Transportation Engineering

Current Field/Career of
Civil Engineering

Republic of the Philippines

BATANGAS STATE UNIVERSITY

College of Engineering, Architecture, and Fine Arts

Pablo Borbon Main II, Batangas City

CE 401 – Civil Engineering Orientation

WRITTEN REPORT

TRANSPORTATION ENGINEERING

Learning Objectives

The students should be able to:

1. Develop an understanding of transportation engineering as a field/career of civil engineering,
2. Recognize the different transportation engineering specialties and the duties associated with it, and
3. Identify and grasp the responsibilities and necessary skills of an engineer in the field of transportation.

Introduction

Mobility has always been crucial to human society. In today's world, the need for efficient and safe transportation has increased so much that the transportation facilities of a state are considered a mark of its progress, leading to a direct correlation between the two. Transportation has consistently played an essential role in the advancement of society as it aids in a country's development by facilitating trade between regions, reducing travel time cost, and improving accessibility, initially with regard to trade routes and harbors, but more recently with respect to land- and air-based frameworks too.

Consequently, a branch of civil engineering, specifically transportation engineering, is the one accountable with the design, operation, planning and management of transportation infrastructure, mobility service, traffic, and travellers for various travel modes with the application of technology and scientific principles (Civil Engineering and Engineering Mechanics, 2020). Thus, it is the transportation engineer's responsibility to plan, design, build, operate and maintain the systems of transport, in such a way as to provide for the safe, efficient, rapid, comfortable, convenient, economical, and environmentally sustainable movement of people and goods. They quantify and optimise our mobility infrastructure networks to meet travel and freight demands, while ensuring safety, equity and sustainability, at minimal levels of congestion and cost.

Respectively, according to Partha Chakroborty and Animesh Das in their book “Principles of Transportation Engineering” in 2017, the following are the important disciplines in the field of transportation engineering.

- **Traffic Engineering**

  This area of transportation engineering manages the analysis, design, and operation of transportation facilities utilized by vehicles of different transportation modes. Such an examination assumes utmost significance in the case of roadways as the number of vehicles using the transportation facilities are the highest as well as the most varied in terms of their type, origins and destinations, purposes, etc. The USA based Institute of Transportation Engineers, ITE, characterizes traffic engineering as “that phase of transportation engineering which deals with planning, geometric design and traffic operations of roads, streets and highways, their networks, terminals, abutting lands, and relationship with other modes of transportation.”

- **Pavement Engineering**

  This area of transportation engineering deals with the structural analysis and design of the way used by different transportation modes. Specifically, pavement engineering is concerned with (i) the analysis, structural design, construction, and maintenance of roadway pavements, runways, taxiways, and rail tracks and their drainage and other associated structures, and (ii) the materials used in the construction of all such structures.

- **Public Transportation**

  The area of public transportation is concerned with the analysis, design, and operation of public transportation systems. A public transportation is a transportation system that operates to move the general public from one point to another. The design of a public transportation system includes the design of routes (including stop locations), design of schedules, determination of fare structures, and crew scheduling.

- **Transport Planning**

Transport planning deals with planning transportation facilities that will be able to meet the present and future needs in a sustainable manner. This field focuses on issues like estimation of future demands, needs and problems; generation of alternative transportation solutions; studying the financial, economic, and technological implications of these alternatives; and analyzing their impact on the environment, land-use and demographic trends of an area. Transport planners are also entrusted with the task of choosing the right alternative and preparing a plan for its implementation.

- **Transport Economics**

  This area studies the various economic costs and benefits of building and operating different transportation facilities. The area focuses on (i) identifying the economic costs and benefits and their incident sectors, (ii) studying the numerous techniques available and formulating new techniques to estimate these costs and benefits, (ii) analyzing the financing and cost recovery aspects of transportation projects, and (iv) suggest economic ways of solving certain transportation problems.

Additionally, the other important disciplines as described by the National Programme on Technology Enhanced Learning (NPTEL) are enumerated below.

- **Geometric design**

  It deals with physical proportioning of other transportation facilities, in contrast with the structural design of the facilities. The topics include the cross-sectional features, horizontal alignment, vertical alignment and intersections.

- **Environmental impact assessment**

  The environmental impact assessment attempts in quantifying the environmental impacts and tries to evolve strategies for the mitigation and reduction of the impact due to both construction and operation. The primary impacts are fuel consumption, air pollution, and noise pollution.

- **Accident analysis and reduction**

  One of the silent killers of humanity is transportation. This discipline of transportation looks at the causes of accidents, from the perspective of humans, roads, and vehicles and formulates plans for the reduction.

- **Intelligent transport system**

With the conception of smart city transmuting cities into digital societies, making the life of its citizens easy in every facet, the Intelligent Transport System becomes an indispensable component among all. Intelligent transportation system offers better mobility, efficiency, and safety with the help of state-of-the-art-technology.

Accordingly, along with the mentioned disciplines are the basic elements to be considered in transportation engineering identified by Chakroborty and Das which are briefly described in the following:

- **Driver**

  Every mode of transportation has a driver who controls the vehicle used in the mode of transportation. This element assumes maximum importance in the roadways where a tremendously large number of drivers interact with each other and the facilities wherein safety should always be considered.

- **Vehicle**

  The vehicles which are used in transportation have certain characteristics (e.g. turning radius, braking distance, accelerating capabilities, etc.) which influence the design and operation of the transportation facility.

- **Way**

  Every mode of transportation uses a specified path that is either constructed or charted. For example, in the case of roadways and railways, the way (road or rail track) has to be laid out and constructed while in the case of waterways and airways, the ways used are only charted paths on water bodies or in the atmosphere.

- **Control**

  In order to ensure safety and efficiency of operation, there are system level controls imposed on the movement of the vehicles. These controls should be static (in the form of rules or road signs like “No U Turn” or “One-Way”) or dynamic (in the form of rail or road signals, or instructions from air traffic controllers, etc.).

- **Terminal**

  This is a location where the vehicles of a mode stop for various reasons including (i) boarding (loading) and alighting (unloading) of passengers (or goods), (ii) resting when not in use, (iii) refuelling, (iv) maintenance, etc.

