# DESIGN GUIDELINES FOR INDUSTRIAL BUILDINGS (HEAVY INDUSTRIES)

## A DISSERTATION

submitted in partial fulfilment of the
requirements for the award of the degree
of
MASTER OF ARCHITECTURE



By
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CHAPTER

## CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the thesis entitled **DESIGN GUIDELINES FOR INDUSTRIAL BUILDINGS(HEAVY INDUSTRIES)** in partial fulfillment of the requirement for the award of the Degree of **MASTER OF ARCHITECTURE** submitted in the Department of **ARCHITECTURE AND PLANNING** of the University is an authentic record of my own work carried out during a period from Ist June 2000 to 27th Feb. 2001 under the supervision of **Prof.S.Y.Kulkarni** .

The matter embodied in this thesis has not been submitted by me for the award of any other degree.

Sandeep Saini
(Candidate's Signature)

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

27.2.2001.
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# CHAPTER - 1

# INTRODUCTION

## 1.1 INTRODUCTION

Era beginning with the end of 18th century was marked by great strides in the field of science and technology and was followed by rapid industrialization. The Industrial Revolution of 19th century brought into existence Industrial Architecture as a distinctive type. The appropriate kinds of buildings materials and construction technologies, extent and nature of mechanical and electrical systems, transportation planning, ecological considerations, geographic location, soil strength etc. highlights the need for integration of Architecture and Planning Design with all phases of Engineering.

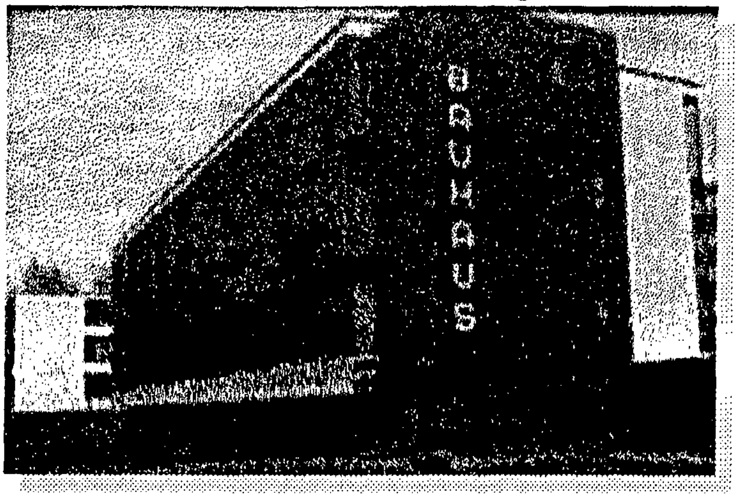



Figure I Bauhaus

Industrial Architecture has produced a contemporary generation of buildings which are as important in the realm of late twentieth century architecture as ecclesiastical buildings were in the middle ages.

The history twentieth century theories, factory aesthetics, can be traced to the Bauhaus school. The programme for sheds, warehouses, speculative industrial buildings are driven by standard requirements; flexibility, economy and standardization and the need for a non specific or dumb space which can accommodate many variations of storage and production processes. In general, the opposite is true for engineering and manufacturing buildings.

Designing a building to accommodate the complex process of manufacturing, presents problems of analysis and research that demands very special Architecture skills. The kind of analysis required must take into account technical, social and theoretical considerations. It has to respond to the hierarchies of management, the needs of work force, the requirements of the manufacturing process, equations of efficiency and the ethos of the corporate philosophy.

Industries are a part and parcel of contemporary life and are often considered as an 'index 'of the progress of mankind .It is because, they have employment potential and economic importance at the national level, at a regional level of working. The industry, which is a simple or complex relationship of input process and output where labor, machine, material, and management to produce economical product. This interaction may be called as an industrial process.

In performing the industrial process certain changes in the immediate surroundings and external environment takes place. The create artificial environment and after physical working conditions, according to the process involved in it The cumulative effect has to bee taken care while planning industries.

