

# Production & Industrial Engineering

# Industrial Engineering

Comprehensive Theory

*with* Solved Examples and Practice Questions



**MADE EASY**  
Publications



## **MADE EASY Publications**

Corporate Office: 44-A/4, Kalu Sarai (Near Hauz Khas Metro Station), New Delhi-110016

E-mail: [infomep@madeeasy.in](mailto:infomep@madeeasy.in)

Contact: 011-45124660, 8860378007

Visit us at: [www.madeeasypublications.org](http://www.madeeasypublications.org)

## **Industrial Engineering**

© Copyright by MADE EASY Publications.

All rights are reserved. No part of this publication may be reproduced, stored in or introduced into a retrieval system, or transmitted in any form or by any means (electronic, mechanical, photo-copying, recording or otherwise), without the prior written permission of the above mentioned publisher of this book.

**First Edition : 2020**

# Contents

## Industrial Engineering

### Chapter 1

#### Product Design and Development ..... 1

1.1	Product Life Cycle.....	1
1.2	Product Policy of an Organization .....	4
1.3	Selection of Profitable Product .....	4
1.4	Product Development.....	5
1.5	Product Analysis .....	9
1.6	Principles of Product Development .....	11
1.7	Challenges for Product Development.....	17
1.8	Value Engineering.....	18
1.9	Concurrent Engineering .....	23
1.10	Production System .....	24
	<i>Student's Assignments</i> .....	29

### Chapter 2

#### Work System Design.....32

2.1	Productivity .....	33
2.2	Classification of Work Study .....	36
2.3	Importance of Work Study.....	36
2.4	Advantages of Work Study .....	36
2.5	Work Study Procedure.....	37
2.6	Work Simplification and Work Study.....	37
2.7	Human Considerations in Work Study.....	38
2.8	Concept Work Content.....	38
2.9	Reasons for Excess Work Content.....	38
2.10	Techniques to Reduce Work Content.....	39

2.11	Method Study.....	40
2.12	Memo Motion Study.....	55
2.13	Cycle Graph and Chronocycle Graph.....	55
2.14	Work Measurement .....	59
2.15	Techniques of Work Measurement .....	60
2.16	Work Sampling.....	75
2.17	Job Evaluation.....	79
2.18	Merit Rating.....	84
2.19	Wage Administration and Incentive Systems .....	86
2.20	Sequencing .....	93
	<i>Student's Assignments</i> .....	111

### Chapter 3

#### Facility Design ..... 116

3.1	Need of Selecting Suitable Location .....	116
3.2	Plant Location Problem .....	117
3.3	Advantages and Limitations of Urban, Sub-Urban and Rural Locations .....	117
3.4	Factors influencing Plant Location.....	119
3.5	Analytical Methods of Location Planning.....	122
3.6	Facilities Layout Design and Facilities Location.....	125
3.7	Assembly Line Balancing .....	134
3.8	Material Handling System .....	144
	<i>Student's Assignments</i> .....	158



# Facility Design

## INTRODUCTION

Plant location or the facilities location problem is an important strategic level decision making for an organization. One of the key features of a conversion process (manufacturing system) is the efficiency with which the products (services) are transferred to the customers.

This fact will include the determination of where to place the plant or facility. The selection of location is a key-decision as large investment is made in building plant and machinery. It is not advisable or not possible to change the location very often. So an improper location of plant may lead to waste of all the investments made in building and machinery, equipment.

Before a location for a plant is selected, long range forecasts should be made anticipating future needs of the company. The plant location should be based on the company's expansion plan and policy, diversification plan for the products, changing market conditions, the changing sources of raw materials and many other factors that influence the choice of the location decision. The purpose of the location study is to find an optimum location one that will result in the greatest advantage to the organization.

### 3.1 Need of Selecting Suitable Location

Following are the answers to the question that when does a facility location (plant location) decision arise?

- It may arise when a new facility is to be located
- In some cases, a poor site restricts the facility or plant operations and subsequent expansions, thereby necessitating setting up the facility at a new site.
- The growing volume of a business makes it advisable to establish additional facilities in new territories.
- New economic, social, legal or political factors could suggest a change of the location of the existing plant.

