CHAPTER 1

Introduction to Civil Engineering

Civil engineering is the oldest branch of engineering which is growing right from the stone age civilization. American Society of Civil Engineering *defines Civil Engineering as the profession in which a knowledge of the mathematical and physical sciences gained by study, experience and practice is applied with judgement to develop ways to utilize economically the materials and forces of nature for the progressive well-being of man.*

In this chapter, scopes of different fields of civil engineering are discussed and the importance of developing infrastructure in the country is presented.

1.1 SCOPE OF DIFFERENT FIELDS OF CIVIL ENGINEERING

Civil Engineering may be divided into the following fields:

(i) Surveying
(ii) Building Materials
(iii) Construction Technology
(iv) Structural Engineering
(v) Geotechnical Engineering
(vi) Hydraulics
(vii) Water Resources and Irrigation Engineering
(viii) Transportation Engineering
(ix) Environmental Engineering and
(x) Architecture and Town planning

Scope of each one of these is discussed below.

(i) Surveying

Surveying is the science of map makng. To start any development activity in an area the relative positions of various objects in the horizontal and vertical directions are required. This is approved

by surveying the area. Earlier, the conventional instruments like chain, tape and levelling instruments were used. In this electronic era, modern equipments like distance meters and total stations are used to get more accurate results easily. The modern technologies like photogrammetry and remote sensing have made surveying easier.

(ii) Building Materials

Shelter is the basic need of civilization. To get good shelter continuous efforts are going on right from the beginning of civilization. Stones, bricks, timber, lime, cement, sand, jellies and tiles are the traditional building materials. Use of steel, aluminium, glass, glazed tiles, plaster of paris, paints and varnishes have improved the quality of buildings. The appropriate mixture of binding materials like lime and cement with sand is known as mortar. The mixture of cement, sand and jelly (crushed stones) with water is known as concrete. The use of concrete with steel bars placed in appropriate position has helped in building strong and durable tall structures. The composite material of concrete and steel is called reinforced cement concrete which is popularly known as R. C C. A civil engineer must know the properties of all the building materials so that they can be used appropriately. Improved versions of many building materials appear in the market. A good civil engineer will make use of them at the earliest.

(iii) Construction Technology

Construction is the major activity of civil engineering which is continuously improving. As land cost is going up there is demand for tall structures in urban areas while in rural areas need is for low cost constructions. One has to develop technology using locally available materials. In India, contribution of Central Building Research Institute (CBRI) - Roorkee and Gaziabad, several educational institutions throughout the country and Nirmithi Kendras in the technology development are noteworthy.

(iv) Structural Engineering

Load acting on a structure is ultimately transferred to ground. In doing so, various components of the structure are subjected to internal stresses. For example, in a building, load acting on a slab is transferred by slab to ground through beams, columns and footings. Assessing the internal stresses in the components of a structure is known as Structural Analysis and finding the suitable size of the structural component is known as design of structure. The structure to be analysed and designed may be of masonry, R. C C. or steel. Upto midsixties considerable improvements were seen in classical analysis. With the advent of computers numerical methods emerged and analysis and design packages are becoming popular. Matrix Method of analysis and Finite Elements Analysis have helped in the analysis of complex structures. A civil engineer has not only to give a safe structure but he has to give economical sections. To get economical section mathematical optimization techniques are used. Frequent earthquakes in the recent years have brought, importance of analysis of the structure for earthquake forces. Designing earthquake resistant structures is attracting lot of researches. All these aspects fall under structural engineering field.

(v) Geotechnical Engineering

Soil property changes from place to place. Even in the same place it may not be uniform at various depths. The soil property may vary from season to season due to variation in moisture

content. The load from the structure is to be safely transferred to soil. For this, safe bearing capacity of the soil is to be properly assessed. This branch of study in Civil Engineering is called as Geotechnical Engineering.