- **User**

Obviously, any transportation system runs to provide service to its users. The users are (i) the public at large for transportation modes that cater to passenger transport or (ii) organizations for transportation modes that cater to goods transport. The transportation system must be sensitive to the needs of its users.

Transportation Engineering Specialties

Transportation engineering includes different specialties as there are various transportation systems being used today such as roadways, railways, waterways, and airways.

Highway Engineering

The history of highway engineering gives an idea about the roads of ancient times. The first mode of transport was by foot followed by the use of animals for transporting both men and materials. These have led to the development of foot-paths. The earliest large-scale road construction is attributed to Romans who constructed an extensive system of roads radiating in many directions from Rome. They mixed lime and volcanic pozzolana to make mortar and they added gravel to this mortar to make concrete. Thus, concrete was a major Roman road making innovation.

The next major development in the road construction occurred during the regime of Napoleon. The significant contributions were given by Tresaguet in 1764. than the lavish and locally unsuccessful revival of Roman practice. This created major drainage problems which were counteracted by making the surface as impervious as possible, cambering the surface and providing deep side ditches. The British engineer John Macadam introduced what can be considered as the 1st scientific road construction method. The modern roads by and large follow Macadam's construction method. Use of bituminous concrete and cement concrete are the most important developments. Development of new equipment helps in the faster construction of roads.

With the advancement of better roads and efficient control, more and more investments were made in the road sector especially after the World wars. It is Highway Engineering which is responsible for the design, construction and maintenance of Highway Roads and Systems, urban streets as well as parking facilities. Its important aspects include overall planning of routes, financing, environmental impact evaluation, and value engineering to compare alternatives. Consequently, traffic engineering is employed which involves planning for the volumes of traffic to be handled, the methods to accommodate these flows, the lighting and signing of highways, and general layout. Older techniques include signs, signals, markings, and tolling while newer technologies involve intelligent transportation systems, including advanced traveller information systems (such as variable message signs), advanced traffic control systems (such as ramp meters), and vehicle infrastructure integration. Similarly, pavement and roadway engineering is applied which involves setting of alignments, planning the cuts and fills to construct the roadway, designing the base course and pavement, and selecting the drainage system. (Transportation Engineering, 2020). Engineers in this specialization:

- handle the planning, design, construction, and operation of highways, roads, and other vehicular facilities as well as their related pedestrian realms,
- estimate the transportation needs of the public and then secure the funding for the project,
- analyze locations of high traffic volumes and high collisions for safety and capacity,
- use civil engineering principles to improve the transportation system, and
- utilizes the three design controls which are the drivers, the vehicles, and the roadways themselves.

Interestingly, Highway Engineering has expanded to include a new area of focus for this discipline on the implementation and use of intelligent transport systems that will eventually revolutionize the way humans travel day to day.

Bridge Engineering

Bridge Engineering deals with the planning and construction of bridges. Bridge planning, design, and construction is an important function of civil engineering. The bridge design will be basically determined by the type of bridge, such as the beam bridge or the suspension bridge. Bridge foundations have to be carefully selected and constructed since they will bear the bridge and the vehicle loads. A bridge is a structure built to span and provide passage over a river, chasm, road, or any other physical hurdle. There are several types of bridges. Here are the five (5) most abundant and common types:

1. Girder bridges

It is the most common and most basic bridge type. In its simplest form, a log across a creek is an example of a girder bridge.

a) Box Girder: Takes the shape of a box. This has two webs and two flanges.

b) Pi Girders: Named for their likeness to the mathematical symbol for pi.

c) I-beam: Very simple to design and build and works very well in most cases. However, if the bridge contains any curves, the beams become subject to twisting forces or torque.

2. Arch bridges

Arch bridges are the types of bridges which pose a classic architecture and the oldest after the girder bridges. Unlike simple girder bridges, arches are well suited to the use of stone. Arches use a curved structure which provides a high resistance to bending forces. Arches can only be used where the ground or foundation is solid and stable because unlike girder and truss bridges, both ends of an arch are fixed in the horizontal direction (i.e. no horizontal movement is allowed in the bearing). Structurally there are four basic arch type bridges:

a) Hinge-less: This uses no hinges and allows no rotation at the foundations.
b) Two-hinged: The two hinged arch uses hinged bearings which allow rotation. This is perhaps the most commonly used variation for steel arches.
c) Three hinged: This adds an additional hinge at the top or crown of the arch.
d) Tied arches: The tied arch is a variation on the arch which allows construction even if the ground is not solid enough to deal with the horizontal forces.

3. Cable stayed bridges

A typical cable stayed bridge is a continuous girder with one or more towers erected above piers in the middle of the span. From these towers, cables stretch down diagonally (usually to both sides) and support the girder. Though only a few cables are strong enough to support the entire bridge, their flexibility makes them weak to a force we rarely consider: the wind. These bridges can be distinguished by the number of spans, number of towers, girder type, number of cables, etc. Typical towers used are Single, Double, Portal, and A-shaped towers. Some typical varieties are Mono, Harp, Fan, and Star arrangements.

CABLE STAYED BRIDGES	SUSPENSION BRIDGES
Have cables attached to the tower(s), which are then supported by foundations.	Called suspenders attached to the bridge and main cable which is then attached to the tower
Force transmission passes from the deck, to the stay cables, to the bridge towers, and lastly, to the foundations	Forces pass from the deck, to the suspenders, to the main cable, to the bridge towers, and to the foundation.

4. Rigid frame bridges

Rigid frame bridges are sometimes also known as Rahmen bridges. The cross sections of the beams in a rigid frame bridge are usually I shaped or box shaped. Though there are many possible shapes, the styles used almost exclusively these days are:

a) Pi-shaped frame: Are used frequently as the piers and supports for inner city highways.
b) Batter post frame: Well suited for river and valley crossings. Piers tilted at an angle can straddle the crossing effectively without construction of foundations.
c) V-shaped frame: V shaped frames make effective use of foundations. Each V-shaped pier provides two supports to the girder, reducing the number of foundations.

