Defense Commander

HARBOR DEFENSES OF THE COLU
BOMB AND GAS PROOF
MINE CASEMATE
FORT COLUMBIA, WASHING
JULY, 1941

In 2 Sheets
Scale ⅛"=1'-0"
Sha

U.S. ENGINEER OFFICE, PORTLAND, OREGON
Submitted
Approved: July 30
Recommended
Hickson
Principal Engineer
Drawn by C.P.
Traced by

CORPS OF ENGINEERS, U. S. ARMY

HARBOR DEFENSES OF THE COLUMBIA

MINE CASEMATE

FORT COLUMBIA, WASH.

MAY, 1942

SCALE: 1/16"=1'-0"

EER OFFICE, PORTLAND, OREGON, DISTRICT

Approved: May 20, 1942

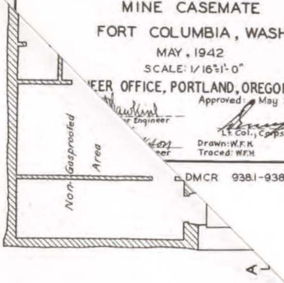
r Engineer

Lt. Col., Corps of Engineers

eer

Drawn: W.F.H.
Traced: W.F.H.

DMCR 938.1-938.2-960



WAR DEPARTMENT

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

HARBOR DEFENSES OF THE COLUMBIA

MINE CASEMATE

FORT COLUMBIA, WASH.

MAY, 1942

SCALE: 1/16"=1'-0"

U. S. ENGINEER OFFICE, PORTLAND, OREGON, DISTRICT

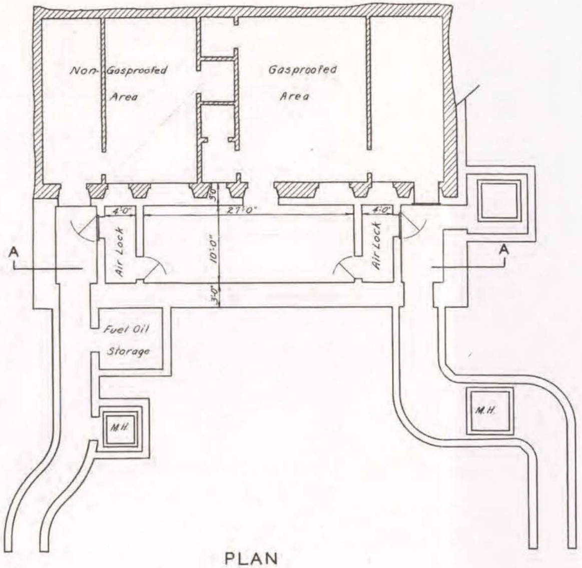
Submitted:
Senior Engineer

Recommended: R.E. Hickson
Principal Engineer

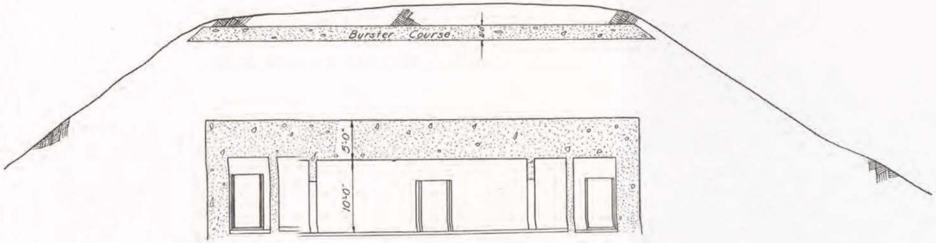
Approved: May 20, 1942
Lt. Col., Corps of Engineers

Drawn: W.F.H.
Traced: W.F.H.

FOR DETAILED PLANS SEE DMCR 938.1-938.2-960



PLAN



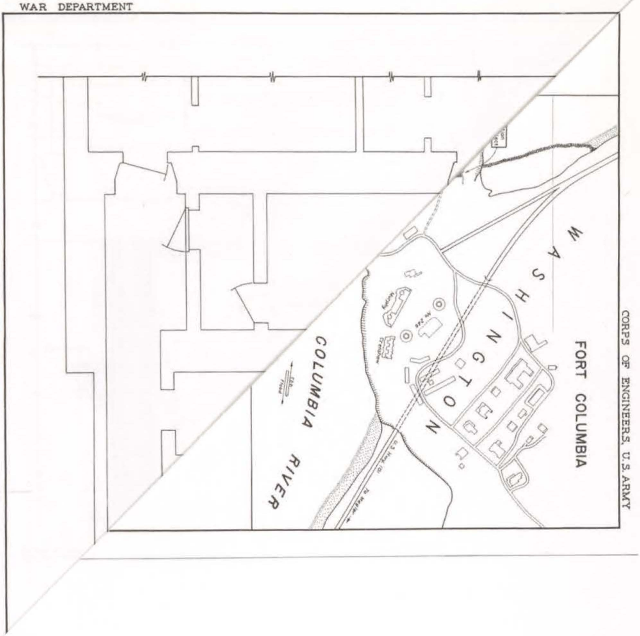
SECTION A-A

D14-5-227

WAR DEPARTMENT

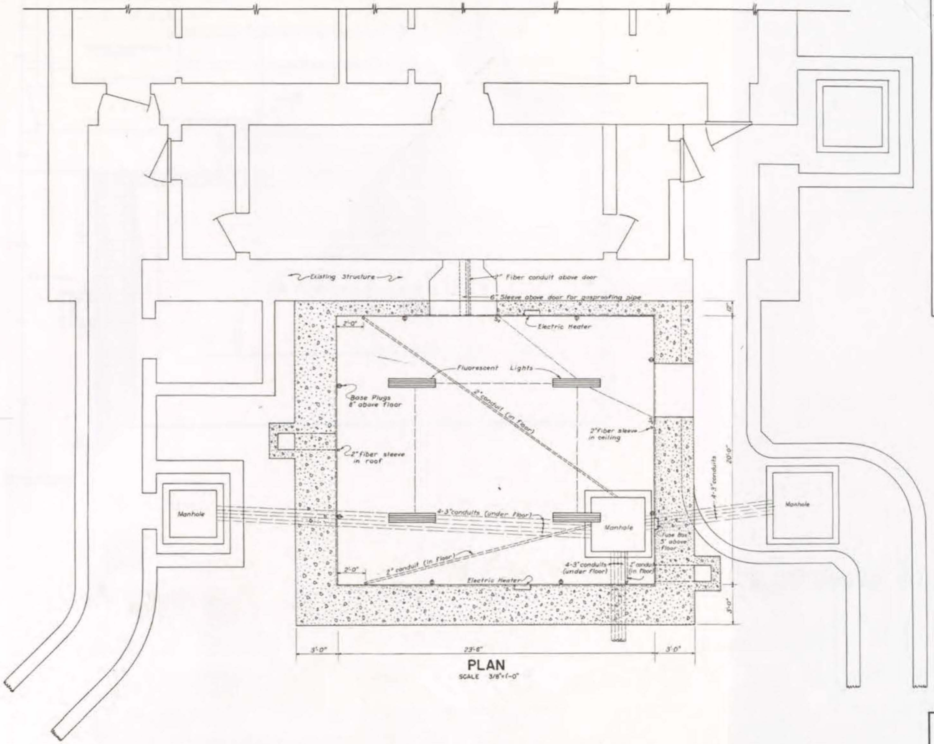
CORPS OF ENGINEERS, U.S. ARMY

FORT COLUMBIA

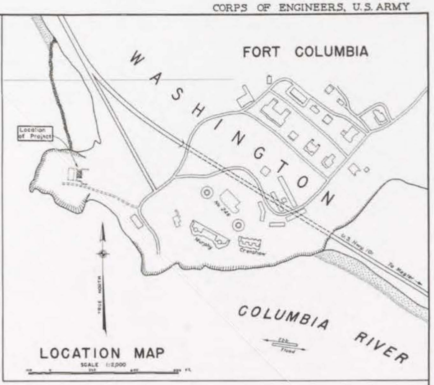


WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY



PLAN
SCALE 3/8"=1'-0"



LOCATION MAP
SCALE 1:2,000

—
5200.10

AS CONSTRUCTED

~~CONFIDENTIAL~~

HARBOR DEFENSES OF THE COLUMBIA
MINE PLOTTING ROOM
ADDITION TO MINE CASEMATE
FORT COLUMBIA, WASHINGTON
IN 2 SHEETS SCALE AS SHOWN SHEET NO. 1

U. S. ENGINEER OFFICE, PORTLAND, OREGON, DISTRICT

SUBMITTED:
SENIOR ENGINEER

RECOMMENDED:
R. E. Hickson
PRINCIPAL ENGINEER

APPROVED: 26 JULY 1943
COLONEL, CORPS OF ENGINEERS
DISTRICT ENGINEER

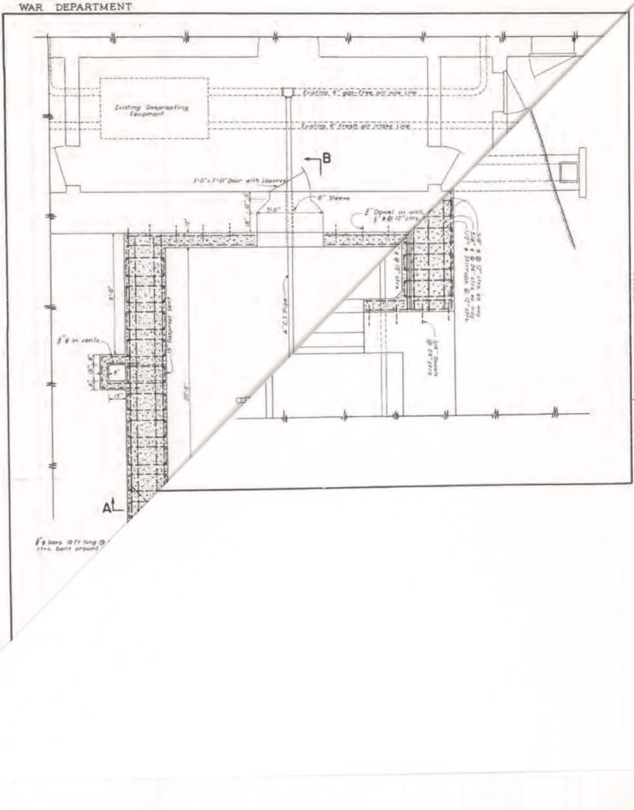
DRAWN BY: MEM DATE: June 1943
TRACED BY: MEM CHECKED BY:

NO.	REVISION	DATE	BY	APR.

