

# CIVIL ENGINEERING

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## Summary

Civil engineering is the oldest of the engineering specialties, and its main task is to perform civil works in order to make the properties of matter and the sources of energy in nature useful to people. The advancement of civil engineering has, therefore, been closely related to that of civilization. In this article, human activities on the earth from ancient times to the present are briefly reviewed first, and then the history of the process to establish the civil engineering discipline is discussed for better understanding of the important role that civil engineering has played in the growth of a mature society, from both technological and social points of view. Broad diversification of civil engineering has resulted from the enormous expansion of society during the latter half of the twentieth century. The various branches are briefly described to show the notable characters that civil engineering has formed to maintain the sustainable development of society. In the final part of this article, the prospects of civil engineering in the twenty-first century is discussed.

## 1. Introduction

The aim of this article is to outline the discipline of civil engineering to readers who are not familiar with this field of engineering. Civil engineering is truly the oldest of engineering specialties and is concerned with public undertaking. In addition, the engineering profession itself has an extremely long history of development and has been

associated with the civilizations established throughout history from ancient times to the present. Thus, the term “engineer” was long been recognized as a person who builds various facilities and structures to satisfy the needs of human activities, including military operations.

People have accumulated broad experience and knowledge, and based on this, they have established a number of techniques to improve their lifestyle over several thousands of years. The adopted technique was gradually refined to the engineering discipline by applying the advanced achievement in science and mathematics to various practical applications. Thus, engineering is defined as the discipline in which science and mathematics are applied for the control and use of the material and power in nature for people. The subjects concerned are: building structures, machines, numerous products, systems, and processes. Engineering is one of the oldest professions in the world, and was traditionally classified into the following four primary disciplines: civil engineering, mechanical engineering, electrical engineering, and chemical engineering.

In ancient as well as medieval times, as military activities were extremely important to protect any state, engineering technology was enthusiastically applied to construct structures such as fortresses, roads, bridges, and tunnels. That is why the title of “engineer” was used only for military engineers for a long time. In an old English dictionary, one may find the word “engineer” defined as “a soldier formerly engaged in siege work, but now having the job of ensuring that military vehicles can move quickly and easily across country by building roads, bridges, tunnels, etc.” That is to say, in those days military engineers had far more technical knowledge than others.

In the eighteenth century the term “civil engineering” was used first to distinguish the newly-recognized profession from military engineering. It is well known that John Smeaton, who was the builder of the Eddystone lighthouse near Plymouth, England, called himself a civil engineer to differentiate himself from the “military engineer”. The profession of civil engineering is thus as old as civilization itself, in a broad sense.

In the following section, the fact that civil engineering is the oldest engineering discipline is elaborated. In section 3, the function of civil engineering is discussed, and in section 4, social development of civil engineering, such as education systems, licensing, and civil engineering societies are described. Finally, in section 5, discussion is directed to the considerations that need to be kept in mind in the twenty-first century in order to maintaining sustainable development of the earth, in particular as it relates to global environmental issues.

## **2. Historical Background of Civil Engineering**

Since human beings appeared on the earth, they survived the severe natural environment by securing food, clothing, and shelter, and gradually improved their ways of living to become more comfortable. Generation after generation, people accumulated their experience and improved their skills, step by step, to establish it as technology. They then kept refining their technology to engineering in general practices by applying the science and mathematics that was available at that time.

The following sections describe the process through which civil engineering emerged from engineering in general as an independent profession. From this review, characteristics of civil engineering should become evident.

## **2.1. Engineering in General**

From ancient times people devoted great efforts to constructing various facilities and structures to make their living conditions safer and more effective. This practice kept improving their skill during a tremendously long period of time, and the techniques they learned were applied to numerous projects in other regions of ancient civilizations. We can now visit and enjoy a number of sites of cultural heritage in the world that, fortunately, have survived to the present. In the following, several well-known works will be described.

In ancient Egypt the Great Pyramid at Giza was constructed in about 2600 B.C. with 2.3 million stone blocks that weigh an average of over 1.5 tonnes each. The height and the base length of the pyramid are 146.6m and 230m, respectively. This magnificent construction project was made possible only with the full use of astronomical and other survey technology.

The Great Wall in China is another spectacular heritage site. The total length of the wall is at present about 2,250km, and the construction project was initiated by Shih-hung-ti, the first emperor of China, in 214 B.C. by connecting the walls that existed at that time. The main purpose of this big wall construction was to protect the state against possible invasion by mounted troops through the state's northern border.

There are many other sites of heritage that can be mentioned, such as the Parthenon in Greece, constructed in 438 B.C.; the Roman road built about 310 B.C.; the Pont du Gard, a three-layer arch bridge for the Aqueduct of Nemausus, in France, constructed in about 15 B.C.; the Colosseum in Rome constructed in 80 A.D.; and the Great Canal in China completed in 610 A.D. connecting several big rivers such as the Yellow River and the Yangtze River.

As explained in the introduction section above, ancient technology was refined to engineering with utilization of the results of science and mathematics. However, in medieval times, engineers were isolated from academic advancement, and they had to work by trial and error. This period is thus regarded as a kind of dark period for the engineering profession.