5. Truss bridges

Of all the types of bridges, truss bridges are most common, usually in steel bridges. Trusses are comprised of many small beams that together can support a large amount of weight and span great distances. Because the truss is a hollow skeletal structure, the roadway may pass over or even through the structure allowing for clearance below the bridge often not possible with other bridge types. Trusses are also classified by the basic design used.

a) Warren truss: Most common truss. Used in spans of between 50-100m.
b) Pratt truss: Identified by its diagonal members which, except for the end ones, all slant down and in toward the center of the span.
c) Howe truss: Diagonal members face the opposite direction and handle compressive forces.

Railway Engineering

A railway is a permanent track composed of a line of parallel metal rails fixed to sleepers, for transport of passengers and goods in trains. The railways have the advantage over the roadways that they can carry a large number of passengers and large and heavy loads to long distances.

Types of Rails

Rails can be divided into three types:

1. Double Headed Rails
2. Bull Headed Rails
3. Flat Footed Rails

What does a Railway Engineer do?

- An Engineer could be expected to be involved in the design, construction, maintenance and operation of all trains and rail transport systems (monitoring and controlling the rail network and the trains). It encompasses a wide range of engineering disciplines, including civil engineering, computer engineering, electrical engineering, mechanical engineering, industrial engineering and production engineering. Railway engineers possess mechanical design skills and knowledge of propulsion systems that allows them to design train vessels.
- A railway engineer is responsible for providing insight and technical engineering expertise on railway projects and systems such as traction power, train and traffic signal controls, fare collection, rail vehicles and more.

Port and Harbor Engineering

Planning and engineering of ports and harbors covers planning of marine terminals and small craft harbors, ship berthing and maneuvering considerations, port navigation, marine structures, inland navigation, marine construction planning, sediment management, and port economics. Port and Harbor engineers handle the design, construction, and operation of ports and harbors, canals, and other maritime facilities.

Harbor

Harbor is defined as a parking or storage space along the coastline which consists of a thick wall, where boats, barges and ships can take shelter from bad weather or are kept for future. There are different types of the harbour which includes:

a) Natural harbor – a landform where a portion of ocean or sea is protected and is so deep to allow vessels to take refuge.
b) Artificial harbor – Constructed to perform the functions of a port.
c) Semi-natural harbours – This is protected on sides by headlands protection and requires man-made protection only at the entrance.
d) Ice-free harbors – For harbors near the North and South Poles

Ports

Ports serve as the transfer hubs for trade which are usually built near natural harbors. These are land facilities constructed to transfer goods between water and land.

- Docks or berths where vessels moor;
- Equipment and personnel to load and unload vessels;

- Connections to land transportation (such as highways, railways, and pipelines); and
- Cargo storage areas.

Some common port facilities provided by the most common sorts of ports throughout the world are as follows:

a) Special Warehouse: For storing the shipment and for maintaining regular stock.
b) Port Reception: It has details of all shipment scheduled and a guide for the port facilities.
c) Other facilities: Hotels, restaurants, restrooms and eateries for the port visitors. If there is no hospital in the vicinity it becomes obligatory for the port to provide with primary medical services.
d) Fishing facilities: Fishing ports allow its customer with fishing aids and amenities.
e) Warm water facility: Warm water port provides warm water even in frosting winters.
f) Loading and Unloading Facility: It is the mandatory part of every port to allow loading and unloading of freight as well as people in a ship.
g) Infrastructure and Equipment’s: A port has piers, basins, stacking or storage areas, warehouses to store various ferry equipment. Each port is equipped with essential equipment for e.g. hauling equipment’s, draggers, cranes, trucks, loaders, etc.
h) Workshop: It is the place where one can get spare parts and accessories of a vessel. Also, the vessels which have gone out of order are repaired and catered in the workshop.

Types of Ports

1. Inland Port – a port on a navigable lake, river (fluvial port), or canal with access to a sea or ocean, which therefore allows a ship to sail from the ocean to the port to load or unload its cargo. Important functions of Inland ports are summarized below as:
   a) There should be well-established distribution centres for freight distribution
   b) It should be made available for ensuring proper storage of hulks and containers
   c) There should be well established logistic department to handle all logistics activities
   d) There should be a proper warehouse to house spare parts of cargo and other machinery
2. Fishing Port – a port or harbor for landing and distributing fish. The only port that depends on an ocean product and depletion of fish may cause a fishing port to be uneconomical. A fishing port comprises:
   a) Hangers: Special areas employed for the preservation of goods and products.
   b) Supply post: Responsible for satiating the fuel and freshwater demand by the ship.

c) Operation and Administration building: Building in which plans are made for the voyage and fishing and management for all legal as well as health issues.
d) Premises: Houses the deals in fish that is either purchase of fish or sale of fish.

3. Dry Port – inland terminals that can be interconnected with a seaport via road or rail transportation facilities, and they usually act as centres of multimodal logistics. A dry port proves useful in the trade of importing and exporting cargo and can help to lessen the inevitable congestion at a nearby seaport.
4. Warm – water Port – These are the ports in which the water is maintained at warmer temperature. The biggest advantage where a warm water port is concerned is that the water does not freeze during the frosty winters. Therefore, it is free to operate all year round without a temporary shutdown during the freezing time. The main reasons for which warm water ports are considered important are as follows:
    a) It allows trade throughout the year, because in chilling winter, warm-water port is still operational and reach the import-export demand of the nation.
    b) These ports made inland waterway trading possible in countries like Ethiopia.
    c) These are the main reason for the expansion of an empire around the globe.
5. Seaport - most common types of ports around the world which are used for commercial shipping activities. These ports are built on a sea location and enable the accommodation of both small and large vessels. Seaports form some of the biggest and busiest ports in the world.
    a) Cruise Ports - specializes in dealing with the activities of cruise ships and provide the platform for the passengers to enter and disembark the cruises.
    b) Port of Call - is paid a brief visit by a ship on the voyage, also used for carrying out repair works. It serves as a stopover port, in between home ports of a particular vessel.
    c) Cargo Ports - These are the special ports to handle cargo only. These ports are also known as “bulk ports”, “break bulk ports” or “container ports”. Cargo like wood, liquid chemicals or fuel, food grains, automobiles, etc. are handled by Bulk ports whereas containerized cargo or cargo in containers is handled by the Container ports.

