Water Resources Engineering

Current Fields/Careers of Civil Engineering

I. INTRODUCTION

A. History

Local

During the Spanish colonization in the Philippines, civil engineering was not by virtue of academic title. There were no schools for civil engineering and the only engineers with academic degrees were Spaniards. Indio builders were called Maestro *de Obras* (Master Builders). It is equivalent as of today to construction foreman.

The first artesian wells were built in Betis, Pampanga by Fr. Manuel Camanes. The water system in Manila (now Metropolitan Waterworks and Sewerage System) had its beginning from the water works constructed by Fr. Juan Peguero in 1686. The first irrigation system was built in Tanay, Rizal by Fr. Jose Delgado. Cavite Friar Land Irrigation System is one of the oldest irrigation systems in the country.

The public supply of fresh water to the city dates from the early 18th century. Before this, Manila had to be content with a fresh water supply based on cisterns. They did not get running water until 1878, when the municipal waterworks was established by Governor Domingo Moriones, through the funding of Don Francisco Carriedo y Peredo. In 1882, the first public water fountain gushed forth its waters, and Manila was successfully provided with fresh water supply.

In 1909, during the American colonial era, Wawa Dam (Montalban Dam) was built over the Marikina River in Rodriguez, Rizal. It was constructed to provide the water needs for Metro Manila. It used to be the only source of water in Manila until Angat Dam was built; Wawa was later abandoned. Furthermore, the first national irrigation systems (NIS) was the San Miguel River

Irrigation System in Tarlac, inaugurated in 1913. Meanwhile, the earliest records of communal irrigations systems (CIS) was on 1914, mostly located in the Ilocos area and known as the *zanjera*.

Caliraya Dam was constructed in 1939 during the Japanese occupation in the Philippines. It was an embankment dam located in Lumban, Laguna. Lake Caliraya initially supplied one of the oldest hydroelectric plants in the country, and later became a popular recreational area for water sports and fishing.

In the 1960's, the Philippines became one of the top countries in the world that produces engineers. Numerous waterworks like construction of dams, improvement of water supply and irrigation systems were accomplished since then. At present, civil engineers with specialization in water resources engineering continue to share their expertise and contribute in developing and improving the water resources management in the country.

International

In Water Resources Engineering, the analysis and synthesis of various water problems was not limited through the use of different analytical tools in hydrologic engineering as well as hydraulic engineering but it also focused on the aspects of design and management.

Over the past 9000 to 10,000 years , water resource engineering has progressed as humans have developed the skills and techniques required to construct hydraulic systems to store and transport water. Early examples include irrigation networks developed by the Egyptians and Mesopotaminas, and the Hobokam in North America. The oldest large dam in the world was the Sadd-el Kafara Dam constructed in Egypt between 2950 and 2690 B.C. The oldest known distribution of pressurized water (about 2000 B.C.), was in the ancient town of Knossos on Crete.

-Ancient Asia

Asians have already utilized a water supply and sewer system during the Bronze and early Iron Ages. The Mesopotamians introduced the clay sewer pipes in wells around 4000 BCE, with the earliest examples found in the Temple of Bel at Nippur and at Eshnunna. It was utilized to remove wastewater from sites and capture rainwater. The first sanitation systems were built in prehistoric Iran. The Pyramid of Sahure in ancient Egypt was discovered to have a network of copper drainage pipes.

The Indus Valley Civilization showed early evidence of public water supply and sanitation. In the city of Lothal, houses had their own private toilet which was connected to a covered sewer network made of bricks. The earliest evidence of urban sanitation was seen in Harappa, Mohenjo-daro and Rakhigarhi. Devices like *shadoofs* were used to lift water to ground level. Stepwells have been mainly used in the Indian subcontinent.

The Minoan civilization in ancient Greece used underground clay pipes for sanitation and water supply. Knossos, its capital, has a well-organized system for bringing clean water, removing wastewater, and preventing storm sewage canals to overflow. In ancient Rome, public latrines (toilets) were built over the Cloaca Maxima. They also had indoor plumbing – a system of aqueducts and pipes connecting homes, public wells and fountains to water sources.

