America's Greatest Projects and Their Engineers I

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Introduction

During the past 150 years, Americans have achieved phenomenal success on our way to becoming the greatest nation in the history of the world. Notwithstanding the many inventions that we have created, such as the electric light bulb and the telephone and the airplane and the internet, Americans have been responsible for some of the greatest and most beneficial projects in the modern era.

The intent of this course, the first in a series, is to determine how these projects benefitted Americans in particular, and also how these great projects were developed and managed. Clearly, some of these projects have positively impacted the entire world as well as the United States of America. Some of these projects were on the so-called "drawing board" for several years, or even decades, before they were initiated and developed. Some, such as the Lunar Landing, involved our government (NASA) and many engineering firms and sub-contractors. Others, such as the first atomic bomb, caused enormous devastation to the Japanese, while ending the proliferation of mass casualties and destruction from the greatest war that the world, hopefully, will ever see.

Many of these projects are probably considered by most Americans to be construction projects, but there is little doubt that any of these projects could have been successfully accomplished without administrative support or without the proper planning and design of quality engineers, architects and designers. The strong efforts of dedicated individual engineers as well as the commitments of architectural/engineering firms and the vision and wisdom of quality project managers all resulted in these projects coming to a successful conclusion. This statement is not intended to demean the construction companies or the many manufacturers who were involved in these projects, because their foresight and experience were paramount to the success of each of these projects.

This first section of this course will focus on the Panama Canal Construction and the many largely unknown events, some dating back to the sixteenth and seventeenth centuries, leading up to its development. In addition, this course also includes a description of the construction of the Hoover Dam, emphasizing the wisdom and tenacity of the engineers in the Federal Government to initiate and plan this huge project, as well as the engineers and supervisors of the contractors in the private sector to carry out such an enormous project. Each of these projects has lessons to be learned and, hopefully, each reader will be motivated to do greater things.

Outline

1. Panama Canal

This course traces the history leading up to the actual opening of the Panama Canal in 1914, including the ideas and the attempts by other nations to develop a canal that would join the two oceans. Course also describes the efforts of individual engineers to achieve such an engineering feat.

A. Early Events

B. Enter the United States

C. U. S. Construction Begins

D. Summary

2. Hoover Dam

Also included in this course is a synopsis of the construction of the Hoover Dam, another early twentieth century project that was on the forefront of engineering technology. This course details the contributions of several engineers who participated in this remarkable achievement.

A. Hoover Dam Approval and Administration

B. Hoover Dam Engineering and Design

C. Hoover Dam Construction

D. Summary

Panama Canal

A. Early Events

Nearly every major project in the United States has been influenced by both the needs of its citizens as well as by the political atmosphere of the country. The history, planning, and construction of the Panama Canal were certainly no exception. Considered by most professional engineers and by nearly all civil engineers to be one of the wonders of the modern world, the Panama Canal was many decades in the planning and political stages.

As early as the sixteenth century an access through the Isthmus of Panama was recognized by European leaders and magnates to afford their nations an advantage in shipping and world power. A direct route between the Atlantic Ocean via the Caribbean Sea and the Pacific Ocean would not only cut weeks from their travels around South America's Cape Horn, and through the treacherous Straits of Magellan, but would also strengthen their nation's economic and military power. Even after the American Revolution in 1776 world powers such as Great Britain and Spain continued to explore alternate routes to travel from the Atlantic to the Pacific.

Panama Railroad Company

Nevertheless, the very first official connection between the two great bodies of water turned out to be a railroad. In 1846 a group of investors in New York City managed to raise $1 million, in order to build a railroad that would transfer people and goods from the east coast to the west coast of the United States and then on to Asia. A survey was commissioned and engineering companies were hired in 1848 by William Aspinwall, who had conceived the idea of constructing the railway and who had the federal contracts to deliver mail between the east and west coasts of the United States. Prior to the railway being built, the many travelers who were intent on reaching the West Coast from the eastern U.S. through Panama had used small boats on the very dangerous Chagres River and mules for the last several miles of the journey, which normally took about seven to eight days.

An optimum route of just over 47 miles was chosen, and construction of the railroad began in January of 1850, but many problems were encountered during the first phase of the construction. The survey had many inaccuracies and gross miscalculations, including not being done during the nine-month rainy season when the Chagres River would rise as much as forty feet. Agreements had to be signed between the firm, known as the Panama Railroad Company (PRC) and the Colombian government, which owned the entire Panama region at that time. A port had to be constructed at each end of the railroad to accommodate the steamships that would bring mail, cargo, and people to and from the Isthmus of Panama. Millions of cubic yards

of fill had to be brought in to allow the railroad to span vast regions of swamp land (fortunately, PRC was given access by the Colombian government to a nearby rock quarry.)