Difference between Port and Harbor

BASIS FOR COMPARISON	PORT	HARBOUR
Meaning	An arrangement, where boats and ships moor and transfer passengers and cargo, to/from land.	An area next to the shore, where water crafts are anchored for getting safety from stormy weather.
Location	A port is located inside a harbor.	A harbor cannot be located inside a port.
Construction	Man-made	Natural or man-made
Onshore facilities	Available	May or may not be available

Comparison Chart

The Philippines is another archipelagic nation with a total of 429 ports that make it possible for locals to move from one island to another comfortably.

What does a Port Engineer do?

Port Engineers are in charge with the maintenance and repair of marine vessels of all kinds, but usually larger cargo ships. They are the ones who manage the repairs and maintenance functions of the furnished operating fleet to be able to minimize loss of revenue and cost of repairs. Port Engineers get to know every vessel in the fleet, including its needs and the time it is required. These Engineers work together with the crew at land as well as at the sea to coordinate regular maintenance. When repairs are needed, they often price out the parts and the work to be done to get the best deal for the company.

Importance of Port and Harbor Engineering

According to Tsinker, G. (1997), port construction has been given very little attention due to the fact that Marine Structures Engineering is very broad by itself whereas it involves various array of engineering disciplines such as civil, structural, geotechnical, hydraulic, strength of materials, corrosion, naval architecture and other knowledge of which is needed to produce a sound and economical design of a modern port or marine terminal. Port and Harbor Engineering exhibits geotechnical and structural aspects of port construction which are an essential feature in this field. This engineering field focuses on the improvement of transportation systems with regards to the bodies of water while still on the reclamation and conservancy of land.

Airport Engineering

Airport is a facility where passengers connect from ground transportation to air transportation. The world first airport was built in 1928 at Croydon near London (England). It was the main airport for London till it was closed down in 1959, after World War II. It is now open as a visitor centre for aviation.

Airport Engineering involves the design and construction of facilities for the landing, take off, movement of aircraft on the ground, parking of aeroplanes on loading aprons, maintenance and repairs of areas, access roads from the city side to airport, and handling of passengers, baggage and freight. The following are the important terms in relation to airport engineering:

1. **Aviation** – means flying with the aid of a machine, heavier than air
2. **Aircraft** – includes glider, aeroplane, helicopter, rocket etc.
3. **Aeroplane** – a power driven and heavier than air flying machine.
4. **Airport** – an aerodrome (area used for arrival or departure of an aircraft) which is principally intended for the use of commercial services.
5. **Airfield** – part of the airport which includes the area for landing and take-off of aircrafts
6. **Landing Area** – used for landing and take-off of the aircraft.
7. **Runway** – a properly prepared and built strip of high-quality road used for landing and take-off of planes.
8. **Terminal Area** – provides space for airline operations, office for airport management and provides facilities like rest room, restaurant. etc. for passengers.
9. **Apron** – paved area in front of terminal building (between landing area and terminal building) for parking of the aircraft

What does an Airport Engineer do?

- Airport engineers design and construct airports. They must account for the impacts and demands of aircraft in their design of airport facilities. These engineers must use the analysis of predominant wind direction to determine the runway orientation, determine the size of runway border, and safety areas, various wing tip to wing tip clearances for all gates and must designate the clear zones in the entire port.
- The airport engineer plans, prepares and/or supervises planning studies for improvements, redevelopment and expansion of the airport, public parking facilities, airport roadway systems, ground transportation systems, surveillance systems, checks on plans submitted

by architects and contractors, oversees construction, and handles real estate and zoning problems.

- Airport engineers analyze survey reports, maps, blueprints and other data. They collect and test soil samples to determine the strength of soil used for a foundation, and they use mathematical models to compute various requirements, including load, stress factors and other structural requirements. Engineers review government standards and ensure that construction is compliant with building codes, city ordinances and other government regulations.

Pipeline Engineering

According to Petropedia, a Pipeline Engineer works on the systems that are used to transport gas and oil products. They are the individuals who are responsible for the development of pipeline routes, determining technical specifications like the pipe size and placement. They play a very significant role in planning the location of depots, stations for maintenance, and other installations of accessories that help in the project. In addition to that, they are also responsible for taking care of environmental issues and regulatory limitations that affect the pipelines.

When the installation of pipelines commences, a Pipeline Engineer participates in the quality control process. The engineer is responsible for every single operation from the beginning till the end of oil supply. A Pipeline Engineer carries out the inspection of installations, perform tests and also checks the components that are against the given plans and specifications. The engineer is required to develop creative solutions immediately whenever a problem arises during the development process even when under pressure to avoid costly delays.

Pipeline engineers are responsible for the design, construction, operation, quality control, and maintenance of pipelines and pipeline transportation systems. Pipeline engineers can have a variety of engineering-related backgrounds, including civil engineering, mechanical engineering, structural engineering, materials engineering and chemical engineering.

What is a Pipeline?

Pipelines are pipes, usually underground, that transport and distribute fluids. When discussing pipelines in an energy context, the fluids are usually either oil products or natural gas. If hydrogen fuel gets extensively developed, pipelines will be needed to transport this secondary fuel. Outside of an energy context, pipelines transport other fluids like water. These lines vary in diameter depending on their use, and are generally located underground. There are two major types of pipelines, liquids pipelines and natural gas pipelines. Liquid pipelines transport crude oil or natural gas in liquid form to refineries where they undergo distillation and other production processes. Natural gas pipelines are used solely for the transport of natural gas to processing plants and are used for distribution.

Environmental Concerns

Although they are a necessary part of the use and transportation of assorted petroleum products, there are environmental concerns with the construction and operation of pipelines that vary depending on how and where the pipelines are being built. Some of the concerns include:

a) Reduction of air quality as a result of dust production during construction and emissions due to the combustion of fossil fuels used for construction equipment.
b) Increased noise pollution as a result of construction and pumping stations.
c) Soil erosion and contamination from construction and any leaks.
d) Loss of plant life as a result of construction, surface disturbances, and changes in water flows.
e) Water resource disturbances in terms of quantity and quality as a result of erosion, herbicides, and leaks.

Known Pipeline Engineers' works in the Philippines

Malampaya Gas Field Project

The Malampaya field is located 80km off the Coast of Palawan Island, in the Republic of the Philippines. This project was developed and is being operated by Shell Philippines Exploration on behalf of the joint venture partners. Philippine Department of Energy led the development.

