Chapter 1: The INDUSTRIAL REVOLUTION

1.1 INTRODUCTION

Industrial Revolution, widespread replacement of manual labour by machines began in Britain in the 18th century and still continuing in some parts of the world. It was the result of many fundamental, interrelated changes that transformed agricultural economies into industrial ones. The changes were in the nature of production and small scale home made goods were manufactured in the factories in large scale. Productivity and technical efficiency grew with the scientific and practical manufacturing process and also enhanced when large groups of business enterprises were located within a limited area. This led to the growth of cities as people moved from rural areas to the urban communities in search of work. The Industrial Revolution was the first step in modern economic growth and development. [1]

The Industrial Revolution began in Great Britain during the last half of the 18th century and spread through regions of Europe and to the United States during the 19th century. In the 20th century industrialisation on a wide scale extended to the parts of Asia and the Pacific Rim.

1.2 INDUSTRIAL REVOLUTION IN GREAT BRITAIN

Then, in the 18th century in Britain, new production methods were introduced which included machines, fresh sources of power and energy and novel forms of organising business and labour. The Industrial Revolution began in Great Britain because social, political and legal conditions were particularly favourable to change. Property rights such as for patents on mechanical improvements were well established. Stable rule of law of Britain induced safety in earnings and thus ambitious businessmen got encouraged for investment in new business ventures; hence crucial for economic growth. In addition, Britain's Government pursued a relatively hands- off economic policy. Several industries played key roles in Britain's industrialisation. Iron and Steel manufacture, the production of steam engines, and textiles were all powerful influences.

1.2.1 CHANGES IN INDUSTRY

a. Iron and Coal

English industrialist Abraham Darby successfully used coke; a high carbon, converted from coal to produce iron from iron ore. Using coke eliminated the need of charcoal, a more expensive, less efficient fuel. Metal makers used coal and coke to speed the production of raw iron, bar iron and other metals. In 1784 Englishman Henry Cort invented new techniques for rolling iron, a finishing process that shapes iron into desired size and form. It enabled the use of iron in many new ways, such as building heavy machinery in the industries. It suited because of its strength and durability.

[1] https://en.wikipedia.org/wiki/Industrial_Revolution

Iron was also vital to the development of the railroads, which improved transportation. Better transportation made commerce easier; it enabled economic growth to spread to additional regions.

b. Steam

The steam engine was the most important machine technology of the Industrial Revolution. Inventions and improvements in the use of steam for power began prior to the 18th century, as they had with iron. As early as 1689, English engineer Thomas Savery created a steam engine to pump water from mines. Scottish inventor and mechanical engineer James Watt made the most significant improvements, allowing the steam engine to be used in many industrial settings, not just in mining. The advancement of using the steam engine meant that the factory could be located anywhere, not just close to water.

In 1775, Watt formed an engine building and engineering partnership with the manufacturer Mathew Boulton and they served as a kind of creative technical centre. They solved technical problems of the companies and often companies too shared information hence leading advances of the Industrial Revolution. Steam engines found many uses in a variety of other industries, including steamboats and railroads.

c. Textiles

The industry most often associated with the Industrial Revolution is the textile industry. In the 18th century, series of extraordinary innovations in textile manufacture reduced and replaced the human labour required to make cloth. British inventor John Kay created a device known as a flying shuttle, which partially mechanized the process of weaving. By 1770, James Hargreaves had invented the spinning jenny, a machine that spins a number of threads at once and Richard Arkwright had organized the first production using water-powered spinning.

Samuel Crompton introduced a machine called mule, which further improved mechanized spinning by decreasing the danger that threads would break and by creating a finer thread. Throughout the textile industry, specialized machines powered either by steam or water appeared. New mills and factories were running with highly productive machines and soon Britain was supplying cloth to many countries. The most important results of these changes were enormous increases in the output of goods per worker. This marvel of rising productivity was the central economic achievement that made the Industrial Revolution such a milestone in human history.

1.3 SECOND INDUSTRIAL REVOLUTION

The second Industrial revolution started in the 19th century, a second wave of technical and organizational advances carried industrial society to new levels. While Great Britain had been the birthplace of the First Revolution, the second revolution occurred most powerfully in the United States. Iron and Steel manufacturing was transformed by vastly more productive technologies. The Bessemer process, developed by Henry Bessemer, enables steel to be produced more efficiently by using blasts of air to convert crude iron into steel. The openhearth furnace, created by William Siemens allowed steelmakers to achieve temperatures high enough to burn away impurities in crude iron.

