

15 Aug 2008, 1:30 pm - 3:00 pm

# Soil Sampling at Sword Beach – Luc-Sur-Mer, France, 1943: How Geotechnical Engineering Influenced the D-Day Invasion and Directed the Course of Modern History

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6th International Conference on
Case Histories in Geotechnical Engineering, Arlington, VA, August 11-16, 2008

# SOIL SAMPLING AT SWORD BEACH – LUC-SUR-MER, FRANCE, 1943: HOW GEOTECHNICAL ENGINEERING INFLUENCED THE D-DAY INVASION AND DIRECTED THE COURSE OF MODERN HISTORY

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ABSTRACT

This paper presents an historical account of covert soil sampling operations conducted by the British Royal Navy's No. 1 Combined Operations Pilotage and Beach Reconnaissance Party on December 31, 1943, near Luc-sur-Mer, France at the beach later given the codename "Sword." With the tactical goal of determining whether the beach sand would support heavy invasion craft such as tanks, trucks, and bulldozers, this commando-style mission provided the field data by which the Supreme Allied Command established the site for the main landing beaches where the initial assault phase of Operation Overlord, the Allied invasion of Normandy, took place on June 6, 1944. Incorporated into a site characterization lecture, this case study illustrates soil exploration methodology and introduces students to the nature, practice and significance of geotechnical engineering as a profession that can directly influence world events and even the course of modern history.

## INTRODUCTION

D-Day was the climactic battle of World War II: history has established this. So when the World paused to remember the 50th anniversary of D-Day a decade ago, many of us were gripped by stories, both heroic and horrific, told about the Allied invasion of Normandy's beaches. One of these stories, effectively dramatized in Steven Spielberg's (1998) Academy-award-winning film, *Saving Private Ryan*, had to do with the return of a US Army private to his mother, an Iowa farmwife who had already lost three sons to the war (Fig. 1). The factual narrative which provided inspiration for *Saving Private Ryan* is documented in historian Stephen Ambrose's definitive account of the D-Day battle (Ambrose 1994, p. 316). We may have learned about this when we saw the film.

Much less known yet equally dramatic, Ambrose's book relates a tale of special interest to the geotechnical engineering community. It is the story of how the success of the D-Day invasion, and therefore the outcome of World War II, and by implication the fate of democracy if not the course of modern history, directly depended on soil bearing analyses to establish whether the beaches of Normandy would support the heavy vehicles and landing equipment needed for the invasion. This issue could not be answered without soil sampling. So, with no protection from German forces other than stealth and the cover of darkness, a team of commandoes from the British Royal Navy deployed to perform the crucial soil sampling operation. This case study tells their remarkable story.

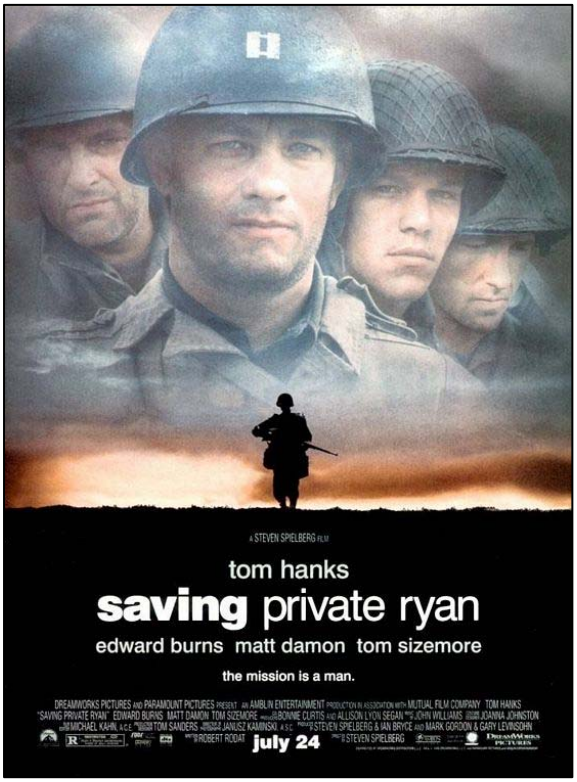


*Fig. 1. "Saving Private Ryan" depicted both the horrors and the heroism of D-Day. (Courtesy, Paramount Pictures)*

GEOTECHNICAL ENGINEERING AND THE D-DAY INVASION

## Historical and Geographical Context

Operation Overlord, the Allied invasion of German-occupied France in June 1944, required the transport of 175,000 fighting men and their equipment, including 50,000 vehicles of all types, ranging from motorcycles to tanks and armored bulldozers, across 60 to 100 miles of open water, overnight, to land on a hostile shore against intense opposition (Ambrose 1994, pp. 24-25). Churchill called it "the most difficult and complicated operation ever to take place." Commanders on both sides recognized it as a winner-take-all battle. In Hitler's words, "The destruction of the enemy's landing is the sole decisive factor in the whole conduct of the war and hence in its final results" (Ambrose 1994, p. 13).