FPIC Black Oil Pipeline

An operating crude oil pipeline in the Philippines. The pipeline was temporarily shut down from November 2010 to June 2011 after FPIC's adjacent white oil pipeline leaked. Its operator is the First Philippine Industrial Corporation (FPIC) with current capacity of100,000 barrels per day and length of 65 mi / 105 km.

Necessary Workplace Skills in Transportation Engineering

According to Zippia, here is the list of the most important skills for a Transportation Engineer in order to be successful in the workplace.

Roadway Design (9%)

- Perform quantity calculations for roadway design.
- Complete roadway design projects, sidewalk projects, trail projects and signal projects.
- Prepare and check roadway design criteria, calculations, and estimated quantities.
- Engineer in the roadway design group for a medium civil consulting firm.

Drainage Design (5%)

- Design and provide technical assistance in drainage design, resolution of drainage complaints, hydraulics evaluations and other hydrology matters.
- Perform geometric and drainage design for various sized highway/roadway projects Assist in overall plan development and writing of bid documents.

Capacity Analysis (4%)

- Conduct manual traffic counts and perform capacity analysis and level of services for existing, no build and build scenarios.
- Signalize and unsignalize intersections using various engineering software packages.

Traffic Control (4%)

- Provide recommendations for efficient functioning of the traffic control systems.
- Prepare construction drawings for transportation projects, including traffic signal design, traffic control markings, and roadway improvements.

Cost Estimates (3%)

- Calculate quantity and cost estimates and prepare the backup quantity shapes and documentation.
- Develop funding approval with project plans and requirements.

Ethernet (3%)

- Coordinate test installation and rearrangement of Ethernet Virtual Circuits with internal and external customers.
- Engage in sales support for TDM, Wavelength, and Layer 2 Ethernet services.

Other Skills: (72%)

Contract Plans, Sonet, DWDM, Project Management, AutoCAD, Corridor, Cell Sites, DS3, New Construction

Notable Transportation Infrastructures in the Philippines

Land Transportation

Epifanio De los Santos Avenue (EDSA)

- Type of Transportation Infrastructure: Highway
- Construction started: 1940
- Maintained by Metro Manila Development Authority and Department of Public Works and Highways

The Epifanio De los Santos Avenue (EDSA) is one of the most popular and iconic highways in the Philippines that serves the National Capital Region and is also a vital highway in the metropolis.

North Luzon Expressway (NLEX)

- Type of Transportation Infrastructure: Highway
- Location: Manila
- Construction started: 1940
- Maintained by Metro Manila Development Authority and Department of Public Works and Highways

The North Luzon Expressway (NLEX) is a 4 to 8-lane limited-access toll expressway that connects Metro Manila to the provinces of the Central Luzon region.

South Luzon Expressway (SLEX)

- Type of Transportation Infrastructure: Expressway
- South end: E2 (STAR Tollway) in Santo Tomas, Batangas
- North end: N140 (Quirino Avenue) in Paco, Manila

- Construction started: 1969

The expressway is a network of two expressways that connects Metro Manila to the provinces of the CALABARZON region in the southern part of Luzon.

Subic-Clark-Tarlac Expressway (SCTEX)

- Type of Transportation Infrastructure: Expressway
- Construction started: April 5,2005
- Opened: July 25, 2008
- Maintained by the Manila North Tollways Corporation

The Subic-Tarlac Expressway or SCTEX is the longest expressway in the Philippines. It is a four-lane highway in the region of Central Luzon that has a total of 94 kms.

Metro Manila Skyway

- Type of Transportation Infrastructure: Skyway
- Construction started: April 7, 1995
- Opened: October 1999
- Operated by the Skyway Operations and Maintenance Corporation (SOMCo)

The Metro Manila Skyway is a project involving elevated highways and the expressway that serves as the main entrance in the south of Metro Manila, across much of the South Luzon Expressway (SLEX).

San Juanico Bridge

- Type of Transportation Infrastructure: Bridge
- Construction started: 1969
- Opened: July 2, 1973
- Owned by the Department of Public Works and Highways

San Juanico Bridge is one of the longest bridges in the Philippines with a length of 2.16 km.

Buntun Bridge

- Type of Transportation Infrastructure: Bridge
- Location: Tuguegarao, Cagayan
- Construction started: 1960
- Maintained by Department of Public Works and Highways

Buntun Bridge has a length of 1.369 that stretches from Tuguegarao City to Solana, Cagayan and spans over the mighty Cagayan River (the largest river basin in the country).

Marcelo Fernan Bridge

- Type of Transportation Infrastructure: Bridge
- Location: Cebu
- Construction started: 1996
- Maintained by Department of Public Works and Highways

Marcelo Fernan Bridge is an extradosed cable-stayed bridge located at Metro Cebu, which has a length of 1.237 km.

Philippine National Railways (PNR)

- Type of Transportation Infrastructure: Railway
- Route: Manila to Bicol Region
- Start of Operations: 1892 (as the Ferrocarril de Manila-Dagupan)
- Maintained by Department of Transportation

PNR linked key cities within the Philippines efficiently and serve as an instrument in national socio-economic development. It also aims to improve the rail transportation of the country.

Light Rail Transit System

- Type of Transportation Infrastructure: Railway
- Location: Metro Manila
- Construction started: 1980
- Maintained by Light Rail Manila Corporation

Light Rail Transit System or the LRTA system, is a rapid transit system serving the Metro Manila area which is also the first metro system in Southeast Asia.

Manila Metro Rail Transit System

- Type of Transportation Infrastructure: Railway
- Location: Metro Manila
- Construction started: 1997
- Maintained by Sumitomo Corporation and Mitsubishi Heavy Industries Engineering

The Manila Metro Rail Transit System or the MRTC system is located along Epifanio de los Santos Avenue (EDSA), one of Metro Manila's main thoroughfares.

Water Transportation

Pasig River Ferry Service

- Type of Transportation Infrastructure: River Ferry Service
- Location: Pasig City, Manila
- Start of Operations: 2007
- Maintained by Metro Manila Development Authority

The Pasig River Ferry Service is a river ferry service that serves Metro Manila, the only water-based transportation that cruised the Pasig River.