Approved:
C.S. Doney
Colonel, C.A.C., Commanding

DMCR 1188.1

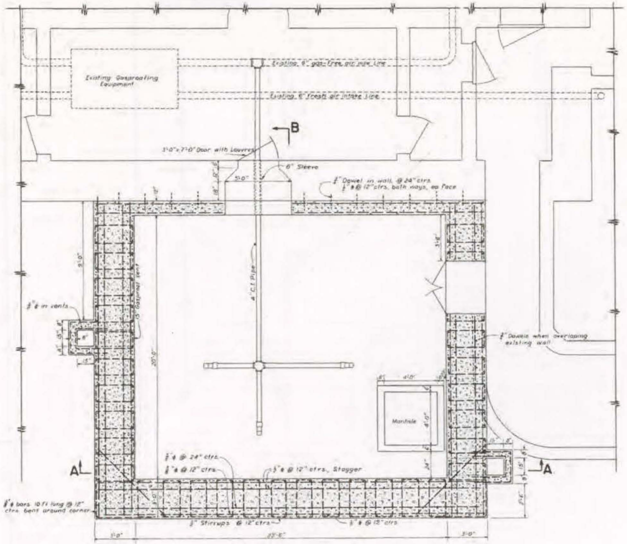
WAR DEPARTMENT



CORPS OF ENGINEERS, U.S. ARMY

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY



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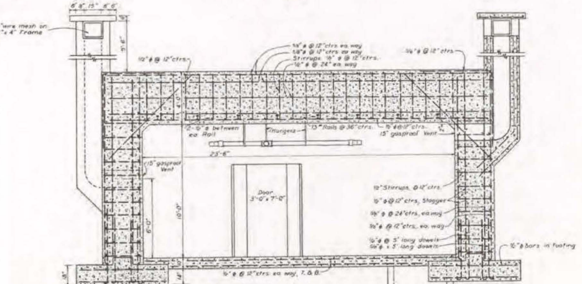
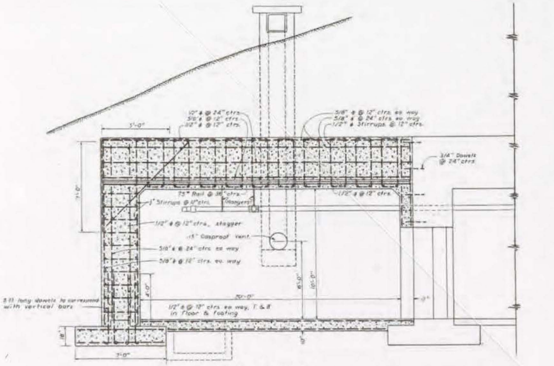
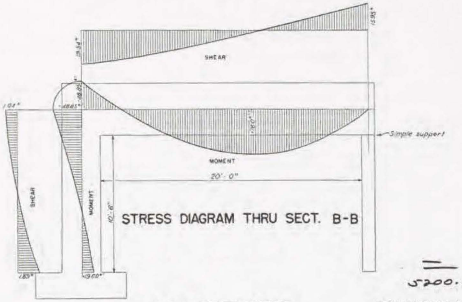


SECTION A-A



SECTION B-B



STRESS DIAGRAM THRU SECT. B-B

5200.10

AS CONSTRUCTED

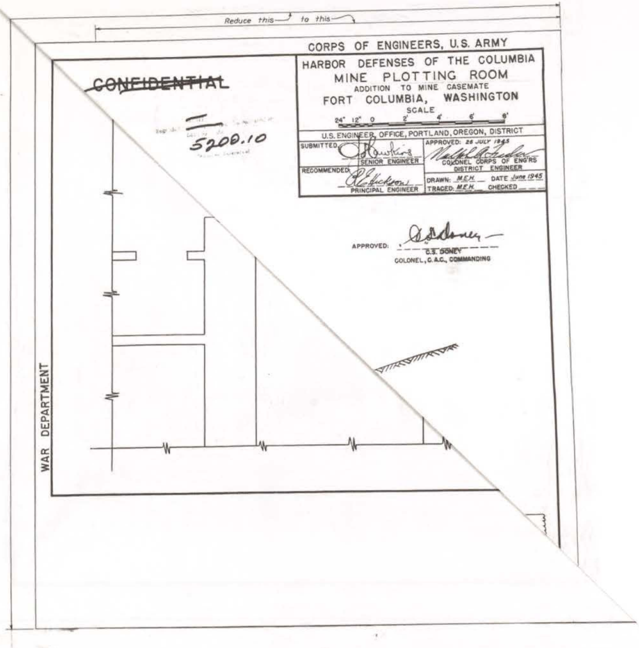
~~CONFIDENTIAL~~

NO.	REVISION	DATE	BY	APP.

HARBOR DEFENSES OF THE COLUMBIA
MINE PLOTTING ROOM
ADDITION TO MINE CASEMATE
FORT COLUMBIA, WASHINGTON
IN 2 SHEETS SCALE 3/8" = 1'-0" SHEET NO. 2
U. S. ENGINEER OFFICE, PORTLAND, OREGON, DISTRICT

Approved: C. S. Doney
C. S. Doney
Colonel, C.A.C.; Commanding

DMCR 1188.2



~~CONFIDENTIAL~~

5200.10

CORPS OF ENGINEERS, U.S. ARMY

HARBOR DEFENSES OF THE COLUMBIA
MINE PLOTTING ROOM
ADDITION TO MINE CASEMATE
FORT COLUMBIA, WASHINGTON

SCALE
24" 12" 0 2' 4' 6' 8'

U.S. ENGINEER OFFICE, PORTLAND, OREGON, DISTRICT

SUBMITTED: Hawkins SENIOR ENGINEER	APPROVED: 26 JULY 1945 COLONEL CORPS OF ENG'RS DISTRICT ENGINEER
RECOMMENDED: Erickson PRINCIPAL ENGINEER	DRAWN: M.E.H. DATE June 1945 TRACED: M.E.H. CHECKED

