Historic Concrete Investigations at Pointe du Hoc, Normandy, France

Toward interpretation and preservation of an important site

BY TANYA WATTENBURG KOMAS AND RICHARD BURT

The Concrete Industry Management (CIM) Program at California State University (CSU), Chico, working on an existing Texas A&M University project, had the honor of participating in a unique research opportunity that was partially made possible through student travel sponsorship generously offered by the National Ready Mixed Concrete Association (NRMCA). In March 2008, Tanya Wattenburg Komas, faculty with the Chico State CIM program, traveled to Normandy, France, to conduct nondestructive testing of the concrete structures at the historic World War II D-Day landing site at Pointe du Hoc with five CIM students, including Chad Golden, Andrew Billingsley, Courtney Sheehan, Alexx McAvoy, and Robert Hostettler. Larry Olson, Owner and President of Olson Engineering, volunteered the use of his company's equipment and his time for on-site student training so they could complete the testing. The involvement of Chico State in the project began as a result of the need to determine foundation depths for use in Texas A&M University's work to document and evaluate the overall site and cliff.

SIGNIFICANCE OF THE SITE

Pointe du Hoc is the most culturally important historic site of the 1944 World War II Normandy invasion. Celebrating the 40th anniversary of D-Day, President Ronald Reagan, on top of the observation post, remarked that "Their mission was one of the most difficult and daring of the invasion: to climb these sheer and desolate cliffs and take out the enemy guns."[1] He was referring to the early morning of June 6, 1944, when Lt. Col. James Earl Rudder led elements of the 2nd Ranger Battalion in one of the most famous and heroic actions of D-Day. Their mission was to destroy 155 mm (6 in.) cannon capable of firing on troops and ships landing on Utah and Omaha Beaches (Fig. 1).[2-5]

Pointe du Hoc is a medium coastal battery consisting of a variety of structures such as gun emplacements, casemates, and personnel and ammunition bunkers. Constructed as part of Hitler's Atlantic Wall campaign, it was strategically placed between the Utah and Omaha invasion beaches. The site was designated as a Class A Historic Site by the French government on February 28, 1955. The site was formally transferred to the American Battle Monuments Commission (ABMC), a small, independent agency of the Executive Branch of the U.S. federal government, for perpetual care and maintenance on January 11, 1979, and remains a monument to those who sacrificed on that fateful day (Fig. 2).

THE QUESTION OF CONCRETE QUALITY

At the height of the construction of the Atlantic Wall from mid-1942 to mid-1944, over 13,234,500 m^3 (17,300,000 yd^3) of

This article originally appeared in the Summer 2008 edition of *Concrete InFocus,* pp. 8-12, and is reprinted with the permission of the National Ready Mixed Concrete Association.

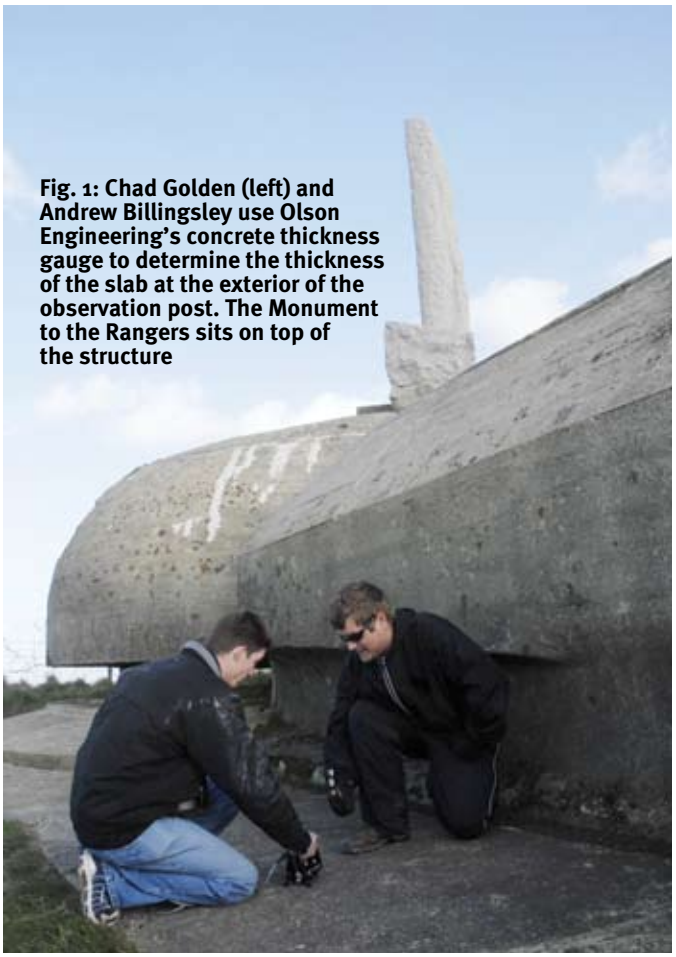

Fig. 1: Chad Golden (left) and Andrew Billingsley use Olson Engineering's concrete thickness gauge to determine the thickness of the slab at the exterior of the observation post. The Monument to the Rangers sits on top of the structure