Apart from finding safe bearing capacity for foundation of buildings, geotechnical engineering involves various studies required for the design of pavements, tunnels, earthen dams, canals and earth retaining structures. It involves study of ground improvement techniques also.

(vi) Hydraulics

Water is an important need for all living beings. Study of mechanics of water and its flow characteristics is another important field in Civil Engineering and it is known as hydraulics.

(vii) Water Resources and Irrigation Engineering

Water is to be supplied to agriculture field and for drinking purposes. Hence suitable water resources are to be identified and water is to be stored. Identifying, planning and building water retaining structures like tanks and dams and carrying stored water to fields is known as water resources and irrigation engineering.

(viii) Transportation Engineering

Transportation facility is another important need. Providing good and economical roads is an important duty of civil engineers. It involves design of base courses, suitable surface finishes, cross drainage works, road intersections, culverts, bridges, tunnels etc. Railway is another important long-way transport facility. Design, construction and maintenance of railway lines, signal system are part of transportation engineering. There is need for airports and harbours. For proper planning of these transportation facility, traffic survey is to be carried out. Carrying out traffic survey, design, construction and maintenance of roads, bridges, railway, harbour and airports is known as transportation engineering.

(ix) Environmental Engineering

Proper distribution of water to rural areas, towns and cities and disposal of waste water and solid waste are another field of civil engineering. Industrialisation and increase in vehicular traffic are creating air pollution problems. Environmental engineering while tackling all these problems provides healthy environment to public.

(x) Architecture and Town Planning

Aesthetically good structures are required. Towns and cities are to be planned properly. This field of engineering has grown considerably and has become a course separate from Civil Engineering.

1.2 TYPES OF INFRASTRUCTURE

Infrastructure facilities involve various civil engineering amenities, electricity, telephone, internet facility, educational and healthcare facilities. Civil engineering amenities in the infrastructure developments are listed below:

(i) A good town planning and developing sites
(ii) Providing suitable roads and network of roads
(iii) Railway connection to important places
(iv) Airports of national and international standards

(v) Assured water supply to towns, cities and rural areas
(vi) A good drainage and waste disposal system
(vii) Pollution free environment.

1.3 EFFECT OF INFRASTRUCTURE FACILITIES

Connecting producing centre to marketing places minimises exploitation from middlemen. Both producer and consumers are benefitted. Imports and exports become easy as a result of which whole world becomes a village. The infrastructure development generates scope for lots of industries. Manpower is utilized for the benefit of mankind. Antisocial activities come under control. Improved education and healthcare give rise to skilled and healthy work force. Quality of life of the people is improved. In case of natural calamities assistance can be extended easily and misery of affected people is reduced. Infrastructure facility improves defence system and peace exists in the country. Improved economical power of the country brings a respectable status in the world.

The world has realized that a government should not involve itself in production and distribution but should develop infrastructure to create an atmosphere for economical development.

1.4 ROLE OF CIVIL ENGINEERS IN THE INFRASTRUCTURE DEVELOPMENT

A civil engineer has to conceive, plan, estimate, get approval, create and maintain all civil engineering infrastructure activities. He has to carry out research and training programmes to improve the technology. Civil engineer has a very important role in the development of the following infrastructures:

(i) Town and city planning
(ii) Build suitable structures for the rural and urban areas for various utilities.
(iii) Build tanks, dams to exploit water resources.
(iv) Purify the water and supply water to needy areas like houses, schools, offices, and agriculture field.
(v) Provide good drainage system and purification plants.
(vi) Provide and maintain communication systems like roads, railways, harbours and airports.
(vii) Monitor land, water and air pollution and take measures to control them.

Questions

1. Briefly give the scope of different fields in Civil Engineering.
2. List various civil engineering amenities covered under infrastructure developments.
3. Discuss briefly impact of Civil Engineering infrastructure developments on the economy and environment.
4. Briefly explain the role of Civil Engineers in the infrastructure development.