Port of Manila

- Type of Transportation Infrastructure: Port
- Location: Tondo, Manila
- Start of Operations: 1901
- Maintained by Bureau of Public Works

Port of Manila is the largest port in the country and also its gateway to international shipping and trade.

Port of Cebu

- Type of Transportation Infrastructure: Port
- Location: Cebu
- Start of Operations: November 21, 2014
- Managed by the Cebu Port Authority

This is the largest domestic port in the Phillipines serving the local population's movements especially from Mindanao and Visayas but it's also serves the international cruise ships and their passengers.

Batangas International Port

- Type of Transportation Infrastructure: Port
- Location: Batangas City
- Opened: 1956
- Operated by the Philippine Ports Authority

Covering 150 hectares the port is the alternative to the Port of Manila when it comes to handling large consignments of cargo and containers.

Port of Subic

- Type of Transportation Infrastructure: Port
- Location: Subic
- Operated and managed by the Subic Bay Metropolitan Authority (SBMA)

It is home to the fourth largest ship building facility globally under the auspices of Hanjin Heavy Industries and construction.

Port of Cagayan de Oro

- Type of Transportation Infrastructure: Port
- Location: Cagayan de Oro, Misamis Oriental
- Operated and managed by the Philippine Ports Authority, PMO Cagayan de Oro

This port recently had a terminal inaugurated as the biggest port passenger port terminal in the Philippines.

Air Transportation

Ninoy Aquino International Airport (NAIA)

- Type of Transportation Infrastructure: Airport
- Location: Pasay, Manila
- Construction started: 1978
- Maintained by Manila International Airport Authority

The Ninoy Aquino International Airport (NAIA) serves as the premier gateway of the Philippines which serves the Metro Manila area and its surrounding regions.

Clark International Airport

- Type of Transportation Infrastructure: Airport
- Location: Clark Freeport Zone
- Opened: June 16, 1996
- Owned by the Department of Transportation, Bases Conversion and Development Authority

The airport serves Central Luzon, Northern Luzon, and to an extent Metro Manila.

Mactan-Cebu International Airport

- Type of Transportation Infrastructure: Airport
- Location: Lapu-Lapu city on Mactan Island
- Construction started: 1956
- Opened: 1960
- Owned by Mactan-Cebu International Airport Authority

It is considered as the second busiest airport in the Philippines, but since opening a new terminal building, it has received more accolades than any airport in the capital region.

Iloilo International Airport

- Type of Transportation Infrastructure: Airport
- Location: Cabatuan, Iloilo
- Construction started: 2004
- Opened: June 14, 2007
- Owned by the Civil Aviation Authority of the Philippines

Iloilo International Airport, also known as Iloilo Airport and as Cabatuan Airport, is the airport serving the province of Iloilo in the Philippines and its capital city, Iloilo City, the regional center of the Western Visayas region.

Notable Transportation Infrastructures around the World

Land Transportation

Guoliang Tunnel Road

- Type of Transportation Infrastructure: Roadway
- Location: Taihang Mountain, Henan Province, China
- Date Started: 1972
- Date Opened: 1977

The Guoliang Tunnel is located in the Taihang Mountains in China's Henan Province, and was built to connect the isolated village of Guoliang to the rest of the world.

The U.S. Freight Rail Network

- Type of Transportation Infrastructure: Railway
- Location: United States

The U.S. freight rail network is widely considered the largest, safest, and most cost-efficient freight system in the world.

Aizhai Suspension Bridge

- Type of Transport Infrastructure: Bridge
- Location: China
- Date of Construction: October 2007 - December 2011
- Date Opened: March 31, 2012

The world's highest bridge, connecting two tunnels in China, is also one of the world's longest suspension bridges.

The Danyang–Kunshan Grand Bridge in China

- Type of Transportation Infrastructure: Bridge
- Location: The spans between the cities of Shanghai and Nanjing
- Date of Construction: 2006-2010
- Date Opened: June 2011

As of June 2011, Danyang-Kunshan Grand Bridge in China held the Guinness World Record for being the world’s longest bridge. This bridge plays a pivotal role to connect the country’s prominent industrial hubs.

Bang Na - Chon Buri Expy

- Type of Transportation Infrastructure: Bridge
- Location: Thailand

The world's longest road bridge is the 34-mile (55-km) long Bang Na expressway in Thailand, a six-lane elevated highway that crosses only a bit of water, the Bang Pakong River.

Lake Pontchartrain Causeway

- Type of Transportation Infrastructure: Bridge
- Location: Southern Louisiana
- Date of Construction: January 20, 1955
- Date Opened: August 30, 1956

The world's longest continuous bridge over water is the Lake Pontchartrain Causeway in southern Louisiana.

Port Mann Bridge

- Type of Transport Infrastructure: Bridge
- Location: Vancouver, B.C.
- Date of Construction: February 4, 2009 - September 17, 2015
- Date Opened: September 18, 2012

The widest bridge in the world (until the Bay Bridge's east span recently opened), the bridge east of Vancouver, B.C., which opened in 2012, remains the second-longest bridge in North America.

Liuchonghe Bridge

- Type of Transport Infrastructure: Bridge
- Location: China
- Date Opened: 2013

Opened in 2013 with a 1,437-foot span, the second-highest cable-stayed bridge in the world rises 1,100 feet above the Liuchonghe River.

Water Transportation

Suez Canal

- Type of Transport Infrastructure: Man-made Sea-Level Waterway
- Location: Mediterranean Sea in Egypt southward to the city of Suez
- Construction Started: 25 April 1859
- Owner/ Constructed by: Suez Canal Company

The Suez Canal is a man-made waterway connecting the Mediterranean Sea to the Indian Ocean via the Red Sea.