APPROVED: C.S. Doney
C.S. DONEY
COLONEL, C.A.C., COMMANDING

Reduce this to this

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY

~~CONFIDENTIAL~~

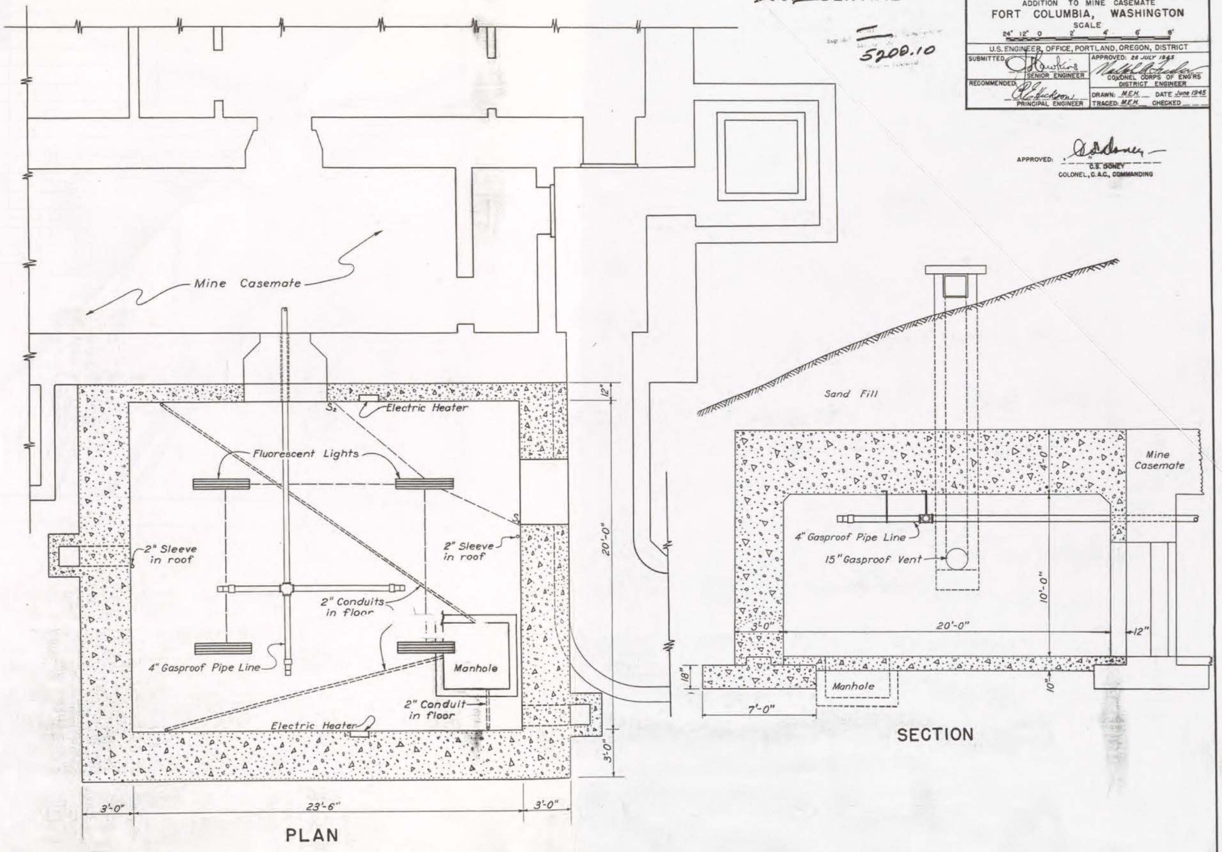
5200.10

HARBOR DEFENSES OF THE COLUMBIA
MINE PLOTTING ROOM
ADDITION TO MINE CASEMATE
FORT COLUMBIA, WASHINGTON
SCALE
24" 12" 0 2' 4' 6' 8'

U.S. ENGINEER OFFICE, PORTLAND, OREGON, DISTRICT

SUBMITTED: J. Hawkins, SENIOR ENGINEER
RECOMMENDED: R. E. Hickson, PRINCIPAL ENGINEER
APPROVED: 26 JULY 1945
COLONEL CORPS OF ENG'RS, DISTRICT ENGINEER
DRAWN: M.E.H. DATE June 1945
TRACED: M.E.H. CHECKED

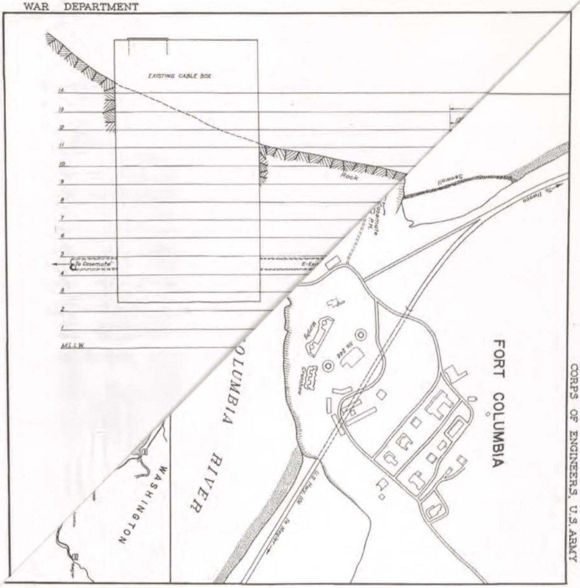
APPROVED: C.S. Doney
C.S. DONEY
COLONEL, C.A.C., COMMANDING



PLAN

SECTION

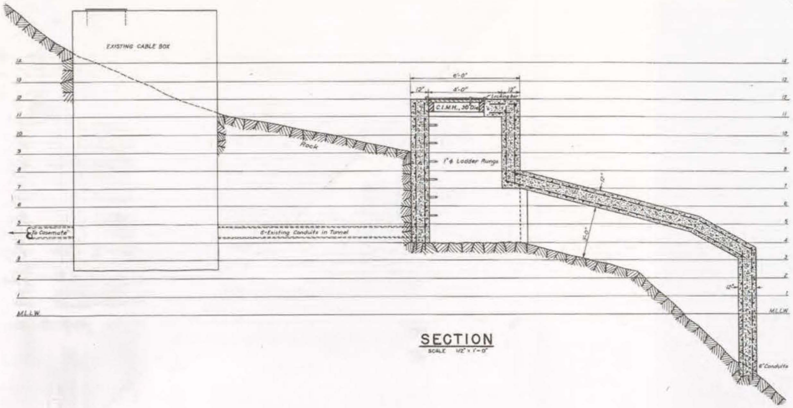
WAR DEPARTMENT



CORPS OF ENGINEERS, U.S. ARMY

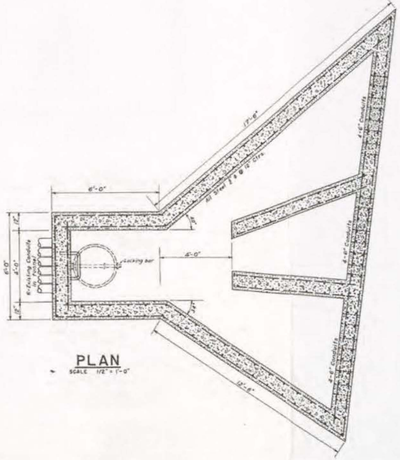
WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY



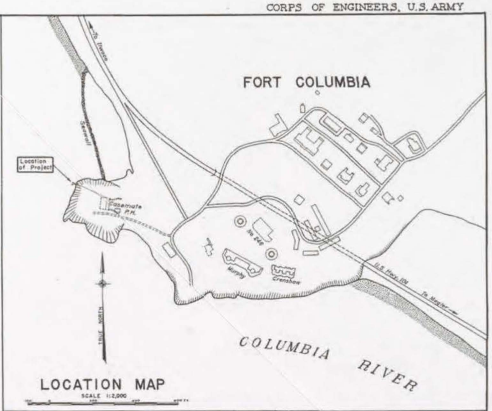
SECTION

SCALE 1/2" = 1'-0"



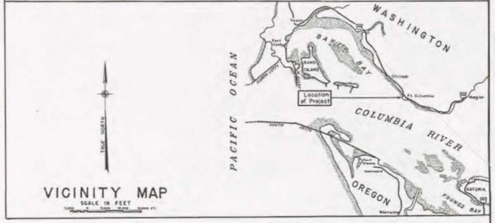
PLAN

SCALE 1/2" = 1'-0"



LOCATION MAP

SCALE 1:2,000



VICINITY MAP

SCALE IN FEET

Approved: C.S. Doney
C.S. Doney
Colonel, C.A.C., Commanding

5200.10

~~SECRET~~

AS CONSTRUCTED

HARBOR DEFENSES OF THE COLUMBIA

MINE CABLE PROTECTIVE APRON

MINE CASEMATE, FORT COLUMBIA, WASHINGTON

SCALE AS SHOWN

U. S. ENGINEER OFFICE, PORTLAND, OREGON, DISTRICT

NO.	REVISION	DATE	BY	APP.