CHAPTER 2

Roads

The path overwhich vehicles and other traffic may lawfully pass is called road. It includes pathway, other related structures like culverts, bridges and land aquired for future widening. The entire area required and reserved for road along its alignment is called *Right of Way*.

Development of civilisation is closely associated with the developments of roads. The first hard surface was constructed in 3500 BC in Mesopotamia. At the same time even in Mohenjodaro and Harappa well built roads were seen. In 600 BC a metallic road of 6 to 7.5 m wide existed in Rajgir near Patna. In about 300 BC, Kautilya got constructed National Highway connecting North West Frontier Province (now in Pakistan) and Patna. Chandra Gupta Maurya and Ashoka contributed considerably for development of road network. Mohammed Tughlaq constructed a road connecting Delhi and Doulatabad. Shershah constructed a Highway from Lahore to Sonargaon (Bengal). In the British rule Lord William Bentinck, Lord Dalhousie, Lord Minto and Lord Ripon contributed a lot for the road development in India.

In 1934 a semi-official technical body known as Indian Road Congress (IRC) was formed to provide a forum for regular pooling of experience and ideas on all matters affecting the planning, construction and maintenance of roads in India. First 20 years road development plan was prepared for whole country in the 1943 conference held at Nagpur. It is known as Nagpur Road Plan. It classified various roads required for the country and aimed at achieving a target of 16 km per 100 square kilometre of the country, by 1963. The second twenty years road development plan was finalised in the IRC meeting held in Bombay in 1959. It aimed at providing 32 km length of road per 100 square kilometre area. This is known as Bombay Road Plan and it covered 20 years from 1961 to 1981. The third 20 years development plan for the period 1981–2001 was finalised in Golden Jubilee Conference of IRC in 1985 held at Lucknow. It aimed at achieving a road density of 82 km per 100 sq. m area.

2.1 TYPES OF ROADS

Various criteria may be used for classifying roads. Depending upon the usage of roads during rainy season they may be classified as

(i) all weather roads and

(ii) fair weather roads.

All weather roads are not flooded during rainy seasons except to a small extent at river crossing for a small length. In fair weather roads overflowing of streams across the road is permitted during monsoon season.

Based on the type of pavement surfaces provided the roads may be classified as

(i) surfaced roads and

(ii) unsurfaced roads.

Surfaced roads are provided with a bituminous or concrete surface while unsurfaced roads may be mud roads or water bound macadam layer roads.

The **Nagpur Road Plan** classified the roads in India into the following five categories:

(i) National Highways (NH)

(ii) State Highways (SH)

(iii) Major District Roads (MDR)

(iv) Minor or other District Roads (ODR) and

(v) Village Roads (VR)

(i) National Highways (NH)

These are the roads connecting important cities, towns, ports etc. of different states. They may even connect the neighbouring countries also. The National Highways have two-lane traffic at least 8 m wide with at least 2 m wide shoulders on each side. The construction and maintenance of these roads is taken care by the Central Government agencies like Central PWD or Military Engineering Service (MES). The National Highways are assigned the respective numbers. The highway connecting Delhi-Ambala-Amritsar is denoted as NH-1. The National Highway connecting Poona-Bangalore-Chennai is called as NH-4. The west-coast highway connecting Bombay to Kanyakumari is known as NH-17.

(ii) State Highways (SH)

These are important roads of a particular state connecting important cities and district headquarters. They connect important cities to national highways. They are maintained by State Public Works Departments and Central Government gives grants for the construction and development of these roads. These highways also have 8 m carriage way and 2 m wide shoulders on each side. The design speed and design specifications of State Highways are same as those for National Highways.

(iii) Major District Roads (MDR)

These are the roads within a district connecting market and production areas to State or National Highways or railway stations. The MDR has lower speed and geometric design specifications than for NH or SH.

(iv) Minor or Other District Roads (ODR)

These roads connect rural areas of production to market centres, taluk centres or other main

roads. These roads have lower design specifications than MDR. These roads are looked after by district authorities with the help of State Government Departments.