In addition, factories and their production output became much larger than they had been in the first stage of Industrial Revolution. This growth enabled by a variety of factors, including technological and scientific progress; improved management; and expanding markets due to larger populations, rising incomes, and better transportation and communications. There were enormous advances in science based industries such as chemicals, electrical power, electrical machinery and petroleum refining. It was in the automobile industry that continuous process methods and the American system combined to greatest effect. The production innovation of Ford Motor Company was moving **assembly line**, which brought together many mass produced parts to create automobile. This moving assembly lines greatly improved efficiency in production industries and the production triumphs of the Ford Motor Company in the second decade of the 20th century signalled the crest of the new industrial age.

1.3.1 Changes in Industry

a. Continuous-process manufacturing

An important American development was continuous-process manufacturing. In this, large quantities of the same product, such as cigarettes and canned food, are made in a nonstop operation. The process greatly reduced the need for manual labour and cut running costs dramatically. Later this process was improved and expanded its use. The basic principle of utilizing gravity-powered and mechanized systems to move and process materials proved applicable in many settings.

b. The American System

American manufacturers shaped a set of techniques later known as the American system of production. This system involved using special-purpose machines to produce large quantities of similar, sometimes interchangeable, parts that would then be assembled into a finished product. This system extended the idea of division of labour from workers to specialized machines.

c. Organization and Work

There was wave of changes in how businesses were structured and work was organised. Carnegie and Rockefeller changed this, giving birth to modern corporations. Within the business unit, Americans pioneered novel ways of organizing work. Engineers studied and modified production, seeking the most efficient ways to lay out a factory, move materials, route jobs, and control work through precise scheduling.

d. Gunpowder making

Frenchman named **EleuthèreIrénée du Pont de Nemours** brought his advance knowledge in chemistry and gunpowder making to the United States. In 1802 he founded what was one of the largest and most successful American businesses, E. I. du Pont de Nemours and Company, better known simply as **DuPont**. This helped revolutionize the methods of war.

The introduction of **hydroelectric power generation** in the Alps enabled the rapid industrialization of coal-starved northern Italy, beginning in the 1890s

1.4 SOCIO-POLITICAL IMPACT

Prior to its rise, the **public** and **private** spheres held strong overlaps; work was conducted at home, shared by both wife and husband. During this period **work** and **home** life began to separate. This shift made it necessary for one partner to maintain the home and care for children. Women maintained the home, while men made up a sizeable fraction of the workforce. With family income coming from men, their power in relation to women increased further. This impacted on the defining of gender roles and was the model for what was later termed as the **traditional family**.

The **mass migration** of rural families into urban areas saw the growth of bad living conditions in cities, **long work hours**, **rise in child labour** (the children received less pay and benefits than adults) and the rise of **nationalism** in most of Europe.

Rise of **capitalism** marked conflict between conservative and the mounting force of change. It was also a struggle between innovation and tradition. **Karl Marx** read that the industrialization process was the logical dialectical progression of feudal economic modes, necessary for the full development of **capitalism**, which he saw as in itself a necessary precursor to the development of **socialism** and eventually **communism**. Marx believed that the industrial **proletariat** would eventually develop class consciousness and revolt against the **bourgeoisie**, leading to a more **egalitarian** socialist and eventually Communist state where the workers themselves would own the means of industrial production.

1.5IMPACT ON ARCHITECTURE

Industrialization burdened Architecture with technical demands, like; wide **span** bridges, **fireproof** structures, heating and ventilating, etc. which required lot of mathematical calculations beyond the knowledge of Architects. Purely utilitarian nature of industrial structures seemed unworthy of an Architect’s Artistic Sensibility.

1.6IMPACT ON ACADEMICS

Academy of Architecture was organized around a string of juried competitions. The French school in Rome was where the ultimate winners were sent for an extended stay. A body of theory formulated in the lectures of great teachers like **Jacques German Soufflot**, which after the French Revolution merged with the Academy of Arts called **Academie De Beaux Arts**. A Technical School was founded to train Engineers: **EcolePolytechnique** gave state recognition to the importance of modern Civil Engineering.It offered the only formal program in architecture in the west with emphasis on design, architecture as art & history and structure.