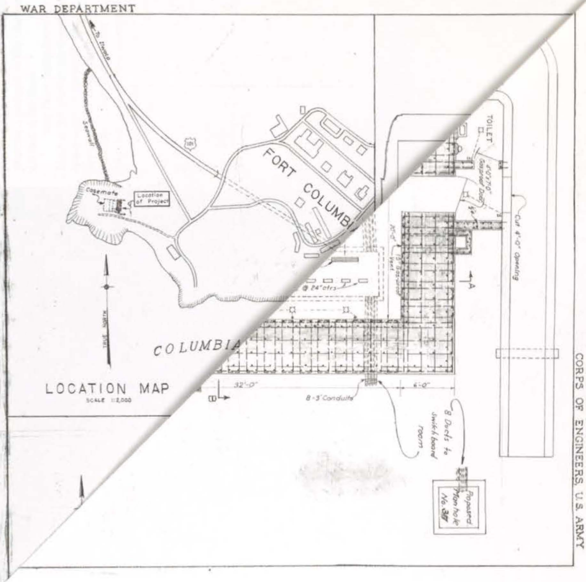
SUBMITTED:
SENIOR ENGINEER

RECOMMENDED:
PRINCIPAL ENGINEER

APPROVED:
COLONEL, CORPS OF ENGINEERS
DISTRICT ENGINEER

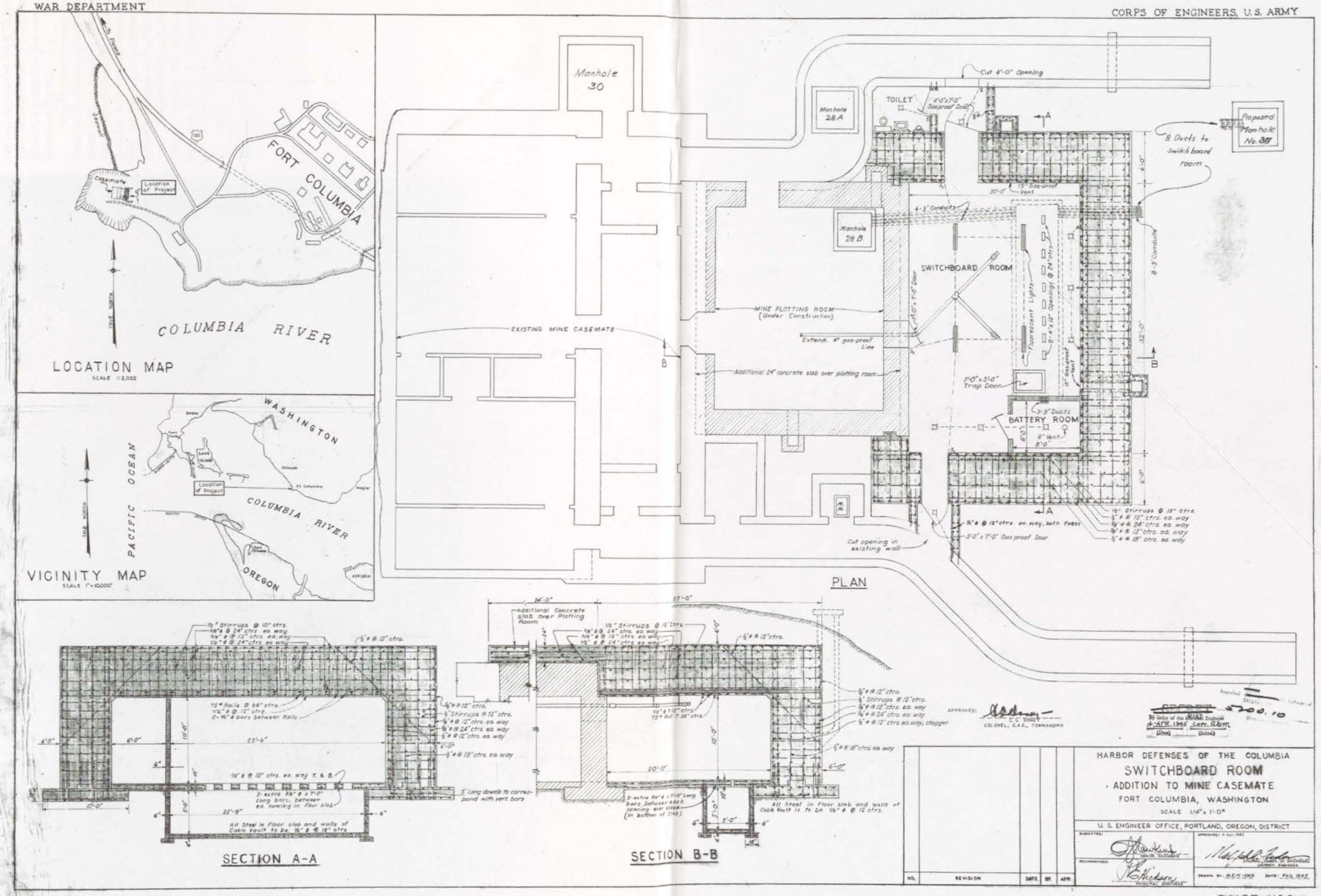
DRAWN BY: MEH
DATE: August 1944
TRACED BY: MEH
CHECKED BY:

DMCR-1182.1


WAR DEPARTMENT
To Ilwaco
Seawall
101
Casemate
Location of Project
FORT COLUMBIA
TRUE NORTH
COLUMBIA
LOCATION MAP
SCALE 1:2,000
TOILET
4'0"x7'0" Gasproof Door
Cut 4'-0" Opening
A
15" Gasproof Vent
20'-0"
@ 24" ctrs
32'-0"
6'-0"
8-3" Conduits
8 Ducts to switchboard room
Proposed Manhole No. 37
CORPS OF ENGINEERS, U.S. ARMY

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY



APPROVED: C. S. Doney
C. S. DONEY
COLONEL, C.A.C., COMMANDING

~~SECRET~~ 5700.10
By order of the Dist. Engineer
4-APR. 1945 Capt. RLM
(Date) (Initial)

NO.	REVISION	DATE	BY	APR.

HARBOR DEFENSES OF THE COLUMBIA
SWITCHBOARD ROOM
ADDITION TO MINE CASEMATE
FORT COLUMBIA, WASHINGTON
SCALE 1/8" = 1'-0"

U. S. ENGINEER OFFICE, PORTLAND, OREGON, DISTRICT

SUBMITTED: Hawkins
SENIOR ENGINEER

RECOMMENDED: R. Hickson
PRINCIPAL ENGINEER

APPROVED: 9 Apr. 1945
Ralph A. Tudor
COLONEL, CORPS OF ENGINEERS
DISTRICT ENGINEER

DRAWN BY: M.E.H.-DKR DATE: Feb. 1945

DMCR 1190

Photographs

The photographs in this section were taken on five trips between February and September 2008. This lengthy photo-documentation is an attempt to provide a portrait of the casemate as it existed at the time.

Very basic equipment was used. Most of the photos are digital and were taken with a Canon G5. The use of a heavy tripod made the interior photos possible. A few photos were made on film, but this sort of publcation is only possible because of digital technology.

Photography has limits in its ability to convey information, but it also provides a way of seeing that adds to understanding in it own fashion. This effort was considered important because it may allow planners and researchers in the future to use information that the author did not realize as important. It was also undertaken because documentation can be an effective means of preservation in itself.

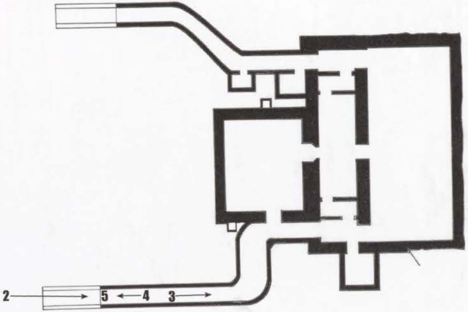
A plan of the casemate with the photo numbers keyed to it is provided with each page.

Following the photos of the casemate interior is a selection of images of the setting and associated features.

Photo 1. Looking south at Fort Columbia's new mine casemate. The west entry tunnel is seen on the right. On the left is the World War I era searchlight powerhouse, with the casemate's east gate just visible behind it to the left. The trees and native plants covering the earthwork were planted by the Army Corps of Engineers as part of the design of the fortification. The result is an intimate relationship between casemate and landscape. February 2008.

All photos: S. Lingo, 2008.

West Entry Tunnel



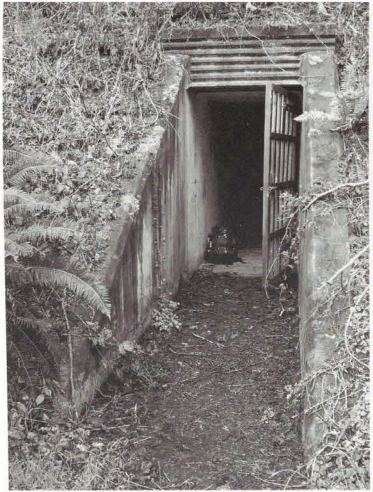


Photo 2. (Above). The west entry to the casemate. The lintel with its stripped classical motif is one of the few decorative elements used in the construction of the casemate. The steel gate is original and hangs on pintle hinges cast in place..

Photo 3. (Middle, bottom). View down west entry tunnel to the first ninety degre turn. The tunnel walls appear to have been finished with a skim coat of plaster.

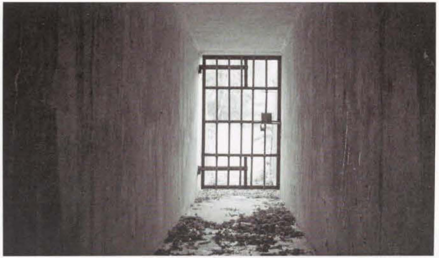
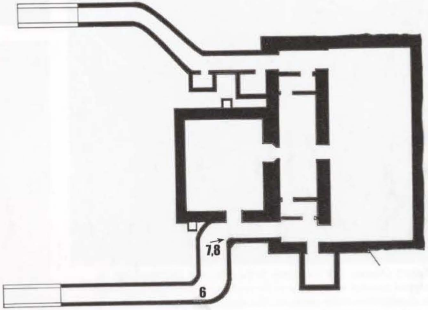


Photo 4. (Middle, top). Looking out from the west entry tunnel. The two-inch chamfer at the junction between wall and ceiling is visible in this photo.

Photo 5. (Above). A number of different paint finishes were used on the casemate tunnel. The buff-orange color seen here was applied in a tapered chevron pattern running from ceiling to floor about eight feet inside the gate.

West Entry Tunnel

All photos: S. Lingo, 2008.



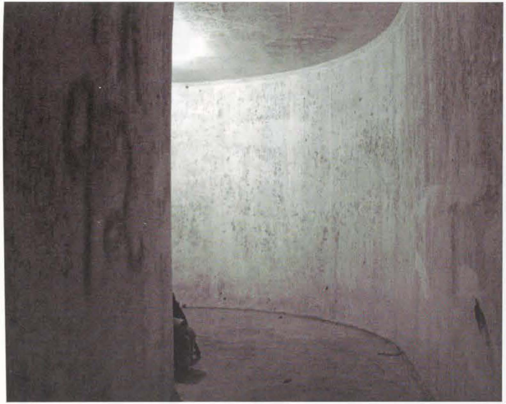


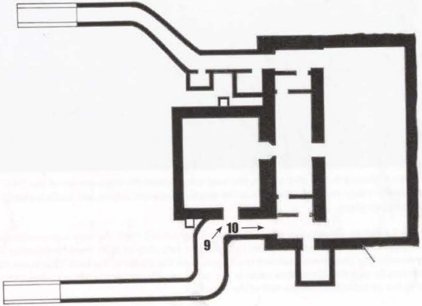
Photo 6. (Above). At the first turn in the west entry tunnel the high quality of the 1941-1943 construction is easily seen. The chamfer at the junction between ceiling and walls is clearly evident again in this photo.