Planning for Operation Overlord commenced in March 1943. The Allied objective was to land, penetrate German defenses, and secure a lodgment in an area suitable for reinforcement and expansion (D'Este 1983, p. 34-35). One obvious question was, "Where?" There were tactical requirements. The site had to be within range of Allied fighter planes based in the United Kingdom. There had to be at least one major port close at hand, but unlike the Pas-de-Calais coast in northern France, where the English Channel is narrowest and therefore the Germans expected an invasion, the site could not be well-defended. Further, the beaches for the landing site had to be suitable for prolonged unloading operations and have exits for vehicles and adequate road networks behind them for rapid, massive deployment inland (Ambrose 1994, p. 71-72). A process of elimination brought the choice down to the Calvados coast of Normandy (Fig. 2).

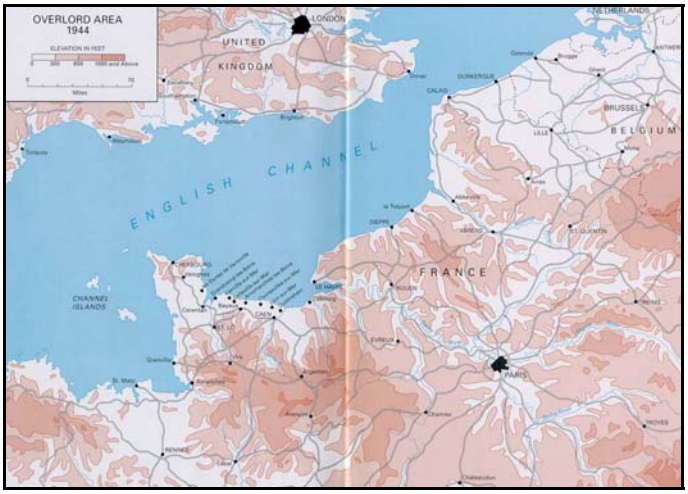


*Fig. 2. Operation Overlord Area Map, including the Calvados Coast of Normandy (Site of the D-Day Invasion) and the Narrows between Dover and Calais. (Courtesy, 88th Infantry Division Blue Devils Map Library)*

In addition to satisfying the tactical requirements, this site also had the strategic advantage of being as close as possible to Germany's industrial heartland, the Rhine-Ruhr region, which was the ultimate objective for the invasion.

## Pre-Invasion Intelligence about the French Coast

With the site established, the British began to collect intelligence about the French coast. Information included some ten million pictures and postcards from British families who had taken pre-war vacations in France, aerial reconnaissance photographs that were put together into panoramic photos, and information on tides, currents and topography from old guidebooks. The French Resistance supplied information on beach obstacles, strong points, and other items of interest (Ambrose 1994, p. 74).

## The Crucial Question

Despite all this information about the Calvados coast, the Allied command still did not know the answer to a crucial question:

> Would the beaches west of the mouth of the Orne River support DUKWs, tanks, bulldozers, and trucks? There was reason to fear that they would not, because British geographers and geologists reported that there had been considerable erosion of the coastline over the past two centuries. The original port at Calvados, the old Roman port, had been two kilometers out from the twentieth century shoreline. French Resistance people managed to smuggle four volumes of geological maps out of Paris, one in Latin done by the Romans, who had surveyed their entire empire for a report on fuel sources. The survey indicated that the Romans had gathered peat from the extensive reserves on the Calvados coast. If there were boggy peat fields under a thin layer of sand on the current coast, it would not hold tanks and trucks (Ambrose 1994, p. 74).

Soil failure, or, in the vernacular of the day, inadequate *bearing capacity*, would strand vehicles, expose troops, and otherwise cause the landing parties to be pinned down under enemy fire. The only way to find out whether the soil was strong enough was to obtain samples, a task for British Special Operations forces (Hogan 1994, p. 171; Hinsley 1988, p. 89).