In ancient and medieval times military engineers were specialists in attacking or defending castles and the like with the use of numerous devices. Those military engineers had access to the then most advanced technical knowledge, which could be applied to public works in peaceful times. That is why only military engineers were called engineers for a long time. Leonardo da Vinci (1452–1519) described himself as an excellent military engineer in his letter of introduction to the duke of Milan.

Progress in technology bred engineering with the introduction of scientific and mathematical knowledge. Thus engineering may be defined as a discipline where

sciences and mathematics are applied for practical needs. Later numerous engineering fields have sprouted alongside those of social development.

## **2.2. Civil Engineering as the Oldest Engineering Discipline**

From the earliest times, engineering works related to both military operations and peaceful activities had been mostly civil works. The beginning of civil engineering as a separate discipline may be traced back to the foundation of the Bridge and Highway Corps in France in 1716. From this corps the *École National des Ponts et Chaussées* (the National School of Bridges and Highways) grew in 1747. The oldest of the four primary and main engineering disciplines is civil engineering, which was developed as a profession from the techniques used in the ancient world. It is concerned with designing, site preparations, and construction of all types of structures and facilities, such as bridges, roads, tunnels, harbors, and airfields.

The term “civil engineer” did not come into use until about 1750, when John Smeaton, the builder of the Eddystone lighthouse near Plymouth, England, is said to have started calling himself a civil engineer to distinguish himself from the military engineers of his time. However, the real profession, which is now called civil engineering, is really as old as civilization itself.

## **3. Functions of Civil Engineering**

Civil engineering is a form of human activity that has been pursued ever since people first wanted to change the natural environment for their own benefit. It was well described by Thomas Tredgold in 1829 when the Institution of Civil Engineers in Great Britain applied for its Charter:

That species of knowledge which constitutes the profession of a civil engineer; being the art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic in states both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks, for internal intercourse and exchange, and in the construction of ports, harbors, moles, breakwaters and lighthouses, and in the art of navigation by artificial power for the purposes of commerce, and in the construction and adaptation of machinery and in the drainage of city and towns.

(Thomas Tredgold, 1829)

Of course, added to the above there are particular forms of construction that serve modern needs, such as airports, highways, dams, tunnels, and power stations of various types, but these are minor refinements of the general theme of civil engineer as the creator of physical infrastructure on which any level of civilization depends.

Civil engineering, the oldest of engineering specialties, is concerned with civil works or public works, including building construction, and consists of several separate specializations, as explained later. The function of civil engineers can be divided into the following three categories, depending on the steps in construction practice: those performed before construction, during construction, and after construction. In the first step feasibility studies, site investigation, and design works are carried out in order to make sure that the proposed project is meaningful and executable. In the second step,

which is the main part of the project, closer co-operation among clients, consulting engineers, and contractors is extremely important to complete the construction projects successfully. Finally, in the third step, it is, needless to say, extremely important that maintenance effort is applied to keep the structures alive, in the sense of function as well as physical quality. In addition to these three categories, investigation activities and/or research are also important to solve not only the practical problems encountered during the course of construction works, but also to gain more advanced knowledge on design and execution of construction.

The profession of civil engineering can be divided into three broad categories: consulting, contracting, and government (or municipal) engineering. Civil engineering itself consists of several distinct specializations, such as structures, construction, foundation, transportation, sanitation, and hydraulics. Nowadays, specialization of civil engineering discipline is becoming broader to include areas such as planning and management, remote sensing, landscape, environment, energy facilities, water management, and infrastructure systems, including national and regional planning, urban planning, telecommunication systems, and disaster prevention systems.

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### **Biographical Sketch**

**Kiyoshi Horikawa** is President, Musashi Institute of Technology, and Professor Emeritus, the University of Tokyo and Saitama University, Japan. He was born in 1927 in Tokyo and received his higher education at the University of Tokyo. He then took the degrees of Bachelor and Doctor in Engineering in 1952 and 1964, respectively. In 1954 he was appointed Assistant Professor at the University of Tokyo, and became Associate Professor and Professor at the same institution in 1955 and 1967, respectively. After his retirement in 1988, he continued his work at Saitama University until February 1992.

He has taken various posts successively, including Dean of the Faculty of Engineering, the University of Tokyo, 1984–6; President of JSCE, 1989–90; and President of Saitama University, 1992–8. In addition, he became President, Musashi Institute of Technology in 1998.

His specialty is coastal engineering. His major interests are wave motions, including storm surges and tsunamis, nearshore currents, coastal sediment, and coastal environment protection. He has published over 100 papers and twenty-eight reference books.

He has worked as a Visiting Professor in the United States, Germany, and China.

He has received a number of honors and awards, including JSCE Award, 1969; International Coastal Engineering Award, ASCE, 1981; Prime Minister's Medal for Cultural Contribution (Japan) (known as the Purple Ribbon Award), 1993; National Citation for Cultural Contributions (Japan), 1999, and others.