Photo 7. (Right). The second turn in the west entry tunnel. Note the very wet conditions at this point in the tunnel. Water was about 1/2" deep in February of 2008. Water infiltration seem to be predominantly from the significant crack system on the inside of the turn. This is one of the few structurally significant problem areas in the casemate. The concrete ceiling in this spot is about 1' thick, not as substantial as the rest of the structure.

Photo 8. (Top Right). Close-up of the crack system, February 2008.

All photos: S. Lingo, 2008.

West Entry Tunnel



Historic Structure Report
New Mine Casemate
Fort Columbia State Park

Volume 2: Photographic Documentation

Shawn Lingo

Terminal Project
Historic Preservation Program
School of Architecture and Allied Arts
University of Oregon
November 2008

Photo 9. (Above) Looking east from the manhole area in the west tunnel. Door frames have been cast in place throughout the casemate in tesitimony to the high quality of workmanship. This feature has the potential to create structural problems from steel jacking if corrosion causes expansion of steel elements.

Photo 10. (Right). View of tunnel end at dormitory and airlock entrance.

All photos: S. Lingo, 2008.

East Entry Tunnel

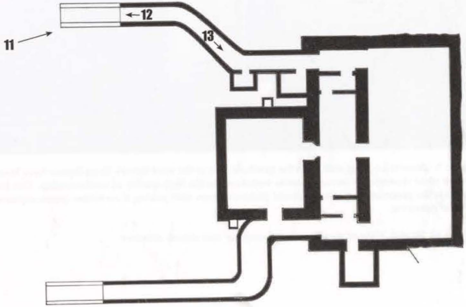
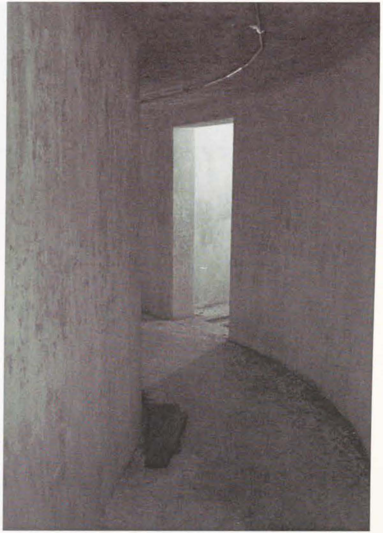


Photo 11. (Left). East entry gate showing retaining wall and relationship to searchlight powerhouse.

Photo 12. (Above). Looking out from east entry tunnel. The gate has been damaged and is sealed shut with plywood panel. Holes provide ventilation.

Photo 13. (Right). View down east tunnel toward oil storage room. Concrete in this section of the casemate is very sound.



All photos: S. Lingo, 2008.

East Entry Tunnel

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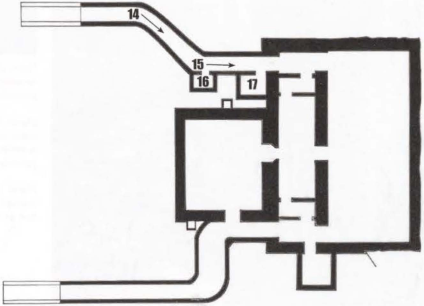


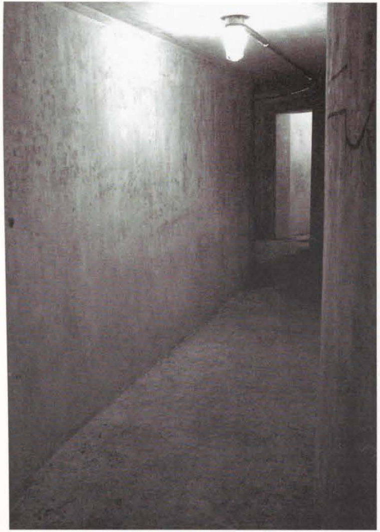


Photo 14. (Above) Longer angle of Photo 13 showing recently installed lighting.

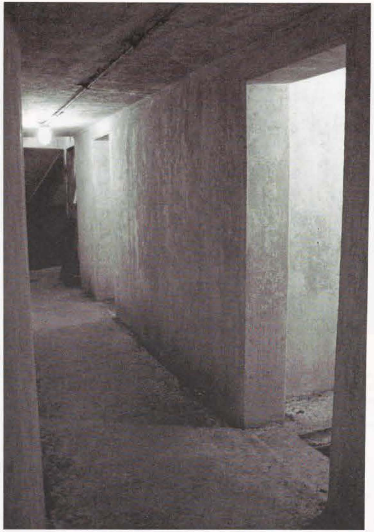


Photo 15. (Above). View from manhole room toward oil storage room and east airlock.

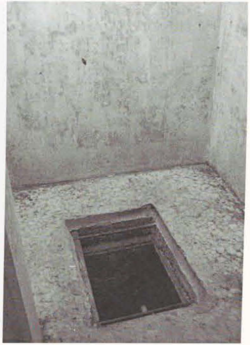
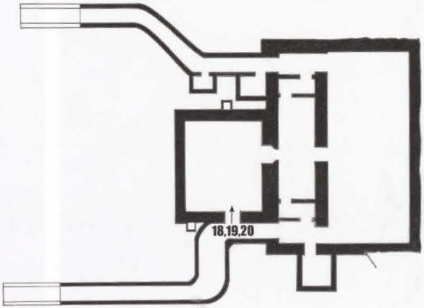


Photo16. (Above Right). Manhole room.
Photo 17. (Lower Right). Oil storage room.

All photos: S. Lingo, 2008.

Plotting Room



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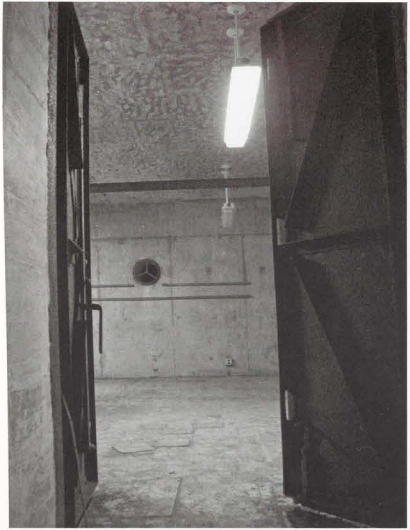


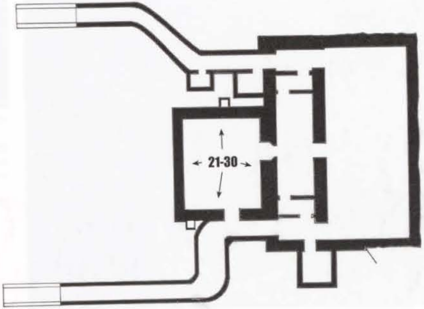
Photo 18. (Left). View from west entry tunnel into plotting room.

Photo 19. (Above). Steel plotting room door with frame cast in place. Form board impressions on wall. Door reveal is four feet thick in this spot. One foot abutting tunnel is original tunnel wall from 1941-43 building phase. Plotting room wall is three feet thick added in 1944-45. Construction joint where cap has been placed is visible at left of photo.

Photo 20. (Above). Remnants of red and black 8″x8″ tile floor covering in plotting room.

Plotting Room

All photos: S. Lingo, 2008.

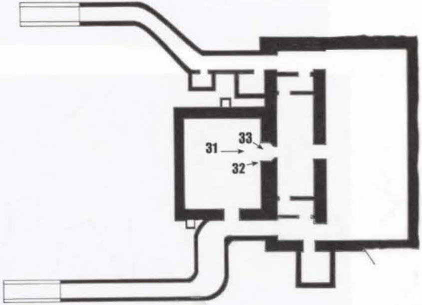


All photos: S. Lingo, 2008.

Photos 21- 30. Ten photo sequence stitched to show 360 degree view of plotting room interior.

All photos: S. Lingo, 2008.

Plotting Room



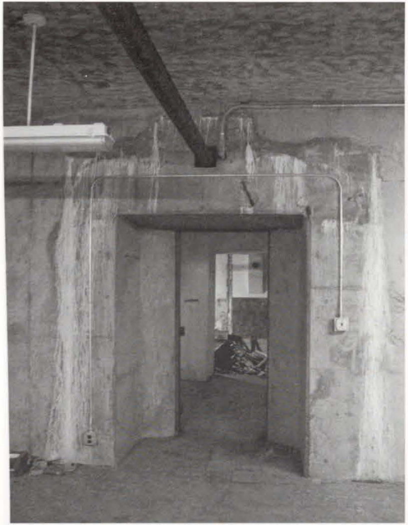


Photo 31. (Above). South doorway between plotting room and gas-proofing room. Note series of cold joints around the top of the door and severe efflorescence. Wall of plotting room is one foot thick here, added to three foor wall of gas-proofing room.

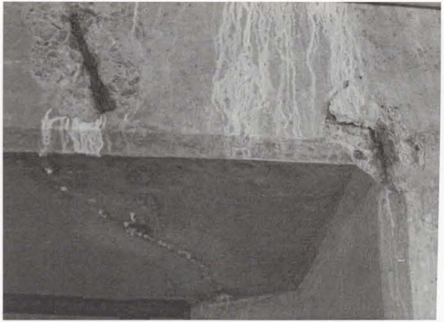
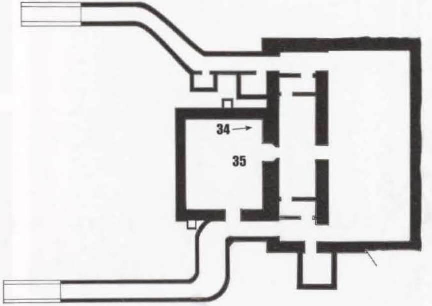


Photo 32. (Above). Closeup of doorway showing spalls with exposed rebar and cracking with stalactites.