-Medieval Europe

Open drains, or gutters, for waste water run-off, known as *kennels*, ran along the center of some streets in London. In Paris, they were called “split streets”, as the wastewater running along the middle physically splits the streets. In 1370, Hugues Aubird designed the first closed sewer Paris, measuring 300 meters long; and was constructed on Rue Montmartre (Montmartre Street). The original purpose of designing and constructing a closed sewer in Paris was more on holding back the stench coming from the odorous waste water rather than for waste management.

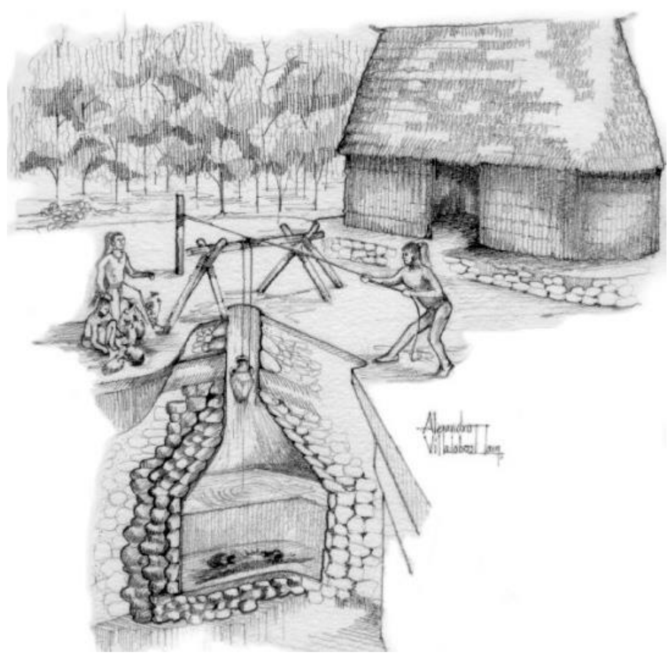
-Islamic Countries

Cities of the medieval Islamic world had water supply systems powered by hydraulic technology that supplied drinking water along with much greater quantities of water for ritual washing, mainly in mosques and *hammams* (baths). They also had sophisticated waste disposal and sewage systems with interconnected networks of sewers. Al-Karaji, a 10th century Persian mathematician and engineer, wrote a book entitled “The Extraction of Hidden Waters”, which presented ground-breaking ideas and descriptions of hydrological and hydrogeological perceptions such as components of the hydrological cycle, groundwater quality, and driving factors of groundwater flow. He also gave an early description of a water filtration process.

-The Maya

The Maya civilization was one of the most dominant indigenous groups of Mesoamerica. They had one of the most sophisticated and complex civilizations in the Western Hemisphere. Unlike other indigenous populations, they are centered in one geographical block covering the entire Yucatan Peninsula and modern-day Guatemala; Belize and parts of Mexico, and the western part of Honduras and El Salvador. The Maya excelled at agriculture, pottery, hieroglyph, writing, calendar-making, astronomy, etc.

As America's first civil engineers, the Maya developed unique water resource technologies that successfully supported a dense population of 1800 to 2600 people per square mile (O'kon, 2007). The region of *Puuc* (Pook) in Yucatan Peninsula has no water sources – no streams, lakes, rivers, or springs – so the Maya developed a way to sustain large populations in this environment. They become excellent in managing rainwater using massive systems of cisterns called *chultuns* to collect and store rainwater.



A *chultun* is a bottle-shaped cavity, excavated by the ancient Maya into the soft limestone bedrock typical of the Maya area in the Yucatan peninsula (Maestri, 2019). Archaeologists and historians report that *chultuns* were used for storage purposes, for rainwater or other things, and after abandonment for trash and sometimes even burials. The word *chultun* probably came from two Yucatec Mayan words *chulub* and *tun*, which mean rainwater and stone. However, archaeologist Dennis E. Puleston suggested that the term is from *tsul* (clean) and *tun* (stone). In modern Maya language, the term refers to a hole in the ground that is wet or holds water.