The probable reasons for replacement of existing facilities to new location are shown in below table.

**Table.** Reasons for replacement of existing facilities to new location

Changes in location of demand Changes in availability of materials Changes in availability of transport Changes in the cost and/or supply of labour Changes in regulations and law Changes in availability of raw materials Changes in policy of industries to relocate on which the firm is dependent
--

## 3.2 Plant Location Problem

The locations of the facility is carried out in three stages:

**First stage :** Selection of a general territory(or region).

**Second stage :** Selection of a community.

**Third stage :** Selection of specific site.

1. **Selection of a region:** This refers to the selection of a particular geographical zone or state taking into consideration such factors as nearness to market and sources of raw materials, basic infrastructure facilities available, climatic conditions and taxation and laws.
2. **Selection of a community:** This refers to the selection of the specific locality within the selected region, The factors, that influence the selection of community are, availability of labour, community attitude, social structure and service facilities.

Generally the following alternatives are available:

- (i) Urban area.
  - (ii) Rural area.
  - (iii) Semi-urban area near the urban area
3. **Selection of a particular site:** This refers to the selection of specific site within the community. The factors that influence the site selection are the cost of the land, availability and suitability of the land. The type of manufacturing process may dictate the site selection. The conditions that govern the particular types of community are as follows:

**(A) Condition that demand city (urban) location:**

- (i) Highly skilled labour requirement.
- (ii) Manufacturing dependent on urban utilities
- (iii) Excellent communication and transportation facility
- (iv) Concentrated suppliers.

**(B) Conditions that demand sub-urban location:**

- (i) Semi-skilled or female workforce required
- (ii) Large space availability for future expansion
- (iii) Community close to large population centre.

**(C) Condition demanding rural location:**

- (i) Large site required for future expansion
- (ii) Requirement of unskilled labour
- (iii) Manufacturing process is dangerous and objectionable
- (iv) Low wage structure
- (v) Lower property tax rates
- (vi) Lower cost of land.

## 3.3 Advantages and Limitations of Urban, Sub-Urban and Rural Locations

**(A) Urban Area**

**Advantages :**

1. Excellent communication network.
2. Good transportation facilities for material and people.

3. Availability of skilled and trained manpower.
4. Factory in the vicinity of market and hence high local demand.
5. Excellent sourcing(sub-contracting facilities).
6. Good educational, recreational and medical facilities.
7. Availability of service of consultants, training institutes and trainers.

**Disadvantages :**

1. High cost of land as compared to rural areas.
2. Sufficient land is not available for expansion.
3. Labour cost is high due to high cost of living.
4. Industrial unrest due to trade union activities.
5. Management labour relations are much influenced by union activities.
6. Municipal and other authority restrictions on buildings etc.
7. High labour turnover.

**(B) Rural Area****Advantages :**

1. Cheaper and ample availability of site.
2. Cheaper labour rates.
3. Less turnover of labours due to limited mobility.
4. No municipal restrictions.
5. Good industrial relations.
6. Scope for expansion and diversification.
7. No slums and environmental pollution.

**Disadvantages :**

1. Poor transportation networks.
2. No good communication facilities.
3. Sourcing of components and materials should be from outside.
4. Far away from market.
5. High absenteeism during harvest season.
6. No educational, medical and recreational facilities.

**(C) Sub-Urban Area****Advantages :**

1. Land available at cheaper rate compared to urban locations.
2. Infrastructures facilities are developed by promotional agencies.
3. Because of nearness to city availability of skilled manpower.
4. Educational, medical facilities are available because of nearness to city.

**Limitations :**

1. Due to concentration, the sub-urban area will become crowded and will become urban in turn with short period.
2. High mobility of workers and hence higher labour turnover.
3. Government incentive and subsidies to promote industries.