Photo 33. Remains of tile floor in doorway.

All photos: S. Lingo, 2008.

Plotting Room



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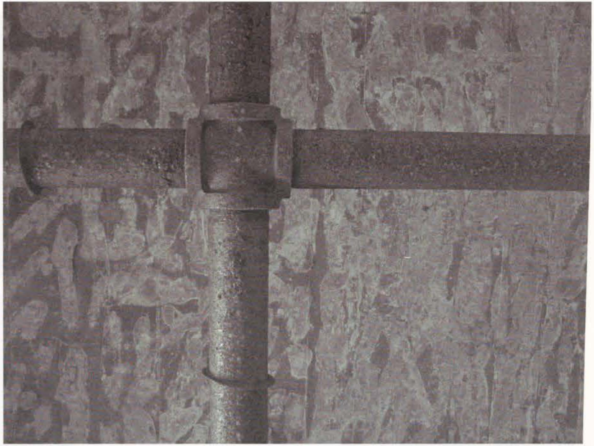


Photo 34. (Left). Light fixtures and acoustic ceiling tiles in corner of plotting room. Of main interest is the fluorescent tube fixture, an early example of this technology. This fixture should be retained and refurbished or used as a model to fabricate reproductions.

Photo 35. (Above). Intersection of gas-proofing pipes, plotting room ceiling. No identified traces of any original finish is found on the overhead gas-proofing pipes. Remains of mastic used to attach acoustic tiles to ceiling. There are none currently in place.

All photos: S. Lingo, 2008.

Plotting Room

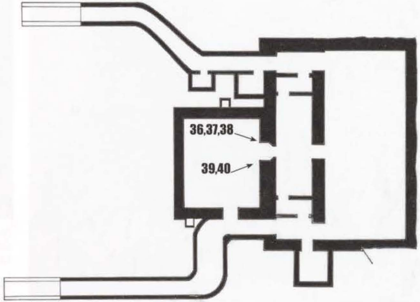
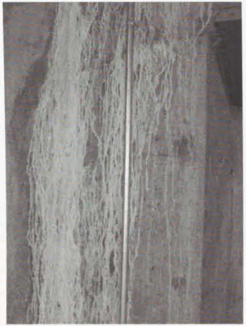


Photo 36. (Left). Detail of construction joint with efflorescence, plotting room south doorway, east side.

Photos 37, 38. (Lower left). Efflorescence and water stain from 37.

Photo 39. (Right). Exposed rebar and construciton joints with efflorescence, plotting room south doorway, west side.

Photo 40. (Bottom right). Heavy efflorescence from above. Note delamination caused by embedded electrical box at lower right.



All photos: S. Lingo, 2008.

Gas Doors

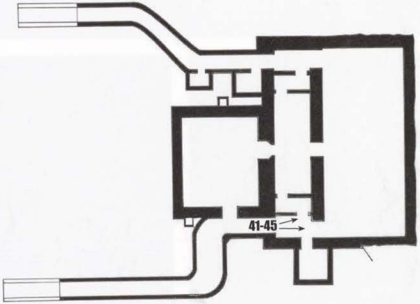
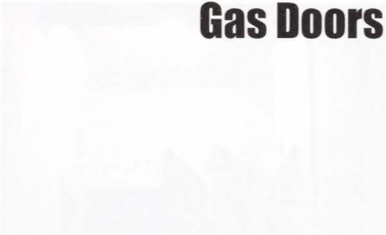


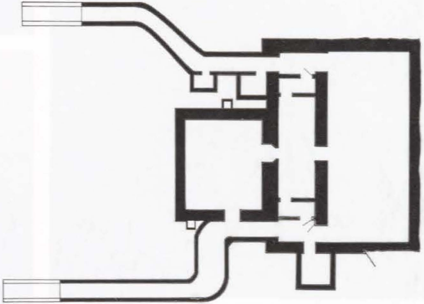
Photo 41. (Above). Gas-proof doors leading straight ahead into dormitory and left into west airlock.

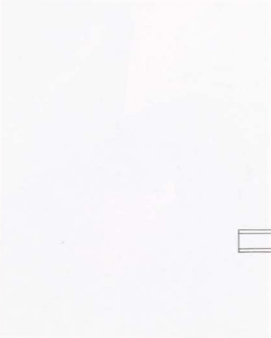
Photos 42-45. (Right). Gas-proof doors details. West airlock.

All photos: S. Lingo, 2008.

Gas Doors







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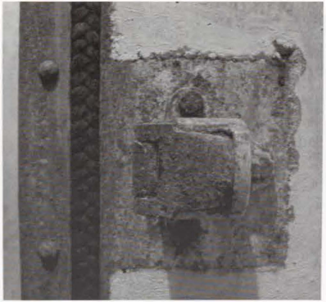


Photos 46-49. Details showing locking mechanisms on gas-proof doors, east air lock. Traces of the original paint are still visible on the doors. Paint scheme appears to be gray with a red primer.

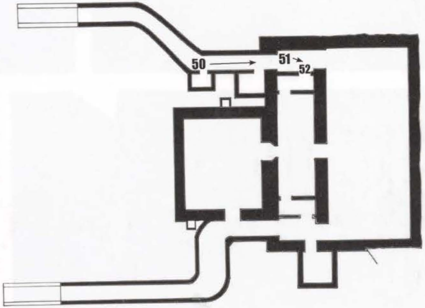
Photo 46. (Above, left). Heavy corrosion on gas-proof door.

Photo 47: (Above, center). Door catch, plate has been cast in place. Woven gasket material is still intact on all the gas-proof doors.

Photos 48-49. (Above, right; lower left). Details of freezer-type door hardware.

All photos: S. Lingo, 2008.

Gas Doors



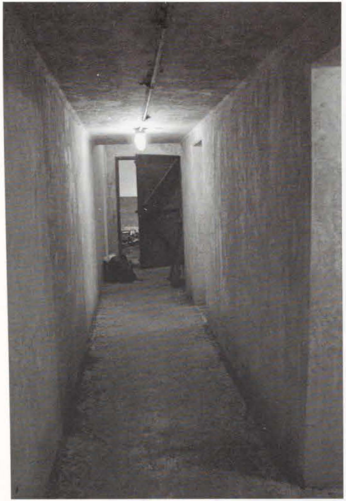
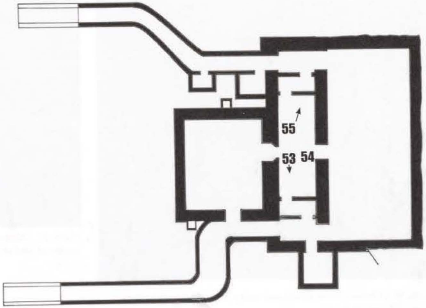


Photo 50. (Above.) View down east entry tunnel toward battery room and east air lock.

Photo 51. (Above). Non gas-proof door to battery room has been removed and is currently in tunnel outside east air lock.

Photo 52. (Above). Slightly elevated door threshold to raise level of air lock above tunnel. Note traces of red primer visible in these photos.

Gas-Proofing Rooms



All photos: S. Lingo, 2008.

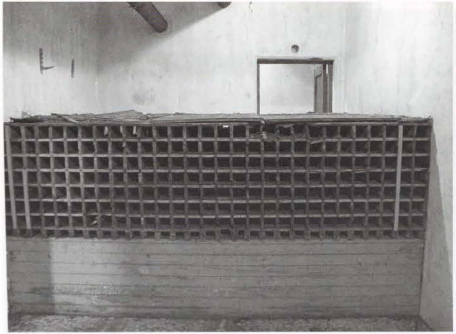


Photo 53. (Above). Map case in west end of gas-proofing room.

Photo 54. (Right). Original electrical box located west of door into casemate operating room.