This unique engineering accomplishment was one of the technical advancements achieved by the Maya during their 2000-year history. It enhanced the inconstant natural water supply. They developed technologies, and sciences that were not "discovered" by the Europeans until the nineteenth century. The Maya also built canals and dams, wells, and reservoirs, and terraces and raised fields to control and conserve water.

-U.S Army Corps of Engineers and the Bureau of Reclamation

The Army Corps of Engineers was created in 1802 with a purpose to improve navigation on existing waterways and to explore western water routes for an expanding nation. In 1824, an act of Congress established the Corps as the nation's preeminent water resources manager. Water resources planning was later added to their responsibilities. The Mississippi River Commission was established in 1879, and the Corps was assigned in charge of planning for an entire river.

In 1902, the U.S. Bureau of Reclamation was created to deal with the physical and hydrological conditions peculiar to the western United States. They worked on reclamation of desert lands for agricultural and municipal uses. Unlike the Corps, the Bureau of Reclamation only covers sixteen westernmost states. Despite the limitations, the Bureau developed into a powerful planner and manager of water resources during the 20th century.

Throughout the 20th century, the U.S Army Corps of Engineers and the Bureau of Reclamation led the United States in the conservation and development of their water resources. As the 21st century opened, the Bureau of Reclamation no longer considered itself a construction agency, but instead a management and planning organization that employs watershed management and river basin planning to assist states and the private sector in meeting all water needs of an arid but highly populated West. Meanwhile, the Corps continues to be a construction and engineering agency, but is also pursuing a number of more environmentally sensitive programs such as wetland protection, mitigation banking, floodplain management, and watershed planning.

B. What is Water Resources Engineering?

Information about Water

About 71 percent of the Earth's surface is covered by water, and the oceans hold about 96.5 percent of it. With that being said, the planet’s water is mostly salt water with just 3 percent fresh water. The greater part of the freshwater is frozen in glaciers and the polar ice caps, the rest can be found as ground water. Though fresh water is deemed to be available as a renewable resource, the supply of pure fresh water is slowly decreasing. The increasing rate of population in the world exceeds the rate of increase of water supply and this results in the shortage of water in many parts of the world. It is reported that during the twentieth century, more than half of all the global wetlands were lost. Water is really essential to human’s daily living and it is also used for agriculture, industry, domestic purposes and environmental events.

Definition of Water Resources Engineering

Water resources engineering is a profession that deals with the provision of water for the use of humans and the different development techniques for the prevention from floods. Water resources engineering also includes planning and management of facilities such as canals for irrigations, sewers for drainage to avoid waterlogging and all other to control the usage and preservation of water.

Sokanu (n.d.) stated that water engineers have many responsibilities, be it technical and non-technical. Significantly, the profession makes it sure that citizens are provided with a continuous supply of clean, uncontaminated water for drinking, living, and recreational purposes. Not only they design water management systems, but often oversee the construction and maintenance of these systems as well, including the demonstration of knowledge in the water industry and environmental issues. Moreover, they are also acquainted to be in charge of creating and developing equipment and systems that are applicable for water resource management for water treatment facilities, underground wells, and natural springs. These systems must be capable of giving the citizens a safe, clean, unpolluted, and continuous reserve of water which is good for drinking, living, and recreational purposes. In fact, the increasing population and continuous demand for more water stimulates this fast-growing industry (Environmental Science, 2020).

II. BODY

A. Branches of Water Resources Engineering or they are also known as:

a. Water and Waste Engineer
b. Water and Sewer Engineer
c. Wastewater Engineer

a. Water and Waste Engineer

In contrast to other water resources engineers, the responsibilities of Water and Waste Engineers are shifted towards more on the following:

1) Designing or overseeing projects involving provision of potable water, disposal of wastewater and sewage, or prevention of flood-related damage;
2) preparing environmental documentation for water resources, regulatory program compliance, data management and analysis, and field work;
3) and performing hydraulic modeling and pipeline design.