### 3.4 Factors influencing Plant Location

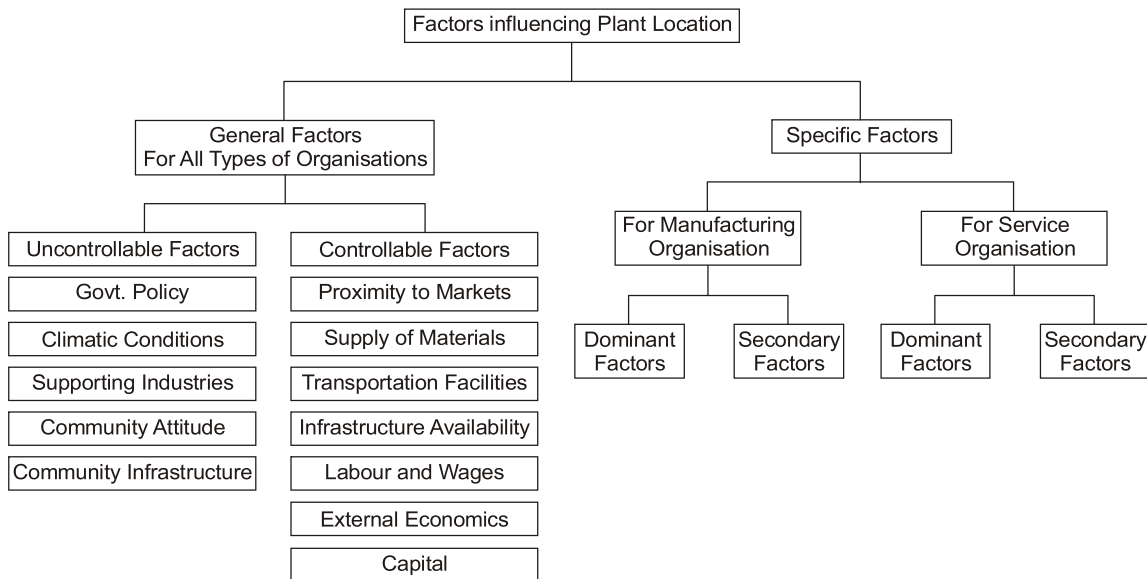
Following are the general factors required for location of plant in case of all types of organisations.

**Controllable Factors :**

1. Proximity to markets
2. Supply of materials
3. Transportation facilities
4. Infrastructure availability
5. Labour and wages
6. External economies
7. Capital

**Uncontrollable Factors :**

8. Government policy
9. Climate conditions
10. Supporting industries and services
11. Community and labour attitudes
12. Community Infrastructure



**Fig.** Factors effecting plant locations

**Controllable Factors**

1. **Proximity to Markets :** Every company is expected to serve its customers by providing goods and services at the time needed and at reasonable price organizations may choose to locate facilities close to the market or away from the market depending upon the product. When the buyers for the product are concentrated, it is advisable to locate the facilities close to the market.

Locating nearer to the market is preferred if

- The products are delicate and susceptible to spoilage.
- After sales services are promptly required very often.
- Transportation cost is high and increase the cost significantly.
- Shelf life of the product is low.

Nearness to the market ensures a consistent supply of goods to customers and reduces the cost of transportation.

2. **Supply of Raw Material** : It is essential for the organization to get raw material in right qualities and time in order to have an uninterrupted production. This factor becomes very important if the materials are perishable and cost of transportation is very high.

General guidelines suggested by Yaseen regarding effects of raw materials on plant location are:

- When a single raw material is used without loss of weight, locate the plant at the raw material source, at the market or at any point in between.
- When weight losing raw material is demanded, locate the plant at the raw material source.
- When raw material is universally available, locate close to the market area.
- If the raw materials are processed from variety of locations, the plant may be situated so as to minimize total transportation costs.

Nearness to raw material is important in case of industries such as sugar, cement, jute and cotton textiles.