## Combined Operations Pilotage Parties

The British Royal Navy had, since 1941, recognized the importance of detailed beach reconnaissance surveys prior to amphibious operations; *viz.*, beach invasions. Such operations required the cooperation of naval and military personnel for their respective tasks. Naval personnel would take soundings, obtain detailed pilotage information such as sailing directions, approach courses for the run-in, bearings, landing marks, coastal silhouettes, and related offshore reconnaissance. Military personnel would perform onshore reconnaissance to obtain details of the texture of the beach, beach exits, gradients, defenses, etc. Each team, known as a Combined Operations Pilotage Party (COPP), had a Royal Engineers

captain, commando trained. All team members required combined operations training – including stalking and unarmed combat – in case of enemy defender interference. The officer in command of the team had to be a Royal Navy navigator or hydrographer. Physical hardening, toughening, and endurance training were essential (Trenowden 1995, pp. 3-6).

COPPs deployed in a variety of craft including canoes, two-man folding boats known as *folbots*, the X-craft midget submarine (Fig. 3), and other small craft (Trenowden 1995, pp. 44-50; Chalcraft 2007).

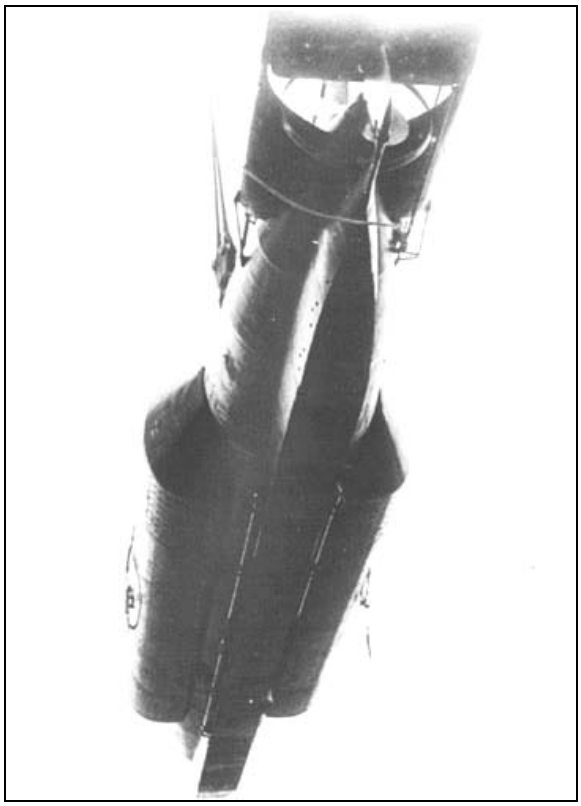

*Fig 3. X-Craft Midget Submarine seen from below.(Courtesy, John Asmussen)*

Each naval beach reconnaissance officer who swam ashore wore a swimsuit designed to give him positive buoyancy and to protect him from the cold, abrasions, and fish stings. The suits were made of rubberized fabric, had tight-fitting cuffs, ankles and hood, and embodied a life-jacket inflated by mouth. They looked like grey rubber frogman's suits but without the fin flippers (Fig. 4). Leather patches protected elbows and knees (Trenowden 1995, p. 6).

The officers did not swim unencumbered: they carried *arms* – a .45 Colt pistol and ammunition – and a fighting knife. COPPists also carried *equipment*: a sounding lead and line, beach gradient reel, wrist watch in waterproof container, under-water writing tablet and Chinagraph pencil, an army oil-immersed prismatic compass, and two waterproofed flashlights for homing on their launch craft. They also would carry survival and evasion equipment: copper acetate fish scares, 24-hour emergency rations, and a brandy flask. In addition, military officers would carry an auger for taking beach samples, rubber sleeves to store the samples in, and a bandolier designed to receive and hold the samples in the order taken (Trenowden 1995, p. 6).

*Fig. 4. WWII-era British Navy Frogman. (Courtesy, Imperial War Museum)*

Commando Soil Sampling Operations: New Year's Eve, 1943

So it was that No. 1 Combined Operations Pilotage Party (COPP-1) was commissioned to gather pre-invasion military intelligence on the beaches along the Calvados coast of Normandy. The landing party consisted of Major Logan Scott-Bowden of the Royal Engineers (Fig. 5) and Sergeant Bruce Ogden-Smith (Fig. 6). Lieutenant Commander Nigel Willmott (Fig. 7), founder of Combined Operations, was in command.