1.7CONSTRUCTION TECHNOLOGY

- **Structural innovations** were made possible by the use of **metal,** also led to increase use of metal in construction. **Bricks and Timber** was produced industrially.
- **Cast iron** columns were used for **compression** replaced wooden posts **and Wrought iron** was used in beams for its **high tensile strength.**
- **Cast iron and Wrought iron** took over as **fire resistant** roofing material.
- **GLASS** (instead of oiled papers) became popular for windows panes.
- Rise of Industrial Architecture; Demand for new types of buildings to meet new socio-economic needs. Temple forms were too inflexible an envelope to contain the complicated functions of a bank or a government building.
- Introduction of modern **hinged and sliding** windows.
- **R.C.C.**: - Modern Revival of Concrete by the invention of **Portland Cement** (1824)
- The compositional forms and design peculiarities of Greece & Rome had to be abandoned for the sake of new building programs.
- Light/ transparent **Glass topped canopy** replaced the solid canopy across gothic vaults
- **Barrel vault** was preferred for spanning commercial arcade or covered shopping street
- **Land** got independent economic value, a **liquid** negotiable commodity.
- **Development in Steel**

  Steel is an alloy of low carbon iron and trace amount of other metals. **1875** onwards, it replaced cast iron and wrought iron for its **high compressive and tensile strength** and was much cheaper to produce.

1.8THE AGE OF IRON

1.8.1 The IRON Bridges

- **Coalbrookdale bridge**,1779- Abraham Darby III & Thomas Pritchand

Cast Iron is used only for Compression as designed in Arches

Coalbrookdale bridge[2]

[2] https://upload.wikimedia.org/wikipedia/commons/thumb/9/92/Iron_Bridge_east_side_in_February

Britannia bridge, Menai Straits, Wales, 1845-50- by Robert Stephenson

It is an example of fabrication of truss bridges. The bridge had stone piersachieving long span of1500 feet between three pylons.

It has Hollow rectangular beam ofRiveted wrought iron plates.

The IRON and Steel Bridges

- Suspension bridges

Menai bridge, 1819-26 - Thomas Telford

Suspension bridges has added beauty in its design.It has logic of use of materials as Masonry pylons-in compression and Steel cables- in tension.

Another most acclaimed suspension bridge of all times is the **Brooklyn Bridge, New York City,1869-83 – J.A and W.A Roebling**

1.8.2 **The IRON Railroad Station**

“Stable of the iron horse” Introduction of **Roof trusses** to cover larger spans.

- Crown street railway station, Liverpool – John Foster II & George Stephenson
- Paddington Station, London - sir M. D. Wyatt & I.K. Brunel
- King’s Cross Station, London – Lewis Cubitt
- St. Pancras Station, London - G.G. Scott, W.H. Barlow, & R.M. Ordish
- Central Station, Newcastle - John Dobson

Paddington Station, London[3]

[3] https://upload.wikimedia.org/wikipedia/commons/2/28/Paddington_station_MMB_55_332XXX.jpg

1.8.3The IRONMarketplace

- **Bibliotheque Nationale and Bibliothequeste Genevieve**,1858-68, Paris – Designed by **Henri Labrouste**

Designed in **Light semi-circular cast iron** in Arches and has 16 slender cast iron columns

Vaults consists of interlaced wires and are covered in plaster

- Cleveland Archade, Ohioby **John Eisenmann& G. H. Smith**

1.8.4**The IRON Exhibition Building**

- **Crystal palace,for Modern World's Fair 1851**

Led by Building Committee Design, London Exhibition Designed by- **Joseph Paxton**(1801-1865)Virtually created the method of **pre-fabrication** i.e. produced at the manufacturers' premises and assembled on site

Build in 6 months, the building was in 18 acre

Designed on 24 feet module, used3800 tons of cast iron,700 tons of wrought iron, 24 miles of rain water gutter, 900,000 sq.ft of glass and 259 miles of sash bar. Its **Lightweight, Skeletal, transparent construction** design pointed towards the future.

Crystal Palace[4]

[4] https://upload.wikimedia.org/wikipedia/commons/e/eb/Crystal_Palace_interior.jpg

Eiffel Tower, Paris Exhibition – **Gustave Eiffel**

Source: https://en.wikipedia.org/wiki/Eiffel_Tower

A 19th century iron lattice tower
Located on the Champ de Mars in Paris

The tower was built as the entrance arch
for the 1889 World's Fair.

The tower stands at 324 m (1,063 ft) tall

- Galerie des Machines, Paris Exhibition – Dutret and Contamin

1.8.5 The IRON **Workplace**

- Corn Exchange, Leeds – Cuthbert Brodrick
- Coal Exchange, London, London – J. B. Bunning
- The Third Royal Exchange, London – Sir William Tite

1.9.6The IRON **Culture** – **Religious buildings**

- St. Isaac’s Cathedral dome, St. Petersburg (Leningrad) – A. Richard de Montferrand
- University Museum, Oxford - Benjamin Woodward

References

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