(v) Village Roads (VR)

The roads connecting villages or group of villages with each other or the roads of higher category. The local district boards are responsible for the construction and maintenance of these roads. These roads are usually unmetalled.

After the **third road development plan (Lucknow Road Plan)** the roads in the country are classified into three classes, viz.

(i) **Primary System**
(ii) **Secondary System** and
(iii) **Tertiary system** or **Rural Roads**

Primary system consists of two categories

(i) Expressways and
(ii) National Highways (NH)

Expressways are superior to National Highways and are provided wherever volume of traffic is very high. They have superior facilities and design speed. No cross-traffic is permitted on Expressways. They are provided with central separator for the traffic in opposite directions. They are fenced so that animals do not enter. Controlled access is provided to other roads and cities and towns. Only fast moving vehicles are permitted. Expressways may be owned by State or Central Government. Golden Quadrilateral connecting Delhi, Bombay, Chennai, Calcutta and Delhi is owned by Central Governments. This line passes through Belgaum, Dharwad-Hubli, Davangere, Chitradurga, Tunkur and Bangalore in Karnataka, Bangalore–Mysore Infrastructure Corridor (BMIC) expressway, which is under construction, is owned by the State Government. The construction works have been under taken on the basis of Build–Operate–Transfer (BOT) by private parties on contract assigned by the respective governments.

The secondary system consists of two categories of roads, namely, State Highways and Major District Roads.

The third category of roads consist of Other District Roads and Village Roads.

Urban Roads form a separate class of roads, which are taken care by municipalities/ municipal corporations. These roads may consist of the following:

(i) Expressways
(ii) Arterial roads
(iii) Sub-arterial Roads
(iv) Collector streets and
(v) Local streets.

Local streets are abutt to private properties like shops and houses. They are connected to collector streets. Arterial and sub-arterial roads are streets primarily to through traffic.

2.2 COMPONENTS OF ROADS

All roads consist of the following components:

(i) Pavement or carriageways
(ii) Shoulders

(i) Pavement or Carriageways

This is the width of road which is designed to handle volume of expected traffic. As per Indian Road Congress specification, the maximum width of vehicle is 2.44 m. A side margin of 0.68 m is required for safe drive of the vehicle. Hence for a single lane road carriageway width works out to be 3.8 m. For road pavements having two or more lanes, the width of 3.5 m per lane is considered sufficient. Number of lanes required for a road is decided by volume of traffic to be handled and also financial considerations. The cross-section of carriageway consists of the following components [Ref. Fig. 2.1]:

(a) Subsoil
(b) Subgrade
(c) Base and
(d) Surfacing.

Subsoil is the natural or prepared soil which will take the load of the road. It is prepared by properly compacting the natural soil.

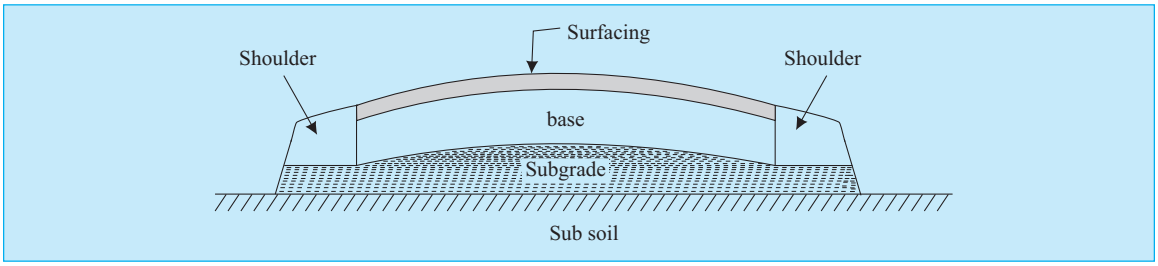

Fig. 2.1 Cross-section of carriageway

Subgrade gives support to the road structure. It should remain stable and dry throughout. Considerable attention is to be given to laying proper subgrade to get stable road surface. The subgrade soil consists mainly of disintegrated rocks like gravel, sand, silt and clay. The desirable properties of subgrade soil are

– stability
– permanency of strength
– incompressibility
– minimum change in volume
– ease of compaction and
– good drainage.