*Fig. 5. Major Logan Scott-Bowden, Royal Engineers, British Royal Navy, COPP-1. (Courtesy, Ian Trenowden)*

*Fig. 6. Sergeant Bruce Ogden-Smith, Commando, British Royal Navy, COPP-1. (Courtesy, Brian Simpkin)*

*Fig. 7. Lieutenant Commander Nigel Clogstoun-Willmott, British Royal Navy, Father of COPP. (Courtesy, Ian Trenowden)*

Part of Scott-Bowden's and Ogden-Smith's training for this mission involved instruction by scientists in how to collect soil samples. The soil-sampling equipment consisted of 10-inch (25 cm) tubes with phosphorescent numbers on their caps, and an 18-inch (46 cm) auger which was pushed fully into the sand and given one-half turn. When pulled up it produced a 10-inch (25 cm) core sample from the lower end. Among the scientists giving the training was Professor John D. Bernal, Cambridge, Chief Scientific Officer to the Chief of Combined Operations. Professor Bernal was one of the scientists who had expressed anxiety about the bearing capacity of the Calvados beaches. He had the ear of Professor Frederick Lindemann, "the Prof", Prime Minister Churchill's scientific advisor (Trenowden 1995, p. 82).

On New Year's Eve 1943, with the expectation that the Germans would be celebrating, the COPP-1 team set out in motor torpedo boats to reconnoiter the area around Luc-sur-Mer, the eastern end of the Calvados coast (Fig 8). They transferred to a hydrographical survey craft and moved closer to shore before Major Scott-Bowden and Sergeant Ogden-Smith went over the side, armed with pistols, daggers, wrist compasses, waterproof flashlights, and sample tubes, to make the 400-yard (370 meter) swim to shore. They had a strenuous swim and the strong cross currents swept them three-quarters of a mile (1.2 km) east of the target area. They were also less than happy to have to land under the glare of a lighthouse beam, rotating every 65 seconds (Trenowden 1995, p. 83).