concrete was placed by the Todt Organization[6] in what was considered at the time one of the greatest construction undertakings since Roman times.[7] The urgent need to construct the defenses led to construction continuing through the winter and increasing allied bombing led to scarcity of high-quality cement and coarse aggregate.[6,8-10] These are all factors that would affect the quality of the concrete.

Construction was underway at Pointe du Hoc in August 1942 when the battery was spotted by aerial reconnaissance and was continuing at the time of the invasion in June 1944.[11] There appear to be two distinct phases of construction. The first phase involved the construction of the six circular gun emplacements for the 155 mm (6 in.) guns and the support buildings (personnel, ammunition, anti-aircraft and hospital bunkers, and the observation post or fire control post). The second phase involved the construction of four gun casemates that were intended to replace the open gun emplacements.

Starting April 25, 1944, the site was subject to intensive bombing from medium and heavy bombers dropping 225, 450, and 900 kg (500, 1000, and 2000 lb) bombs. The easy identification of the Pointe resulted in accurate attacks during daylight raids. Destruction of the site continued on D-Day when the site was subjected to naval bombardment from several ships, including the 355 mm (14 in.) guns of the USS Texas. Photographs taken after the battle show the site virtually covered with bomb and shell craters that are still clearly present today (Fig. 3).

Fig. 2: The beach and cliffs at Pointe du Hoc. The Monument to the Rangers can be seen above the cliff. *(Photo courtesy Texas A&M University)*

Fig. 3: Students standing at the base of a bomb crater

Fig. 4: Inside the observation post, Courtney Sheehan tests relative concrete strength with a Schmidt (rebound) hammer while Chad Golden uses a cover meter to determine location, size, and cover of embedded reinforcing

Several questions remain regarding the concrete fortifications at Pointe du Hoc. What are the differences in the quality of the concrete between the different structures and different construction phases? How did the quality of concrete affect the amount of damage sustained during Allied bombing? How much deterioration of the concrete and corrosion of the reinforcing bars has occurred since D-Day, especially given the location in the high chloride environment near the ocean?

CONCRETE EVALUATION PROJECT

Setting the stage for the concrete evaluation was ongoing survey and documentation work and cliff evaluation by the team from Texas A&M University funded by a grant from ABMC. That work at the site began in September 2006 with the goal of producing a comprehensive site plan and determining the conditions of the eroding cliff face.

Observations of the remains of the structures noted during the survey and documentation work performed by Texas A&M from 2003 to 2006 suggested anomalies that raised concerns about the consistency and quality of the concrete and thus questions about the future stability of the structures. Among the noted anomalies were that some of the structures were remarkably intact while others showed extensive damage as a result of the bombing. A plausible explanation for this is that the concrete may not have cured completely at the time of the invasion, and there appeared to be differences in aggregate types and grading.

Chico State became involved in the project because of its expertise in historic concrete evaluation and repair as part of the CIM program. While the on-site testing began because of the need to determine foundation depths, the project afforded the CIM students the opportunity to become proficient at operating the Olson Engineering state-of-the-art nondestructive testing equipment while collecting valuable data about the overall existing conditions of the concrete and reinforcing in several key structures. It also allowed the students to compare the use of newer equipment with more traditional units such as the Schmidt hammer (Fig. 4).

RESEARCH METHOD

There have been three components to the concrete research to date, including laboratory testing, historic document research, and on-site testing. Laboratory tests were completed in December 2006 at CTLGroup, Chicago, IL. CTLGroup donated the use of its laboratory facilities and allowed the faculty from CSU Chico to work with its professional personnel to conduct laboratory testing of concrete and cement samples from the Pointe du Hoc site. The tests were undertaken to determine the mixture proportions and compressive strengths of two samples of concrete from different structures built at different times. Tests were also performed to determine the cement composition from a sample obtained from a hardened sack of cement that remained on the site from the date of original construction. The cement appears to have been intended for use in completing a new concrete block casemate that was destroyed by a bomb prior to completion (Fig. 5 and 6). The combined tests revealed similarities and differences between the concrete samples.