They also provide technical direction or supervision to junior engineers, engineering or computer-aided design (CAD) technicians, or other technical personnel.

b. Water and Sewer Engineer

Water and Sewer Engineer's works are associated with paving and grading drainage design in project types ranging from large-scale to small work; creating master plan scale, smaller neighborhoods and site-specific, small scale, and detailed designs. Their expertise also encompasses all phases of project development, including conceptual planning, stormwater modeling, detailed design and analysis, utility coordination, government agency permitting, and project construction. An example of their specific work is designing utility drainage projects, which require building 3-D surface models to delineate drainage basins; extracting data on surface area and volumes; then extracting those results into pipe flow diagrams; and finally importing this information into stormwater models (CMA, 2014).

c. Wastewater Engineer

Lastly, wastewater engineers are responsible for performing activities that can effectively manage or safely transport water that is no longer usable. This includes wastewater treatment and detecting the degree to which water is polluted through technologies such as remote sensing. Also, the profession may provide insight to businesses or government entities on how to better clean or channel wastewater away from sources like rivers and estuaries so they don't become contaminated (UCR, n.d.).

B. Importance of Water Resources Engineering

Resources, by their very nature, are finite. There are only a small handful that are naturally renewable – such as wind, solar, hydro and biomass. While water may be renewable in terms of the many different ways it can be used and reused, it's not as abundant as it once was, which many earth scientists and climatologists point to as a function of climate change. The Bureau of Reclamation provides some perspective as to just how limited this resource is in terms of usability, despite its vastness. If the world's water supply were roughly 26 gallons, the amount of freshwater available for safe usage would be the equivalent to 0.003 liters. That's equal to roughly a half-teaspoon. This means that allocation of water resources is very imperative and that there should be someone managing these resources. This is where water resources engineers do their jobs.

Significantly, water resource engineers, as mentioned above may be charged to develop new systems or processes for private or government entities that can preserve freshwater sources and find new ones. This may require the assistance of civil engineers in designing water purification methods through desalination or creating new equipment for contaminant transport when water is used for irrigation purposes. In addition, understanding what works and what doesn't when it comes to water resource management is often a combined effort and may involve a number of different analyses, including hydrologic, which is the study of the water cycle and directions in which it flows, which may be influenced by weather and other environmental forces.

In addition, they do develop new equipment and systems for water resource management facilities. Water resource systems are something we rely on a day to day basis of our life. Some systems that they have done are those dams that stored water, where they can be released for irrigation and drinking purposes during drought conditions. And during floods, water which is in the thousand million cube amount can be diverted from low lying areas can reduce the effect of damage.

C. Works and Responsibilities of Water Resources Engineers

- Designing sewer improvement plans or flood defence programmes, and associated structures, such as pumping stations, pipework and earthworks
- Keeping up to date with environmental matters; being aware of policy and developments
- Supervising the operation and maintenance of water and sewage infrastructure
- Using computer simulations to analyze, for example, potential dam failure
- Advising on best management of water in its natural state
- Developing of conceptual and numerical models of the hydrological cycle
- Designing and developmenting of plans using standard methodologies
- Devising flood defence strategies
- Monitoring flood levels at times of high risk
- Development of conceptual and numerical models of the hydrological cycle
- Design and development of plans using industry standard methodologies
- Assessment of uncertainty and risks including extreme events e.g. floods and droughts
- Root cause analysis and problem solving

Some Local Projects by Water Resources Engineers

The Pampanga Delta Development Project (Pampanga, Philippines) by TCGI Engineers

Small Water Impounding Management (Nationwide, Philippines) by TCGI Engineers

Agno River Basin Flood Control Study (West Part of Central Luzon) by TCGI Engineers

Some International Water Resources Engineering Project

Hoover Dam (USA)

Water Pipeline Installation (India)

D. Key Skills

- Excellent analytical skills
- Team-working skills
- Root cause analysis and problem-solving skills
- Good time management
- Communication skills
- Technical and commercial reporting skills
- AUTOCAD skills
- IT skills

Like other engineers, water resource engineers have distinct personalities too. They tend to be investigative individuals - they’re intellectual, introspective, and inquisitive. In addition, they are curious, methodical, rational, analytical, and logical. Some of them are also realistic, meaning they’re independent, stable, persistent, genuine, practical, and thrifty.