The architect is not concerned with the technical details of industrial process but he has to study the facts resulting out of these and see that necessary measure have to be taken to ensure safe and healthy working conditions, on the other hand he should not think only on preservation of biological balance and control of pollution, but also oppose the aesthetic pollution.

The scope of an architect in industrial building design is for achieving safe and healthy physical working condition, rational utilization for real estate, control of pollution within and in the surrounding areas and aesthetically pleasing appearance.

Therefore, the primary duty of an architect is to provide with satisfactory and conducive physical working conditions within and to safeguard the natural external environment from any disturbances. Thus, an architect has to device effective control human convinces, has to deal with the b8uilding codes, factory laws and act s and other physical characteristics, in overall design. Thus an architect has to study the problems created in an industry by which physical planning, infrastructure, and working conditions are altered and life of people working is affected.

## 1.2 OBJECTIVES

The aim and objectives of the dissertation are as follows:

- To study the different industrial process.
- To study the various types of plant layout.
- To study various parameters required for design of industrial building.
- To study an example as a case study.
- Evolve a design guideline for the particular industrial building type.

## 1.3 Scope

The scope of an architect in industrial building design is for achieving safe and healthy physical working condition, rational utilization of real estate, control of pollution within and in the surrounding areas and aesthetically pleasing appearance.

As an architect is principally involved in the designing of envelope for the plant layout i.e. considering the three components of an industry namely- Man, machine and material.

A set of guidelines for an industrial building for achieving and incorporating the following:

close co-operation of competent engineers, structural and mechanical, and this before he begins rather than after. He must also be prepared to do quite accurate estimate and business-like accounting and managing. With this external equipment what he needs most is a great store of common sense and open-minded because industrial architecture demands complete freedom from canons of prejudices which often govern other types of design.

Factory design is just the opposite of magic. There is no necessity of knowing all about line production or manufacturing processes. Most of managers have very definite ideas on these subjects. The architect's job is to listen, question intelligently, and interpret the requirements practically

## 1.5 LIMITATIONS

Due to the vast scope of the study and considering the limited time, the study has been limited to study of building factors and environmental factors, which control physical and occupational environment.

# *CHAPTER – 2*

# *"LITERATURE REVIEW"*

## 2.1 Basic Industrial Processes

***In order to summarize the complex and complicated industrial process an attempt has been made to represent them in the most compact and condensed form. They are identified as:***

**(a)Attrition**

**(b)Vaporization,**

**(c)Combustion,**

**(d)Chemical, and**

**(e)Electrolysis.**

The use of these processes to produce any product, many permutations, and combinations of the above five, in various proportions is obvious. They are explained below:

### 2.1.1 Attrition

It is the process in which the material wears away due to friction and/or grinding. In this physical change takes place, where material of larger size and shape, is reduced to smaller size and of required shape, to be used in further processes of production, or as a final product. It is used in many industries where the process demands only physical change and no chemical action. Any industry, in which the attrition process is extensively adopted, gives out solid particles of different sizes and shapes or even so small that may not be visible to naked eye. They are generally grouped as dusty industries.

The process of attrition is used in most of the process, manufacturing and engineering industry in different forms. (Ref. Table No. 1).

**Table No .1**

**'Manufacturing processes applied to metals'**

| S.No | Process | Scope | Typical use |
|---|---|---|---|
| **1.** | Brake forming | Long or short folds | Open sectional forms. |
| **2.** | Broaching | Shaving and shaping or cross sectional forms | Splines, key ways, holes |
| **3.** | Casting<br>(a)Send<br><br>(b)Investment<br><br>(c)Die | Large and small bulk of complex shape.<br>Small to medium bulk of complex shape.<br>Need to parts of nonferrous metals, high | Machine frame, casting, covers,<br>Turbine blades, menifold.<br>Impeller, link parts, housing. |