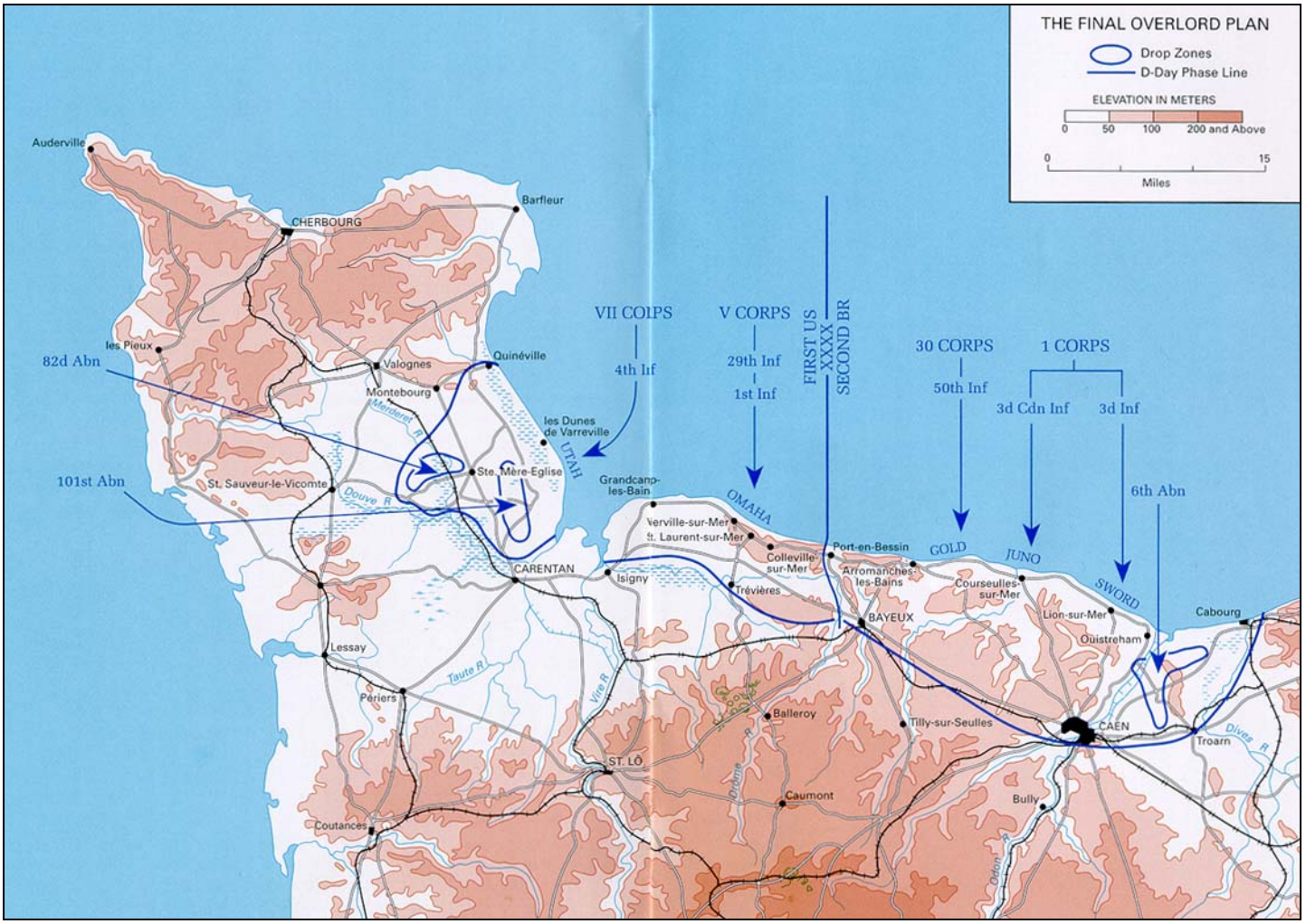


*Fig. 8. The Overlord Invasion Beaches, Normandy, France (west to east): Utah, Omaha, Gold, Juno and Sword. (Courtesy, 88th Infantry Division Blue Devils Map Library)*

> They came in on a rising tide at the seaside village of Luc-sur-Mer on the beach later given the code name Sword (Fig 9). They could hear singing from the German garrison. They crawled ashore, walked inland a bit, went flat when the beam from the lighthouse swept over the beach, walked some more. They made sure to stay below the high-water mark so that their tracks would be wiped out by the tide before morning. They stuck their tubes into the sand, gathering samples and noting the location of each on underwater writing tablets they wore on their arms (Ambrose 1994, p. 74).

Major Scott-Bowden and Sergeant Ogden-Smith filled their bandoliers with tube samples of wet sand, taken according to the required pattern. Then, after examining a potentially dangerous area of exposed peat which had stood out clearly on aerial photographs, they went out into the surf to return to their recovery craft. Because they were so heavily-laden, and because of the force of the breakers, Scott-Bowden and Ogden-Smith had much difficulty getting out to sea. By timing it right and by hard swimming, they eventually made it on the

*Fig. 9. Post-invasion activity on Sword Beach, June 6, 1944. (Courtesy, Imperial War Museum)*

third try. However, during their struggle to get out through the breakers, they lost their auger and a fighting knife. Luckily, they were out past the low tide line where it was felt the items would become buried in the sand, so the secrecy of the mission was not compromised (Trenowden 1995, p. 84).

Three weeks later, this time deployed from the X-20 midget submarine, Scott-Bowden and Ogden-Smith performed periscope reconnaissance and more onshore military reconnaissance near Vierville and along the Omaha Beach area (Fig 10). Two scale models of the landing beaches were prepared using all the information gathered (Slee 2007).

*Fig. 10. Omaha Beach, Vierville Looking East. The plateau is 150 feet (45 m) above sea level. It is several hundred yards (meters) from the high tide line to the foot of the sloping bluffs. (Courtesy, Major J.C. Hatlem)*

Bearing Capacity Analysis

Notwithstanding the drama of these beach reconnaissance and soil sampling operations – feats of bravery for which the King invested Major Scott-Bowden, Sergeant Ogden-Smith, and Lieutenant Commander Clogstoun-Willmott with military medals – today's student of soil mechanics might wonder: "How much could be learned from an 18-inch (46 cm) auger and 10-inch (25 cm) tube sample of beach sand?"

Recall that the primary concern of the Allied Command was whether peat and soft clay existed on the beaches. Stated another way, was there enough cover sand on top of the clay and peat to support armored invasion equipment, especially the heavy, single-axle trucks and trailers?