E. Education Requirements

The Environmental Science Org. (n.d.) stated that Water Resource Engineers are expected to obtain at least a Bachelor's degree. Meanwhile, some companies also demand that one attend an

ABET-accredited program to help with the licensure process, a requirement for all engineers. The Accreditation Board for Engineering and Technology, Inc., or known as ABET is a non-governmental organization that endorses post-secondary education programs in fields of applied and natural science, computing, engineering and engineering technology. Obtaining an engineering license usually includes passing the Fundamentals of Engineering Exam. This field also requires becoming an intern or Engineer-in-Training for a required amount of time. However, requirements for obtaining a license in this field may vary from state to state. Most Water Resources Engineers pursue Masters Degrees. In reality, one out of five Civil Engineers pursue higher education not only to increase chances of being hired but to increase the possibility of landing a higher-paying position.

F. Employment and Salary Information

Local

Water Resource Engineers are organized, possessing problem solving skills, and paying close attention to detail to identify possible water resources issues. With these skill sets, these engineers have an annual salary ranging from Php 306,000 to Php 560,000. These salaries vary based on the position and the organization or company of the water resources engineer.

On the other hand, Indeed (2020) stated that the average salary for a Water Resources Engineer is Php 13,146 per month in the Philippines. Salary was estimated based on 11 salaries submitted anonymously to Indeed by Water Resources Engineer employees, users, and collected from past and present job advertisements on Indeed in the past 36 months.

International

As in most other fields, the overall pay of water engineers is primarily a result of how often expertise they have and their educational degree. Many water management engineering positions include a bachelor's degree, at a bare minimum. The more experience you have, such as a Master of Environmental Engineering degree, the more you expect to gain. According to the latest estimates accessible from the Bureau of Labor Statistics, environmental engineering professionals usually earn around $87,600 which was the average in 2018. The top 10%, though, gained nearly $137,100 and were typically federally employed.

G. Working Environment

Typical water engineers workers privately owned water firms, regulatory bodies, the conservation body, public health departments of local authorities, private consultants or contractors and charities.

Water engineers devote much of their time in an office looking over details and developing new management schemes for water resources. Parts of their day may however be spent on construction sites, overseeing the construction of their projects. When supervising repairs on specialized machinery they can often go to more manufacturing settings. Many full-time jobs, often putting in more than 40 hours a week to adequately supervise projects, and ensure that it runs smoothly.

H. Some Water Resources Engineering Agency and Organizations

Water Resource Engineers and those who wish to become Water Resource Engineers can look to the following government sites for guidance:

Water Laws & Regulations From the U.S. Environmental Protection Agency (EPA).

The EPA is a U.S. government agency that regulates environmental law to protect the country's natural resources and public health. Water Resource Engineers must be familiar with the country's laws and regulations surrounding water in order to build safe, legal systems that can benefit the public.

Water Resource Engineers can also browse through these organizations and websites for valuable resources:

American Academy of Water Resource Engineers (AAWRE).

This is a non-profit organization dedicated to advancing the education and knowledge of ethical practices to Water Resource Engineers. Significantly, they provide a Diplomate, Water

Resource Engineer (D.WRE) certification that helps Water Resource Engineers gain specialized knowledge in the industry and increase hire ability.

American Society of Civil Engineers (ASCE).

ASCE, a professional organization for civil engineers, provides education and career opportunities, conferences around the country, as well as links to professional publications and other information resources. This can be a valuable resource to civil engineers, including Water Resource Engineers.

National Water Resource Board.

The National Water Resources Board (NWRB) is a government agency coordinating and regulating all water resources management development activities. They are tasked to formulate and develop policies regarding water utilization and appropriation, the control and supervision of water utilities and franchises, and the regulation and rationalization of water rates. Its main objective is to achieve a scientific and orderly development of all water resources of the Philippines consistent with the principles of optimum utilization, conservation and protection to meet present and future needs.

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