| | | | |
|---|---|---|---|
| | | finish and accurate dimensions. | |
| **4.** | Contour cutting | Surfacing | Level beds. |
| **5.** | Deep drawing | Large. Small in thin walled. | Cups, containers, tubes. |
| **6.** | Die heading | High speeds production of small parts. | Bolts, nuts, rivets, studs. |
| **7.** | Drilling | Circular hoes. | Holes, joining and bushing. |
| **8.** | Extruding | Sectional forms in length | Tubes and various sections. |
| 9. | Grinding | Precision finishing | Rods, bore, cone, surfaces. |
| 10. | Hibbing | Generation of shapes | Gear teeth |
| 11. | Honing | Precision finishing | High grade finishes. |
| 12. | Jig boring | Placement and cutting of precision holes. | Figures and futures gear housing. |
| 13. | Milling | Standard machine for flat surfacing | Flat surfaces. |
| 14. | Pressing boring | Pressing thin sheet to 3D | Cap, covers, vessels |
| 15. | Planning/shapi | Production of flat | Machine tool, bed |

| | | | |
|---|---|---|---|
| | ng | surfaces. | plates. |
| 16. | Roll forming | Curving extruded forms. | Truck frame, wheel rim |
| 17. | Sintering | Compacting of particle under pressure and heat. | Small levers, wheels |
| 18. | Stamping | Quantity production of flat surfaces. | Washer, tanks, patterns etc. |
| 19. | Turing all forms. | Machine production | Shafts, drums, tapered. |
| 20. | Welding | Joining of metals by fusion | General. |

## 2.1.2 Vaporization

It is a process in which liquids are changed into gases at ordinary temperature or even at higher or lower temperature. It, may be or may not be, associated which different pressure conditions for acceleration of the process.

It is one of the processes in which removal of moisture is done for drying or as a requirement of the industrial process.

Vaporization is commonly adopted in chemical industries, process industries and most of the obnoxious industries. It is partly used in engineering industry for drying and finishing, of the product, as part of appearance engineering.

This is a process that may emit fumes and thus create problems for the interior and exterior working conditions and also for an industrial buildin(

### 2.1.3 Combustion

Combustion is the process of burning and is extensively used in various industries. In this process fuel is burned, to produce power for the prime mover. In some cases it is used for heating and cooking operations, within the industrial process itself. Direct or indirect heating is required in many industrial processes which is possible only due to combustion.

It is extensively used in metal, or metallurgical industries, where shaping and forging of metal is required often. It is also used in chemical and process industries mainly and in general almost in all industries.

The fuel used in combustion process, which are never perfect burning, leaves out unburned by-products like bits of carbon, carbon monoxide gas and products from impurities of the fuel. This unburnt by-products are the major harmful contaminants, and causes atmospheric pollution. In cases where very high temperature is required for process and it is achieved by combustion and causes nitrogen and oxygen of the air to combine into nitric, which further oxidizes to form nitrogen dioxide - one of the most troublesome component of air pollution. It irritates the eyes and mucous membranes, damages vegetation, and contributes to photochemical smog. The pollutants of combustion process even damage property, wild life and domestic life, visibility limitations, psychological effect on human and damage his health.

### 2.1.4 Chemical Process

In chemical; process the change in the material is mainly due to the reaction of chemical substances present or introduced it during the industrial process. The acceleration of process could be achieved by changing temperature, pressure, vacuum or cooling, or in various combinations of the above. It helps to achieve speed in production and better and improved product.

It is commonly used in most of the chemical, engineering and extractive or refining industries. It creates gases, fumes, irritants and poisons. It also commonly gives out large quantity of industrial waste and causes water and soil pollution. The problem of selecting building material, resistant to the chemicals used, is special problem arising due to this industrial process mainly.

### 2.1.5 Electrolysis

In this process electrically charged positive and negative ions are contributing to the industrial process. The major requirement of this process is electrical supply of different voltage. The electrically charged substances create a definite direction of movement within them. This movement of ions is used in the industrial process.

It is commonly used in most of the industrial processes and in particular in the engineering industry8. It is extensively used in electroplating works, galvanizing and ionization of metals.