The minimum depth of sand that analysts were seeking to confirm was 14 inches (36 cm) (Trenowden 1995, p. 7). This particular depth derived from the experiences of Sir Malcolm Campbell, a British racing motorist who held the world land speed record during the 1920s and 1930s and who was viewed as the leading authority on such matters (Fig. 11). Racing at locations including Daytona Beach and Bonneville Salt Flats, Sir Campbell had worked out that a minimum of 14 inches (36 cm) of compacted beach sand was necessary to support his race vehicle. In fact, Sir Campbell used a spring-loaded, impact-type device, something like a steel pogo stick, to confirm the required sand thickness prior to racing. The device was noisy and could not be used by COPPists in stealth-type operations, hence, their use of augers (Educational Broadcasting Corporation 2004).

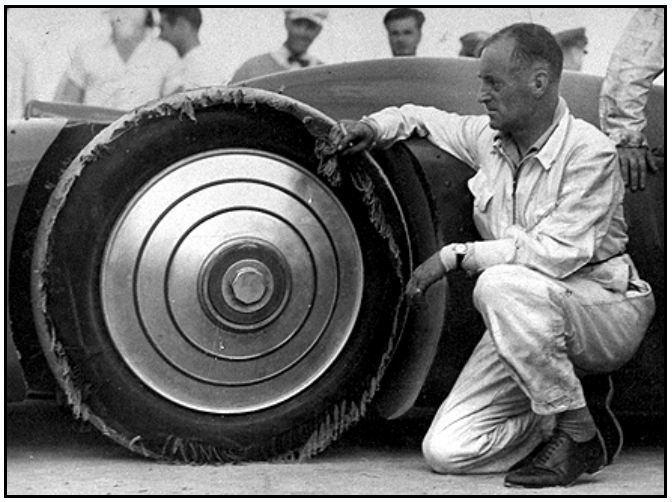

*Fig. 11. Having set the land world speed record on multiple occasions at Daytona Beach in the 1930s, Sir Malcolm Campbell was the recognized authority on beach support of vehicular traffic (Courtesy, www.sirmalcolmcampbell.com)*

Differing reports exist about the evaluation of the beach samples. One source states that the samples revealed that large portions of the beach were underlain by soft blue clay, a problem for which the invasion planners devised countermeasures consisting of wire-reinforced canvas matting to support the armored trucks and tanks (Educational Broadcasting Corporation 2004). However, another source states that "the samples showed that the sand could bear the necessary weight" (Ambrose 1994, p. 75). Either way, in addition to the field measurements of beach sand thickness, Major Scott-Bowden was called to Supreme Headquarters Allied Expeditionary Force in late-January, 1944, to give an account of his reconnaissance, and to answer questions. It was this interview that ultimately settled the matter.

Arriving at Supreme Headquarters, the 23-year old Major found himself facing Admiral Bertram Ramsay (the British naval commander in chief), Lieutenant General Omar Bradley (the principal American ground commander), as well as five more British admirals, five more American admirals, and four more generals (Trenowden 1995, p. 88). They peppered him with questions for about an hour. General Bradley, in particular, was interested in what Scott-Bowden had to say:

> General Bradley took Scott-Bowden back to the large-scale map and pressed him for answers to many questions, mostly related to getting tanks from the beach onto the ridge above… Scott-Bowden was able

> to say, that he'd seen two Percheron horses, in tandem, pulling a small cart up the slope from a construction site; so the track should be suitable for light tanks… (Trenowden 1995, p. 88).

Apparently this was enough. When General Eisenhower and his team arrived in London, they accepted the plan. And so it was settled. The D-Day invasion would come against the Calvados coast of Normandy (Ambrose 1994, p. 77).

Postscript

Upon completion of his interrogation at Supreme Headquarters, Major Scott-Bowden told General Bradley that COPP's other duty was assisting in assault pilotage and that he hoped they would be allowed to do that on D-Day. Bradley replied that he would see what he could do. Logan Scott-Bowden ultimately got his wish. He was present on D-Day to assist in piloting in the American troops to Omaha beach, as was Bruce Ogden-Smith (Trenowden 1995, pp. 88, 140-143). Among the thousands of Allied soldiers who landed on Normandy's beaches that day (Fig. 12), they were the only two who had been there before (Howarth 1959, pp. 184-189).