The **base** may consist of two layers, top layer being called as base and bottom one as sub-base. Base course and sub-base course distribute the load through a finite thickness. Sub-base is made with stabilised soil or selected granular soil, bricks or boulders. However, it is better if graded aggregates with soil are used instead of boulders. Base course is provided with broken stone aggregates.

Surfacing is the topmost layer of carriageway which takes load from traffic directly. It has to provide a smooth nonslippery and stable surface for the vehicles. It should be impervious and should protect base and subgrade from rainwater. It may be provided with bituminous material or with cement mixed with baby jelly.

(ii) Shoulders

The width of carriageway is extended on both sides of carriageway by a minimum of 2 – 5 m. It acts as service lane for the broken down vehicle and in case of blocking of carriageway it serves as emergency lane. The requirements of shoulders are

(a) its colour should be different from that of pavement surface so that they are distinct in vision.

(b) they should have sufficient load bearing capacity so as to support loaded trucks in wet weather also.

(c) surface of shoulder should be rough compared to pavement so that drivers are discouraged to use it as regular lane.

Other Components of Roads

Some of the roads will be having the following components also:

(a) traffic separators

(b) kerbs

(c) footpaths

(d) parking lanes

(e) cycle tracks

(f) gaurd rails and

(g) fencing

Traffic separators are provided to separate the traffic moving in apposite directions. It avoids head on collision between vehicles moving in opposite directions. Traffic separator may be in the form of pavement marking or parkway strips whose width vary from 3 to 5 m. If width is to be reduced due to unavoidable situations 1 in 15 to 1 in 20 transitions are provided.

Kerbs are provided to show the boundary between carriageway and shoulder or footpaths. They provide lateral stability to the base course. There are three classes of kerbs which are based on the height of the kerb and its function.

Class I kerbs are known as low kerbs or mountable kerbs. Their height with respect to pavement edge varies from 70 to 80 mm. These kerbs permit vehicles to mount on in case of emergency.

Class II kerbs are known as urban parking kerbs or low speed barriers. Their height above pavement edge varies from 150 mm to 200 mm. They are provided with 25 mm batter to prevent scrapping of tyres of vehicle. These kerbs discourage encroachment of slow speed vehicles but at the same time, in case of acute emergency, permit parking of vehicles with some difficulty.

Class III kerbs are known as high speed barriers also. Their height varies from 230 mm to 450 mm. They prevent vehicles leaving carriageways. They are usually provided in hill roads and bridges.

Footpaths are provided for pedestrian to separate them from vehicular traffics. They are usually required in city roads. The width of footpath is kept 1.3 m or more, depending upon volume of pedestrian traffic. To encourage pedestrian to use footpath, surface should be smooth and comfortable.

Sometimes **parking lanes** are provided in cities to streamline vehicle parking.

In urban areas, if cycles are also popular, separate **cycle tracks** are provided. Usually a minimum width of 2 m cycle tracks are provided.

When the height of fill exceeds 3 m, the **gaurd rails** are provided on the edge of shoulders to avoid accidental fall of vehicles down the fill.

In express Highways **fencing** is provided to prevent animals or other traffic entering roads haphazardly.

Typical cross-sections of various roads with their components are shown in Figs. 2.2 to 2.6.