It gives out fumes, irritants, poisonous liquids and industrial wastes. The protection against likelihood of electrical shocks, short circuits are necessary. It needs different types of liquid transportation system and standby pumps and tanks, for efficient production. The process may demand auxiliary facilities such as neutralization plant, ion exchanger or detoxication plant. In order to inspect the product, for its quality, it needs tidy and bright workroom so that flaws in plating process could be recognized easily. The flexibility of electrical services and shockproofness is the important factor of process, which affects architectural design. The corrosive acid vapors, mainly given out during the process, reject the use of steel as structural members but favour concrete.

Keeping objective of the dissertation, it becomes necessary to narrow down the range of processes to match the scope of the dissertation. In doing so classification of industry is necessary by which range could be narrowed.

## 2.2 Classification of Industries

There are various methods of classification of industries according to the purpose it is called for. Therefore, an attempt has been made to classify the industries to suit to architectural design from the various types of classification.

The most general classification of industry is done as per the service characteristics on the basic **industrial product**. It may be as:

**(a) Basic industry,**

**(b) Service Industry,**

**(d) Consumer goods industry**

The other method of classification of the industries be based on **process** involved in it, such as:

**(a) Extractive industries,**

**(b) Process industries,**

**(c) Oil and fats based industries,**

**(d) Forest based industries, etc.**

The other method of classification of industry is on the basis of **employment potentials** such as:

1. **LABOR INTENSIVE,**
2. **MACHINE INTENSIVE.**

The basic for classification of industries may be as capital intensive or labor intensive also. The above classification may hold good for collection of statistical data and for industrial census.

In order to assess the **physical criteria** for the planning and designing of industries following type of classification of industries, is advantageous:

It is based on

**(a) production capacity,**

**(b) Load handling capacity,**

**(c) Nature of process**

Involved in it like,

(i) Continuous or

(ii) Interruptable[8],

Or depending on

(d) Consumption of power, i.e.

(i) Large scale,

(ii) Small scale,

(iii) Cottage industries,

(e) Accessibility requirement,

(f) Type of industrial waste discharged,

(g) Obnoxious characteristics,

(h) Hygienic requirements,

(i) Pollution qualities and its harmful effects on surrounding, and

(j) Statutory status given to industries on account of human safety and risk involved in it, and lastly as

[8] Grant I.W. and Grant, E.L., 'Handbook of Industrial Engineering and Management', Prentice Hall of India (P) Ltd., New Delhi, 1969, Chapter 1.

(k) Mill or Factory, where the process and product are linked together with envelope for classification of industries.

## 2.2 GENERAL TYPES OF INDUSTRY

### 2.2.1 Heavy Industries

Heavy industries are those involving the processing of metals and the production and assembly of relatively large metal components. As with all primary process industries, the architectural character of plant engaged in metal processing is generally distinct. In heavy industries, the size of end product almost always bears a direct relationship to the scale of building housing its production.

The various heavy industries commonly need large sites and structure is invariably ponderous in nature owing to the great demand for support placed on the roofs and floors by gantries, cranes and heavy equipment. The finishes are coarse in comparison of to those used in factories manufacturing light products and services demands are normally larger.

The architect must have a fundamental enthusiasm for industrial processes involved to achieve successful results.

### 2.2.2 Light Industries

Light industries are those engaged in the manufacture and assembly of relatively small components. Some processing of the raw materials is often involved. The products of light industry are infinite in number. The more remote the industries are from the primary process industries, that is the later their activities occur in the production sequence between extraction of raw materials and finished product, the more complex becomes their process operations This lack of simplicity makes distinction between one light industry and another extremely difficult. Power and service needs are not usually heavy, but operating and handling cost are considerable. Flexibility is imperative in the design of a factory for producing.

### 2.2.3 Process Industry

**Industrial production involves four operations: extraction of raw material, processing, assembling and distribution to the consumer. Thus, industrial architecture involves solely the** housing of the processing and assembling sequence. Process industries are those which involve the alteration of natural raw material into an artificial forms. Assembly industries are those which are engaged in the manufacture of articles from raw materials of an almost invariably artificial nature, that is, the product of a primary process industry. They include textile weaving, baking, printing and heavy industry.