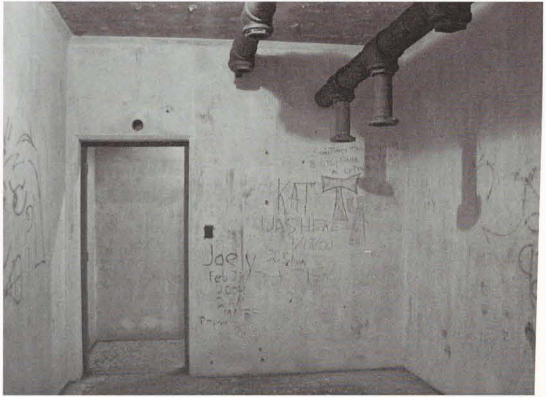
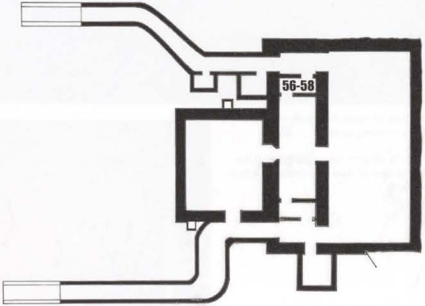
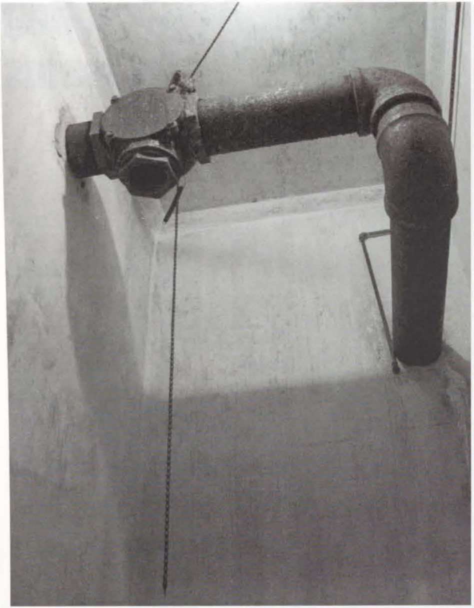


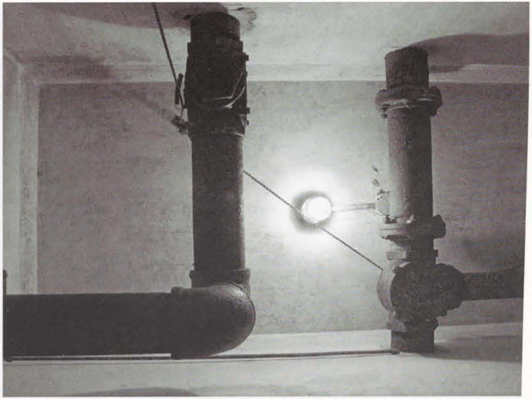
Photo 55. (Above). East end of gas-proofing room. The cannister filters and air pumps that formed the gas-proofing equipment would have occupied this space, connected to the two down-pipes. Graffiti in these photos was removed by work crews in September 2008.

All photos: S. Llrgo, 2008.

Air Locks







Photos 56-58. Views of gas-proofing apparatus in east air lock. Overhead pipes were connected to the air pumpps and canisters on the other side of the wall. The chain hanging from the pipe in the photo at far left was connected to the foot treadle below.

Gas-Proofing Rooms

All photos: S. Lingo, 2008.

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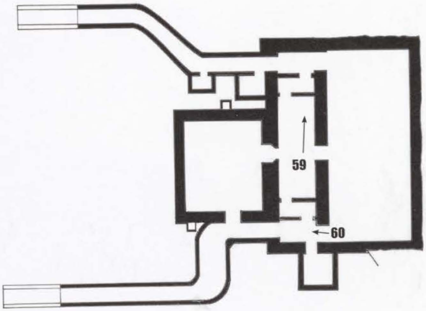


All photos: S. Lingo, 2008.

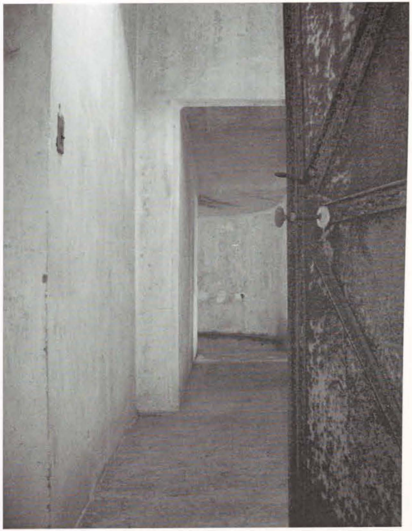
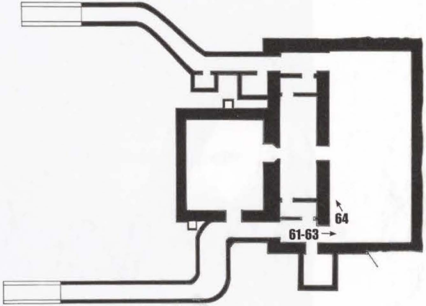


Photo 59. (Left). Main gas-proofing pipes, looking east in gas-proofing room. Flanged down sections were connected to air pumps and canister filters.

Photo 60. (Above). Looking north past gas-proof door from dormitory.

All photos: S. Lingo, 2008.

Dormitory Rooms



All photos: S. Lingo, 200

Photos 61 (Far left, top), 62 (Far left, bottom). Interior of dormitory. World War 2-era plywood lockers almost completely occupy the space.

Photo 63. (Left). Historic electrical switch, dormitory. Note spalls and delamination caused by corrosion of electrical box.

Photo 64. (Above). Connection of dormitory partition wall with north casemate wall is tenuous and should be repaired.

All photos: S. Lingo, 2008.

Dormitory

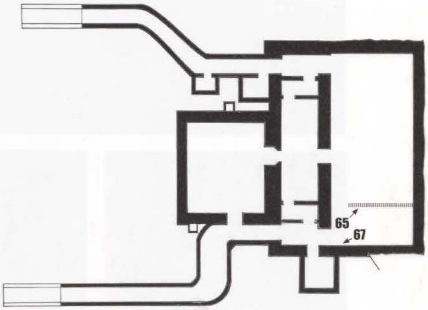


Photo 65. (Above). Several layers of historic paint are visible on the beadboard east partition wall of the dormitory.

Photo 66. (Right). Bead board partition wall at Fort Stevens casemate. In spite of differences in lighting and weathering conditions, the two structures and their color schemes are obviously related.

Photo 67. (Left). Peeling paint and spalled concrete with exposed rebar indicate moisture problems in the west wall of the dormitory. The concrete in this section of the casemate was poured directly against the rock outcrop of Chinook Point.

All photos: S. Lingo, 2008.

Casemate Operations Rooms

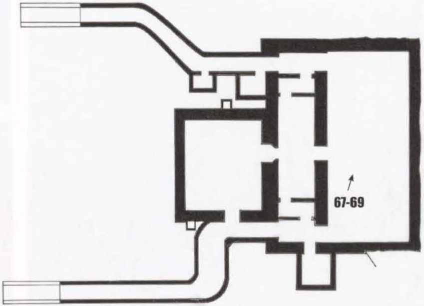


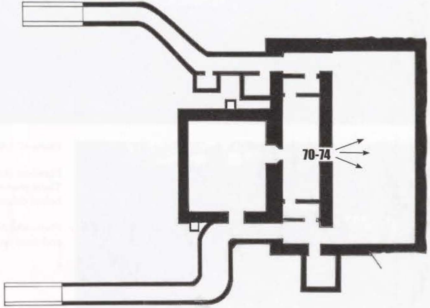
Photo 67. (Above, left). Looking west from dormitory across casemate proper.

Photo 68. (Left). Looking into operating room cable gallery from dormitory. These photos show the generally ruinous state of the casemate operating room before debris was removed in September 2008.

Photo 69. (Above, right). Ceiling of operating room showing from board finish and inset wooden elements.

All photos: S. Lingo, 2008.

Operating Room

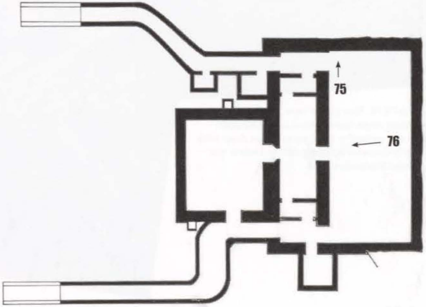


All photos: S. Lingo, 2008.

Photos 70-74. Five photo view south-west across operating room from central casemate door. The cable gallery is filled several feet deep with severely decayed building debris. Debris was removed September 2008.

All photos: S. Lingo, 2008.

Battery & Engine Rooms



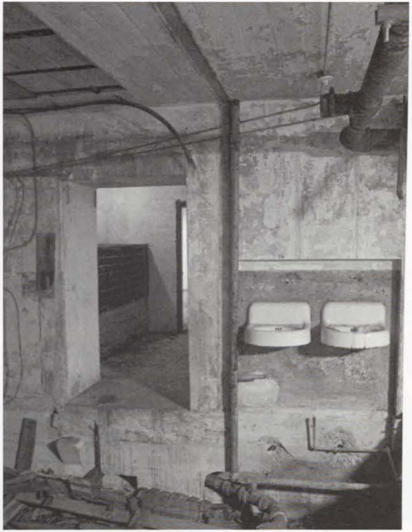


Photo 76. (Left). Looking back across engine room toward latrine sinks. The point of view would originally have been in one of the closets that divided the casemate into two roughly equal sections. This view would not have existed during the casemate's operational lifetime. The rabbet to accomodate the partition wall of the latrine is seen in the concrete to the right of the door.

Photo 75. (Above). Battery room sink on east wall of casemate. Concrete infill above door from 1943 tunnel addition is shown. Repainting the casemate is not recommended based on the desire to preserve historic finishes. Although the interior of the 1921 casemate was painted, the 1941-43 addition appears to have received a plastered finish. Additional testing is necessary to determine the exact nature of the finishes.

Engine Room

All photos: S. Lingo, 2008.