Air Transportation

Singapore Changi Airport

- Type of Transport Infrastructure: Airport
- Location: Changi, East Region, Singapore
- Construction Started: 9 July 1933
- Opened: 1 July 1981

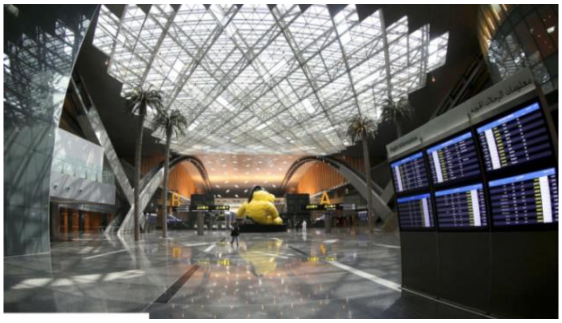
Singapore Changi Airport is a major civilian airport that serves Singapore, and is one of the largest transportation hubs in Asia. It is currently rated the World's Best Airport by Skytrax for the eighth consecutive year since 2013.

Denver International Airport

- Type of Transport Infrastructure: Airport
- Location: Colorado
- Date Opened: February 28, 1995

Denver International Airport is the largest in the United States at more than 33,000 acres, twice the size of Manhattan.

Hamad International Airport



- Type of Transport Infrastructure: Airport
- Location: Qatar
- Date Opened: April 30, 2014

Opened in 2014 and the building spanning over 5,500 acres, Qatar's new main airport has everything from a 200-room hotel to a swimming pool.

References

Books

Chakroborty, P. and Das, A. (2017). *Principles Of Transportation Engineering*. 2nd ed. Delhi: Asoke K. Ghosh, PHI Learning Private Limited, Rimjhim House, 111, Industrial Estate, Delhi-110092, pp.11-13.

Electronic References

About Civil.com (2017, August). *Article about Bridge Engineering*. Retrieved September 1, 2020 from https://www.aboutcivil.org/bridges.html

Anonymous. (n.d). *San Juanico Bridge*. Retrieved September 1, 2020 from https://en.m.wikipedia.org/wiki/San_Juanico_Bridge

Avjobs, Inc. (n.d.). *Aviation Career Directory*. Retrieved August 31, 2020 from https://www.avjobs.com/careers/index.asp?Job_Title=Airport Engineer

Bathla, A. (2017, December 25). *Railway Engineering- Basic Introduction*. Retrieved August 31, 2020 from https://www.slideshare.net/AmanBathla5/railway-engineering-basic-introduction?fbclid=IwAR1iR9Jz4LyhqvJyUii8OdPB4jpxMoEcTMvxbikd-add99jvj-Pk8Y1JSdw

Bhattacharya, S. S. (1982). *Strategic Importance of the Suez Canal*. Retrieved August 31, 2020 from https://en.wikipedia.org/wiki/Suez_Canal

Billington, P., Shirley-Smith, H. (2020, May 07). *Bridge.* Retrieved August 31, 2020 from https://www.britannica.com/technology/bridge-engineering

Browne, Clayton.(2020). *How to Become A Pipeline Engineer*. Retrieved September 3, 2020 from https://work.chron.com/become-pipeline-engineer-12379.html

Business Insider India. (2016, October 05). *The 21 countries in the world with the best infrastructure*. Retrieved August 31, 2020 from https://www.businessinsider.in/finance/the-21-countries-in-the-world-with-the-best-infrastructure/slidelist/54693930.cms

Cailo, R., Hashim, N., and Siniligan, P. K., (2018). *Port and Harbor Engineering*. Retrieved August 28, 2020 from https://slideplayer.com/slide/12777130/

CEPA. (2015, June 08). *Types of Pipelines*. Retrieved September 3, 2020 from http://www.cepa.com/about-pipelines/types-of-pipelines

Civil Engineering and Engineering Mechanics. (2020). *Transportation Engineering*. Retrieved August 28, 2020 from https://www.civil.columbia.edu/transportation-engineering

Civil Engineering Hub. (2017). *History of Highway Engineering*. Retrieved September 1, 2020 from https://civilengghub.blogspot.com/2017/02/history-of-highway-engineering.html

Dasgupta, S. (2019). *What are the Different Types of Ports for Ships?. Marine Ports*. Retrieved August 28, 2020 from https://www.marineinsight.com/ports/what-are-the-various-types-ofports/#:~:text=There%20are%20five%20major%20types,cargoes%20as%20well%20as%20passengers.

Editors of History.com. (2019, July). *Golden Gate Bridge*. Retrieved September 1, 2020 from https://www.history.com/.amp/topics/landmarks/golden-gate-bridge

Editors of Highest Bridge.com (2019, August). *Millau Viaduct*. Retrieved September 1, 2020 from http://www.highestbridges.com/wiki/index.php%3Ftitle%3DMillau_Viaduct

Encyclopedia Britannica. (2020). *Roads And Highways | Transportation*. Retrieved August 29, 2020 from https://www.britannica.com/technology/road

EV Learners. (2017). *San Juanico Bridge and its History*. Retrieved August 29, 2020 from http://evlearners.com/san-juanico-bridges-history/

Federal Railroad Administration. (n.d.). *The Freight Rail Network*. Retrieved August 31, 2020 from https://railroads.dot.gov/rail-network-development/freight-rail-overview

Flores, M. (2017). *10 Longest Bridge in the Philippines. FAQ.ph.* Retrieved August 29, 2020 from https://faq.ph/10-longest-bridges-in-the-philippines/

FPIC Black Oil Pipeline. Retrieved September 3, 2020 from https://www.gem.wiki/FPIC_Black_Oil_Pipeline

Gammon, K. (n.d.). *LiveScience. What's the World's Longest Bridge?*. Retrieved August 31, 2020 from https://www.google.com/amp/s/www.livescience.com/amp/34448-worlds-longest-bridge.html

ICONTAINERS: Five Major Ports in the Philippines. Retrieved September 3, 2020 from https://www.icontainers.com/us/2020/03/30/top-five-ports-philippines/

Iloilo International Airport. Retrieved August 31, 2020 from https://en.wikipedia.org/wiki/Iloilo_International_Airport

Jamal, H. (n.d.). *About Civil Engineering*. Retrieved August 31, 2020 from https://www.aboutcivil.org/railway-engineering

Jamal, H. (2017). *Airport Engineering. Transportation Engineering*. Retrieved August 28, 2020 from https://www.aboutcivil.org/airport-engineering-definitions