The bad news was that after two years of construction, less than eight miles of track had been laid, and the original investment of $1 million had been depleted. The good news was that gold had been discovered in California a few years earlier, and more and more people were appearing every day to seek their fortunes. They were willing to pay large fees to the PRC to take them at least part way across Panama by rail. As the result of these unexpected revenues, the entire railroad was able to be completed by 1855 from end to end at an additional cost of $7 million. The engineers and construction crews had managed to overcome the many problems that would continue to plague them in the future: not just a rainy season that lasted from April to December; or flood waters that caused the nearby Chagres River to rise, but also the alligators that proliferated in the swamp lands, and the diseases of cholera, malaria, and yellow fever that were carried by the millions of mosquitoes and were responsible for the deaths of an estimated 5,000 to 10,000 construction workers.

Furthermore, the railroad was in a continuously rebuilding stage, in large part due to the climate conditions of that area. Because of the nearly bottomless swamplands, the ballast under the tracks was constantly being added. The original railroad ties of pine had to all be replaced within a year, due to the high humidity, with creosote-impregnated ties. Every wooden bridge and trestle was eventually replaced with iron structures, and locomotives, gondolas, and passenger cars were made of iron and other metals. Due to the advances in engineering and technology during that era of the Industrial Revolution, as well as the gold rush in California and the willingness of the ownership to reinvest in the nuts and bolts of the business, the Panama Railroad eventually became the most profitable railroad in the world.

Suez Canal

At about the same time that the PRC was beginning to emerge as the world's preeminent railroad, the French embarked on a project that would connect the eastern Mediterranean Sea to the Red Sea and on into the Indian Ocean. Ferdinand de Lesseps, a career French diplomat, had befriended Egyptian royalty in his role as ambassador, and in 1856 was granted exclusive rights to build a canal through the Isthmus of Suez. The British, who had the largest naval fleet in the world at that time, were extremely opposed to the project. They were initially embittered by this seeming takeover by France of Egypt, which had once been an English colony, and that their monopoly on trade with India and Southeast Asia would be jeopardized. However, the advantage of shorter trade access to India (still a British colony at that time) as well as to southeast Asia markets assuaged the British. Within a few years after voicing their objections, and having been assured by the French that slave labor would not be utilized during

the construction of the canal, the British reluctantly agreed to the project. Great Britain came to recognize the great benefits of the Suez Canal to the entire world.

The Joint Venture that was formed allowed that the Egyptians owned the land, and the French, who were financing the project, would retain a ninety-nine years lease on the canal. The preliminary planning of the Suez Canal had begun as far back as Napoleon Bonaparte's time as ruler of France. However, inaccurate surveys indicated that the water levels between the two seas were significantly different, so that the project was abandoned. De Lesseps had read about attempts to build a canal in the Suez, and commissioned a survey team to provide sea level information at each end of the isthmus. He and his team discovered that the original survey had numerous errors in the elevation calculations and, except for some differences in the tides, the seas were at the same level. De Lesseps, a developer without any engineering background, determined that a sea level canal could be constructed.

Construction of the Suez Canal, a single lane canal measuring slightly over 102 miles long, was begun in April of 1859 under French management. De Lesseps plan was to construct a smaller utility canal the full length of the main canal to move machinery and workers. The project had several delays due to lack of capital, even though more than 200 million Francs had been raised initially by de Lesseps' company. A further delay occurred when the royal emirate of Egypt died in 1864, and the French government had to rescue the project financially.

John Robinson McLean, a British civil engineer who later became the President of the Institution of Civil Engineers in London was instrumental in developing the actual dredging plan for the canal, and designed methods to use two different-sized dredges to both dredge the canal and build up the embankment. The initial single lane canal did have two large lake areas to allow ships going in opposite directions to pass each other. There are still some major improvements being made to the Suez Canal, the last being in 2015. The original plan was to dig a canal, using forced Egyptian labor, deep enough to fill with water and allow small dredgers to float to the worksites and dig a deeper canal. The smaller dredgers would then dig deep enough to allow the larger dredgers to float to the worksites and dig to the final depth of about 25 feet, which at the time was sufficient for the draft of all maritime travel. Constant improvements in dredging equipment and embankment techniques over the decades have seen the depth of the Suez Canal today reach 66 feet.

Enter the French in Panama

The French, largely due to the great financial success of the Suez Canal, were quite open and in favor of the Atlantic to Pacific Canal project. The fact that the project would be under the direction of Ferdinand de Lesseps, the developer of the Suez Canal, allowed the French to initially raise in the vicinity of US$100,000,000. Whereas many nations had understood the

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