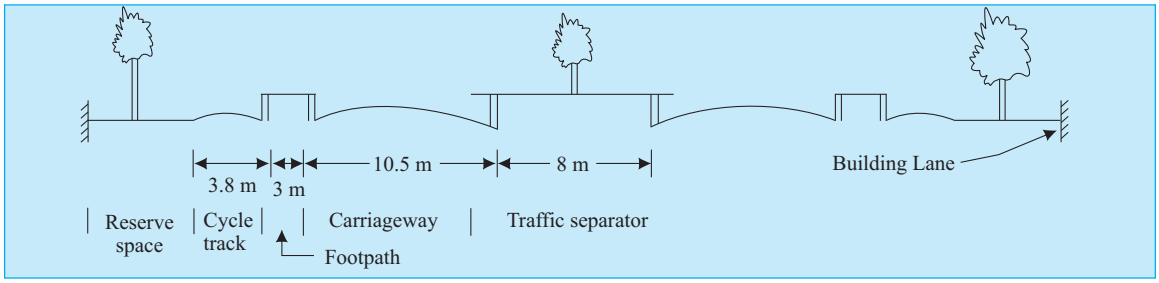

Fig. 2.2 Cross-section of divided highway in urban area

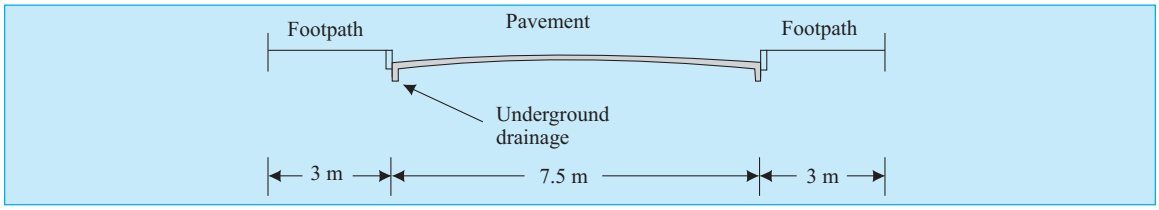

Fig. 2.3 Cross-section of city road in built-up area

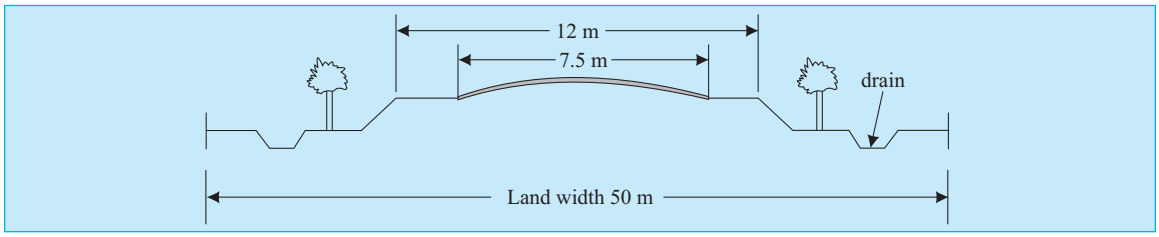

Fig. 2.4 Cross-section of two-lane NH or SH in rural area

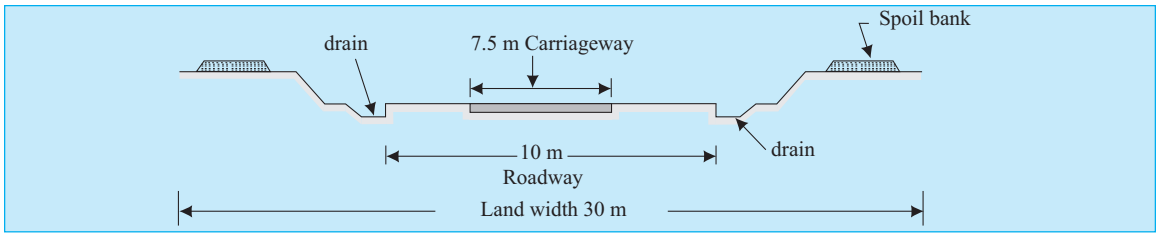

Fig. 2.5 Cross-section of MDR in cutting