## USING THIS CASE STUDY IN THE UNDERGRADUATE ENGINEERING CLASSROOM

### Relationship to the Geotechnical Curriculum

This case study fits nicely into the site characterization portion of an undergraduate geotechnical engineering course. Besides being a dramatic story of historical significance in its own right, this case study effectively illustrates several aspects of site characterization. One is how *non-intrusive* exploration tools and methods, such as obtaining and analyzing information from published geologic maps and reports, reviewing aerial photographs, and the like, can provide a more clear picture of the geotechnical issues at a particular site. The case study also illustrates the limitations of non-intrusive methods: in many cases field soil sampling *is* necessary to answer the critical questions. But, field sampling operations are more focused, cost-effective and fruitful when they have been developed based on a sound non-intrusive study.

This case also illustrates *intrusive* site exploration, that is, field soil sampling philosophy, tools, and procedures. Topics include the selection of appropriate soil sampling tools and the

*Fig 12. U.S. troops at Omaha Beach on the morning of June 6, 1944. (Courtesy, Franklin D. Roosevelt Library)*

need for training in proper sample collection techniques. Sample preservation methods are emphasized, as is the importance of carefully and systematically noting field sample locations to facilitate reliable data analysis. Other points include an awareness of the cost, expense and effort associated with field sampling, and the risk of bad things happening when one leaves his equipment in the field.

In addition to non-intrusive and intrusive aspects of site characterization, this case study delves into soil bearing analyses in a basic way. This includes the application of empirically-derived theory based on limited data, intuition and the observational method. And when theory and analytical solutions are not conclusive, this case study illustrates the benefit of a load test – even something as simple as two draft horses pulling a small cart up a slope. Ultimately, this case study reveals the importance of site characterization relative to achieving the intended design objective.

### Telling "the Story"

The author has related this case study to undergraduate students in the introductory geotechnical engineering course for ten years, and to professionals in a geotechnical continuing education course for two years. Without embellishment the story is riveting. But when placed within the context of a geotechnical learning environment, it is given added poignancy. Students are informed that today's soil-sampling operations probably will not require them to make a 400 yard (370 m) swim in mid-winter under cover of darkness carrying "pistols, daggers, wrist compasses, watches, waterproof flashlights, and sampling tubes." However, should they find themselves in such a situation, the goal of the instruction is for them to know what they are doing.

### Instructional Materials and Teaching Aids

This case study can be shared briefly, as an introduction to a site characterization lecture, in no more than 5 minutes. Two teaching aids are necessary: (1) an image of the *Saving Private Ryan* movie poster, and (2) a copy of the Ambrose *D-Day* book.

The *Saving Private Ryan* poster serves at least two functions. First, it provides a colorful and engaging connection to pop culture. Many if not most students have seen the film, and they are drawn to it. Second, the poster establishes a connection with the Ambrose book in that the true story which inspired Spielberg's fictional account about Private Ryan is included in the Ambrose text. This lays the groundwork for telling the commando soil sampling story, also from the Ambrose text.

Having set the stage, it is effective simply to read aloud the brief account (about 1 ½ pages) from Ambrose's book. The story begins on page 73 – "Already the British had collected an enormous amount of intelligence on the French Coast," and ends on page 75 – "The samples showed that the sand could bear the necessary weight." The military acronyms that Ambrose uses quickly get burdensome, so one can ad-lib, fill in details, or condense the material as appropriate.

For the instructor who wishes to provide students with a more comprehensive telling of this story, the greater detail, images and historical accounts provided in this paper provide a place to start. Two film documentaries are also available: "D-Day Remembered: The American Experience" (Guggenheim 1994) and "D-Day: Secrets of the Dead" (Educational Broadcasting Corporation 2004). The latter of these documentaries includes an interview with and personal recollections from Logan Scott-Bowden (retired from distinguished military service at the rank of Major General), and a dramatization/re-enactment of the Sword Beach soil-sampling operation.

## CONCLUSION

Engineering has been called the "invisible profession" or the "stealth profession" because most people are either unaware of or rarely consider the critical role that engineers play in society (eweek.org 2007). In response, engineers are mounting campaigns to enhance and improve their image by portraying engineering as an exciting profession open to everyone (asce.org 2007). For the instructor in a geotechnical engineering classroom, this case study affords an excellent way for students to connect with the material. Incorporated into a site characterization lecture, this dramatic case study illustrates soil exploration methodology and introduces students to the nature, practice and significance of geotechnical engineering as a profession that can directly influence world events and even the course of modern history.

## ACKNOWLEDGEMENTS

The author thanks the many individuals who gave permission to reprint their photographs for this paper.

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