Locating and evaluating historic documents related to the concrete materials and construction at the site are ongoing. This research has revealed such historic documents as those from the Ministry of Supply's Advisory Council on Scientific Research and Technical Development "Anti-Concrete Committee" organized by Allied Forces in 1944 to "review and coordinate existing work on methods of destroying or breaching concrete and reinforced concrete structures." The documents contain information on the composition of other similar concretes tested in or around 1944-1945. A comparison of current research results and data obtained from the historic documents showed similarities in

Fig. 5: Cement that was never used as a result of the D-Day invasion. The form is that of the sack in which the cement cured after having been left on the ground after D-Day

Fig. 6: Casemate that appears to have been under construction at the time of the D-Day invasion and was destroyed by a bomb prior to completion. The sack of hardened cement in Fig. 5 sits nearby

Fig. 7: Chad Golden (on top of the casemate) holds a transmitter that is sending ultrasonic pulses through the approximately 2 m (80 in.) of concrete to where Robert Hostettler (inside) is holding the receiver. Andrew Billingsley (seen through the barbed wire) is running the test data via a field-ruggedized computer on the velocity of the sound waves to determine soundness of the concrete

Fig. 8: Close-up of ultrasonic pulse velocity test on an observation post interior wall with two-sided access

Fig. 9: Alexx McAvoy and Robert Hostettler conduct an impact echo test on the observation post. Impact echo tests can be conducted with one- or two-sided access

RETURN TO NORMANDY

Plans for returning to Pointe du Hoc are underway. Led by Bob Warden of Texas A&M University; Tanya Komas of California State University, Chico; and Richard Burt of Auburn University, the new 3-year project phase will include student researchers from these three institutions and a student from each of the other Concrete Industry Management programs. The principal investigators are now establishing funding, scope, and logistic details for the project's on-site work, data analysis, and reporting.

The new phase is expected to result in the publication of historic structures reports for the 20 structures at the site. The reports would describe the original designs, construction materials and methods, bomb damage, and subsequent deterioration. They would also detail the research methods, as well as provide recommendations for structural stabilization and options to allow safe visitor access. The investigators plan to compare new and traditional nondestructive evaluation technologies. Using existing records of ordinance types and trajectories used against the site, investigators also plan to evaluate the performance of structures produced using different types of concrete and construction methods.

An overall historical report will address unanswered questions, including: Was Pointe du Hoc unique in its fortification strategy? What does it share with contemporary fortifications? How accurate was Allied intelligence regarding the fortifications? What is the present state of visitation at the site, and how should the experience be strengthened? An option under consideration is to use computer graphics to produce a 3-D digital model illustrating such items as the events of D-Day, current conditions, and stabilization alternatives. This would serve the stabilization efforts as well as provide interpretive tools that are presently not available.

Questions about the project, including how individuals and corporations can provide support, should be addressed to Tanya Komas, California State University, Chico, at tkomas@csuchico.edu, (530) 898-4487.

concrete characteristics between the concrete tested in 1944-1945 and that tested from Pointe du Hoc in 2006.

Although the necessarily small samples tested in the lab yielded important information, the on-site testing was essential to better understand the condition of the concrete at the site. Nondestructive tests that were performed for three structures of particular interest included visual inspection, rebound hammer, pulse velocity (Fig. 7 and 8), impact echo (Fig. 9), and reinforcing bar location/size/cover (Fig. 4). Data from this effort is currently being analyzed in terms of the historical data and accepted concrete industry repair practice. Tests that were discussed but not performed during this phase of the project due their destructive nature and time limitations, manpower, and other factors included extent of carbonation, chloride intrusion, and embedded reinforcement corrosion (corrosion was visually assessed where possible).

CONCLUSION

It is the hope of the collaborative Texas A&M University and California State University, Chico, teams and many others that the important work of surveying, evaluating, and preserving the landscape and structures at Pointe du Hoc will continue. The importance of this endeavor cannot be understated, particularly as it relates to the younger generations. For the faculty and student researchers from both institutions, their hands-on experiences with this project have not only enabled them to learn a great deal about site and structural documentation and evaluation, but also gave them the life-changing experience of having participated in honoring the individuals who sacrificed so much at that pivotal point in the history of the world.

The continued presence and accessibility of sites such as Pointe du Hoc promises to help keep alive the memories and lessons of this and other such important sites along the Normandy Coast and throughout the world.

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