Jaime, J. (2015, April 21). *Port and Harbor Engineering.* Retrieved September3, 2020 from https://www.slideshare.net/JJaime_OFFICIAL/port-and-harbor-engineering

Kaushal, A. and Singh, J. (2015). *Airport Engineering. Engineering*. Retrieved August 28, 2020 from https://www.slideshare.net/jaspreetrooprai138/airport-engineering

Khan, M. A., H.D., M.Phil., DIC, P.E. (2015). *Bridge Engineering*. Retrieved August 31, 2020, from https://www.sciencedirect.com/topics/engineering/bridge-engineering

Lamb R. and Morrissey M. (2000, April). *How Bridge Work*. Retrieved September 1, 2020 from https://science.howstuffworks.com/engineering/civil/bridge6.htm

Largest projects in the Philippine economy. Retrieved August 31, 2020 from https://en.m.wikipedia.org/wiki/Largest_projects_in_the_Philippine_economy

Lee. (2020). *These Philippine Airports Are on Par With the World's Best*. Retrieved August 31, 2020 from https://www.esquiremag.ph/life/travel/best-airports-in-the-philippines-a2502-20200309-lfrm

Mactan-Cebu International Airport. Retrieved August 31, 2020 from https://en.wikipedia.org/wiki/Mactan%E2%80%93Cebu_International_Airport

Malampaya Gas Field Project, South China Sea. Retrieved September 3, 2020 from https://www.offshore-technology.com/projects/malampaya/

National Programme on Technology Enhanced Learning (NPTEL). (2020). *NPTEL :: Civil Engineering - Transportation Engineering I*. Retrieved August 31, 2020 from https://nptel.ac.in/courses/105/101/105101087/

Natural Resources Canada. (2015, June 08). *Pipeline Safety*. Retrieved September 3, 2020 from https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/files/pdf/14-0277-%20PS_pipelines_across_canada_e.pdf

Nigh B. (2015). *Business Insider. Locals chiseled the Guoliang Tunnel into-and through- the side of a mountain*. Retrieved August 31, 2020 from https://www.google.com/amp/s/www.businessinsider.com/guoliang-tunnel-built-into-mountain-2015-12%3famp

Petropedia. (n.d.). *Pipeline Engineer*. Retrieved August 29, 2020 from https://www.petropedia.com/definition/7104/pipeline-engineer#:~:text=A%20Pipeline%20Engineer%20is%20an,the%20pipe%20size%20and%20placement.

Port Engineer. (n.d.). *What does a port engineer do?*. Retrieved August 28, 2020 from https://www.careermatch.com/job-prep/career-insights/profiles/port-engineer/

Railway Engineering. (2013, March 10). Retrieved August 31, 2020 from https://whatisengineering.com/what-is-railway-engineering/

Railway Engineering. (n.d.). Retrieved August 31, 2020 from http://www.railwayeng.com/

Randstad (2019, June 30). *What are the different rail engineering roles?*. Retrieved August 31, 2020 from https://www.randstad.co.uk/career-advice/job-profiles/what-are-different-rail-engineering-roles/

Road Traffic Technology. (2013). *The world's longest highway*. Retrieved September 1, 2020 from https://www.roadtraffic-technology.com/features/feature-the-worlds-longest-highways/

San Juanico Bridge. Retrieved August 31, 2020 from https://en.wikipedia.org/wiki/San_Juanico_Bridge

Seah P. (2015). *Changi Airport: A significant story for Singapore's young*. Retrieved August 31, 2020 from https://en.m.wikipedia.org/wiki/Singapore_Changi_Airport

Singh, J. (2015, February 18). *Airport engineering*. Retrieved August 31, 2020 from https://www.slideshare.net/jaspreetrooprai138/airport-engineering?fbclid=IwAR0Pr_ji1JRr62h8G1Vboz2a43d9jEGoWfV6dPIP52L58YcUKPWxvOucTII

Skyway (Metro Manila). Retrieved August 31, 2020 from https://en.m.wikipedia.org/wiki/Skyway_(Metro_Manila)

Study.com (2019, September 25). Air*port Engineer: Job Description and Education Requirements*. Retrieved August 31, 2020 from https://study.com/articles/Airport_Engineer_Job_Description_and_Education_Requirements.html

Surbhi, S. (2017). *Difference between Port and Harbour*. Retrieved August 28, 2020 from https://keydifferences.com/difference-between-port-and-harbour.html

Team, G. (n.d.). *Rail systems engineer*. Retrieved August 31, 2020 from https://www.goconstruct.org/construction-careers/what-jobs-are-right-for-me/rail-systems-engineer/

The 15 Countries With the Best Transportation. (n.d.). Retrieved August 31, 2020 from https://www.travelandleisure.com/travel-tips/ground-transportation/best-easiest-countries-for-ground-transportation

The Free Dictionary by Farlex. (2020). *Airport Engineering*. Retrieved August 28, 2020 from https://encyclopedia2.thefreedictionary.com/airport+engineering

Thomas, T. (n.d). *Ports and Harbors. Water Encyclopedia*. Retrieved August 28, 2020 from http://www.waterencyclopedia.com/Po-Re/Ports-and-Harbors.html

Transportation Engineering. (2020). *Transportation Engineering*. Retrieved August 29, 2020 from http://www.thecivilengg.com/transportation_engineering.php

Travel Triangle (n.d.). A *Guide To Danyang-Kunshan Grand Bridge: History And Top Places Nearby*. Retrieved August 31, 2020 from https://www.google.com/amp/s/traveltriangle.com/blog/danyang-kunshan-grand-bridge/amp/

Verdict Media Limited (2020). *Subic-Clark-Tarlac Expressway*. Retrieved August 31, 2020 from https://www.roadtraffic-technology.com/projects/subic-clark/

What is Engineering. (2016). *What is highway Engineering*. Retrieved September 1, 2020 from https://whatisengineering.com/topic/what-is-highway-engineering/

World Heritage Encyclopedia. (2020). *Transportation in the Philippines*. Retrieved August 29, 2020 from http://self.gutenberg.org/articles/eng/Transportation_in_the_Philippines

Zippia. (2020). *Transportation Engineer Skills*. Retrieved August 29, 2020 from https://www.zippia.com/transportation-engineer-jobs/skills/