3. **Transportation Facilities** : Speedy transport facilities ensure timely supply of raw materials to the company and finished goods to the customers. The transport facility is a prerequisite for the location of the plant. There are five basic modes of physical transportation, air, road, rail, water and pipeline. Goods that are mainly intended for exports demand a location near to the port or large airport. The choice of transport method and hence the location will depend on relative costs, convenience, and suitability. Thus transportation cost to value added is one of the criteria for plant location.
4. **Infrastructure Availability** : The basic infrastructure facilities like power, water and waste disposal, etc., become the prominent factors in deciding the location. Certain types of industries are power hungry e.g., aluminum and steel and they should be located close to the power station or location where uninterrupted power supply is assured throughout the year. The non-availability of power may become a survival problem for such industries. Process industries like paper, chemical, cement, etc., require continuous. Supply of water in large amount and good quality, and mineral content of water becomes an important factor. A waste disposal facility for process industries is an important factor, which influences the plant location.
5. **Labour and Wages** : The problem of securing adequate number of labour and with skills specific is a factor to be considered both at territorial as well as at community level during plant location. Importing labour is usually costly and involve administrative problem. The history of labour relations in a prospective community is to be studied. Productivity of labour is also an important factor to be considered. Prevailing wage pattern, cost of living and industrial relation and bargaining power of the unions' forms in important considerations.
6. **External Economies of Scale** : External economies of scale can be described as urbanization and locational economies of scale. It refers to advantages of a company by setting up operations in a large city while the second one refers to the "settling down" among other companies of related Industries. In the case of urbanization economies, firms derive from locating in larger cities rather than in smaller ones in a search of having access to a large pool of labour, transport facilities, and as well to increase their markets for selling their products and have access to a much wider range of business services. Location economies of scale in the manufacturing sector have evolved over time and have mainly increased competition due to production facilities and lower production costs as a result of lower transportation and logistical costs. This led to manufacturing districts where many companies of related industries are located more or less in the same area. As large corporations have realized that inventories and warehouses have become a major cost factor, they have tried reducing inventory costs by launching "Just in Time" production system (the so called Kanban System). This high efficient



production system was one main factor in the Japanese car industry for being so successful. Just in time ensures to get spare parts from suppliers within just a few hours after ordering. To fulfill these criteria corporations have to be located in the same area increasing their market and service for large corporations.

7. **Capital** : By looking at capital as a location condition, it is important to distinguish the physiology of fixed capital in buildings and equipment from financial capital. Fixed capital costs as building and construction costs vary from region to region. But on the other hand buildings can also be rented and existing plants can be expanded. Financial capital is highly mobile and does not very much influence decisions. For example, large Multinational Corporations such as Coca- Cola operate in many different countries and can raise capital where interest rates are lowest and conditions are most suitable.

Capital becomes a main factor when it comes to venture capital. In that case young, fast growing (or not) high tech firms are concerned which usually have not many fixed assets. These firms particularly need access to financial capital and also skilled educated employees.

### Uncontrollable Factors

8. **Government Policy** : The policies of the state governments and local bodies concerning labour laws, building codes, safety, etc., are the factors that demand attention.  
In order to have a balanced regional growth of industries, both central and state governments in our country offer the package of incentives to entrepreneurs in particular locations. The incentive package may be in the form of exemption from a safes tax and excise duties for a specific period, soft loan from financial institutions, subsidy in electricity charges and investment subsidy. Some of these incentives may tempt to locate the plant to avail these facilities offered.
9. **Climatic Conditions** : The geology of the area needs to be considered together with climatic conditions (humidity, temperature). Climates greatly influence human efficiency and behaviour. Some industries require specific climatic conditions e.g., textile mill will require humidity.
10. **Supporting Industries and Services** : Now a day the manufacturing organization will not make all the components and parts by itself and it subcontracts the work to vendors.  
So, the source of supply of component parts will be the one of the factors that influences the location. The various services like communications, banking services professional consultancy services and other civil amenities services will play a vital role in selection of a location.
11. **Community and Labour Attitudes** : Community attitude towards their work and towards the prospective industries can make or mar the industry. Community attitudes towards supporting trade union activities are important criteria. Facility location in specific location is not desirable even though all factors are favouring because of labour attitude towards management, which brings very often the strikes and lockouts.
12. **Community Infrastructure and Amenity** : All manufacturing activities require access to a community infrastructure, most notably economic overhead capital, such as roads, railways, port facilities, power lines and service facilities and social overhead capital like schools, universities and hospitals.  
These factors are also needed to be considered by location decisions as infrastructure is enormously expensive to build and for most manufacturing activities the existing stock of infrastructure provides physical restrictions on location possibilities.

The following table shows the comparison between rural and urban locations based on various factors discussed.