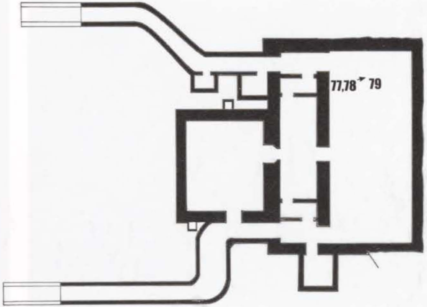
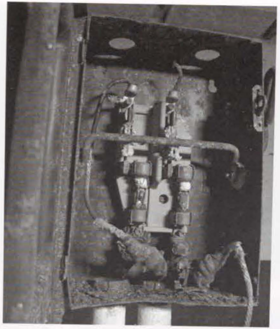


Photo 77. (Above). Two electrical control boxes in what would have been the engine room of the casemate.
Photo 78. (Right). Detail of the control box door. Plate reads: "Witte Engine Works, Kansas City, Mo., U.S.A. [??] SB654W Model No. 51A2 [?] ??8KW Volts 110 Type AC".

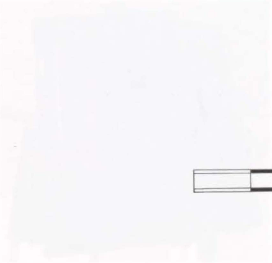


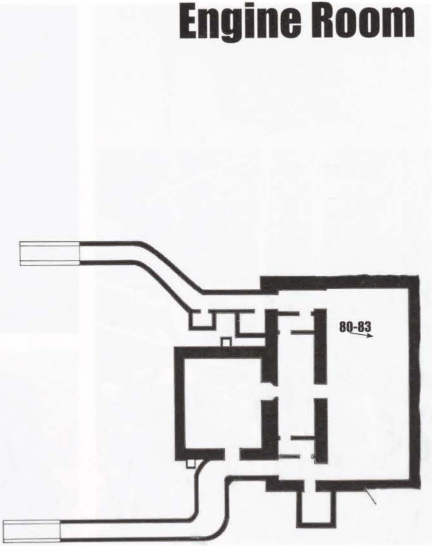
Photos 78, 79 (Above & top center). Views of the control box interiors. these boxes, along with the mine cables, are the only casemate electrical equipment left in place. No additional equipment was found during the clean-up in September 2008.

Engine Room

All photos: S. Lingo, 2000.

[illegible]





[illegible]

Photo 80. (Above). Concrete bases for engine and generator in front of engine room fuel oil tank. Base in the foreground held the belt driven generator that was powered by the engine.

Photo 81. (Top center). Detail of generator base.

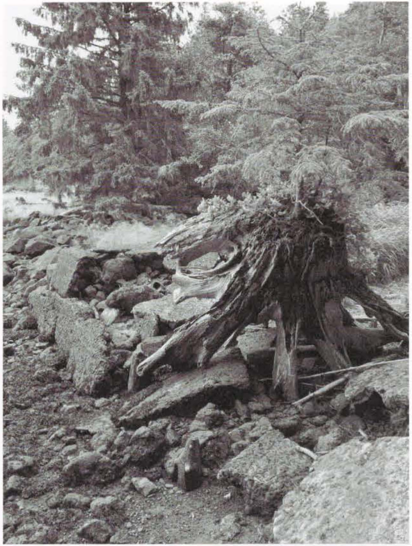
Photo 82. (Bottom center). Corroded metal reinforcing steel has caused significant spalling in ceiling of engine room area. The reinforced concrete ceiling is five feet thick at this point, so this spalling has not yet created any structural concern.

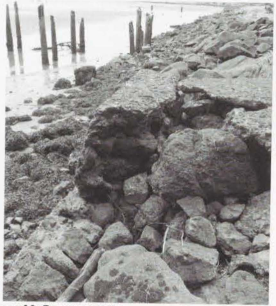
Photo 83. (Below). Large pieces of concrete falling from the ceiling do create a safety issue for casemate visitors.

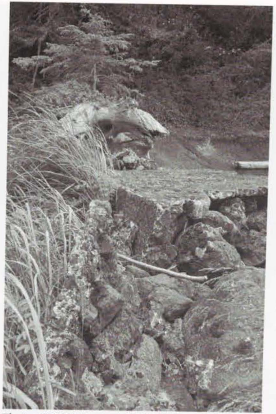
Cable Gallery

Photo 84. (Above). Cable protective apron at high tide.

Photo 85. (Right). Cable gallery at low tide. The concrete is badly deteriorated.







Photos 86-88. (Above and left). Various views of cable protective apron remains. Parts of the cable housing probably date from the first 1911 casemate on this site. A 1944 project added a more secure cable entry point.

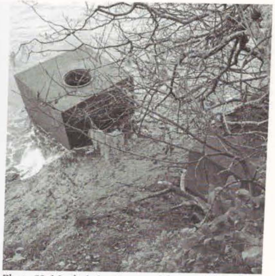
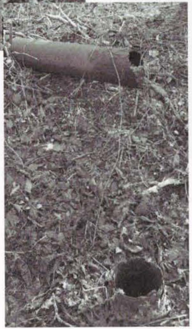


Photo 89. Manhole leading to cable tunnel. Local lore says that this is the prefered point of unauthorized entry to the casemate. The lower box is part of the 1944 improvements.

All photos: S. Lingo, 2008.

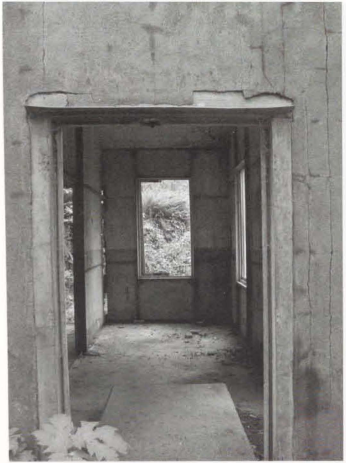
Exterior

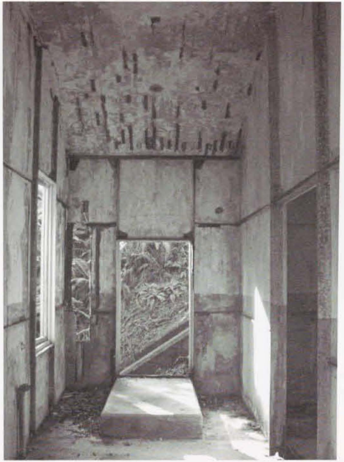
Photos 90-95. Due to the attempts to conceal the presence of the fortification and nearly seventy years of plant growth, the exterior of the casemate has few distinguishing features. A number of ventilator stacks rise up through the earthwork. The earthen covering of the burster course has slumped revealing its southeast corner.



Associated Features

Searchlight Power house



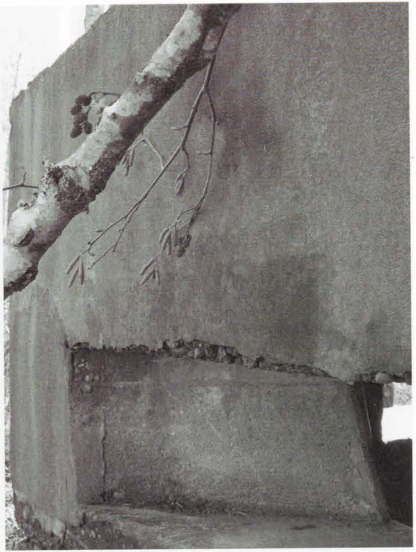


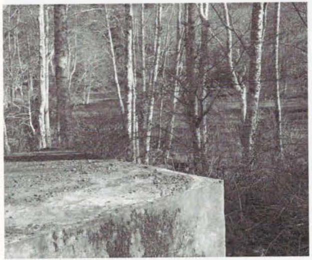
Photos 96-99. The searchlight powerhouse is a World War I vintage building constructed of concrete and expanded metal lath panels. It provided power to the searchlight station on Chinook Point. It is visible in construction photos of the casemate. The building is in a serious state of deterioration.

Associated Features

Pillbox

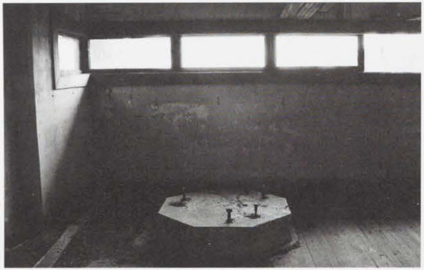
Photos 100 - 103. There is a pillbox located slightly southwest of the west casemate entrance. It provided cover to the landward approaches to the casemate. The structure measures approximately 10'x10'. The earth has blocked the entrance.





Associated Feaures
Mine command station & dormitory

Though these two structures are not physically situated near the casemate, they played a role in the function of the casemate operations.



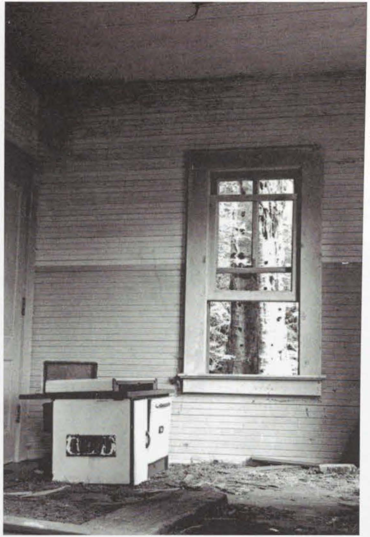


Photo 103. (Left). The mine command station is a two-story structure on Scarborough Hill. It housed the observation equipment for mine plotting and, until 1945, the mine plotting room. Photos 104-105. Above and Top left. The dormitory is a Sewell type building on Scarborough Hill. It was constructed around 1911.

All photos: S. Lingo, 2008.

Photos 106- 109. Views from Chinook Point and wildflowers growing on the casemate earthwork.