## 2.3 Factors influencing plant layout

*DEFINITION-*

"Plant layout embraces the physical arrangement of industrial facilities. This arrangement either installed or in plan, includes the spaces needed for material movement, storage, indirect laborers, and all other supporting activities or services, as well as for operating equipment and personnel".

RICHARD MUTHER,

**The main objectives of Plant layout may be summed as the most economical to operate and yet safe & satisfying for employee .it is the integration of all the facilities into one big operating unit.**

To analyze and classify the arrangements or layouts for production, we should clearly understand what production is. Production results from men, material, and machinery (including tools and equipment),together with some form of management and that at least one of them must be moved. Plant layout embraces the physical arrangement of industrial facilities. This arrangement either installed or in plan, includes the spaces needed for material movement, storage, indirect laborers, and all other supporting activities or services, as well as for operating equipment and personnel.

Before we begin to analyze and classify the arrangements or layouts for production, we should clearly understand what production is. Production results from men, material, and machinery (including tools and equipment), together with some form of management. Men work on some kind of material with the aid of machinery.

## 2.4 Seven types of movement

***Element Moved and Description***

| ***Movement*** | ***Example*** |
|---|---|
| **1). Move the material**<br>Probably the most common element moved. Material moving from workplace to workplace , from one operation to the next. | **Bottling plant, machine shop oil refinery.** |
| **2). Move the man**<br>Operators move from one workplace to the next performing the necessary each piece of material. machinery (at least their | **straightening up material in storage turning over or mixing operations on material in or vats.** |

| | |
|---|---|
| tools) with them. | |
| **3) Move the machinery**<br>Worker moves various tools or machines into place to work on one major piece of material. | **Mobile welding machine, mobile forge shop lifted onto ship's deck.** |
| **4).Move material and men**<br>Worker moves with the material performing a certain operation at each machine or workplace. | **Toolmaking installing "special parts" on a production line.** |
| **5). Move material and machinery**<br>Materials and machinery or tools are brought to men who perform the operation. Seldom practical except at individual workplaces. | **Tools and fixtures moving with the material through a series of machining operations.** |
| 6). **Move men and machinery**<br>Workers move with the and equipment, generally around a large fixed piece of material. | **Paving a highway; the itinerant tools shears grinder.** |
| 7). **Move material, men, and** | **Certain assembly** |

| | |
|---|---|
| **machinery**<br>It is usually too expensive<br>and unnecessary to move | **work where tools<br>and materials are<br>small.** |

## 2.5 Types of layout

### 2.5.1 Layout by fixed position: -

Operations are performed with the material (in the case of

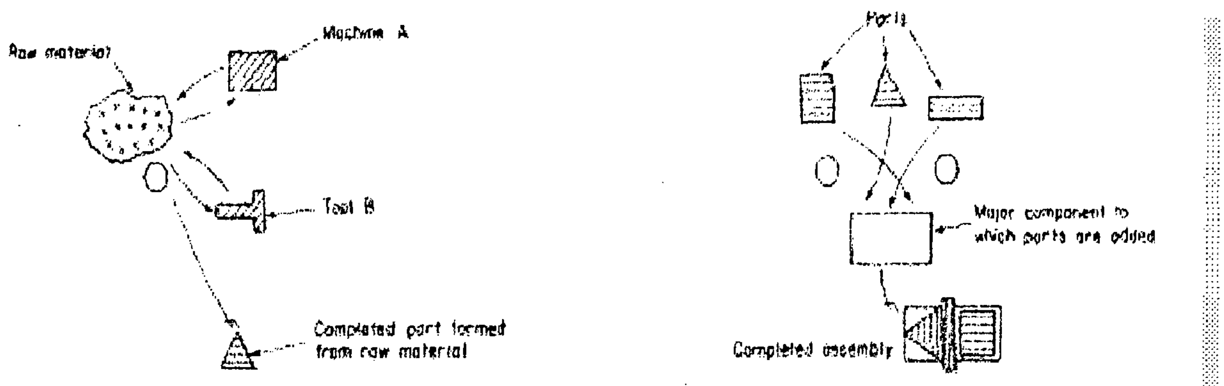



**Figure II LAYOUT BY FIXED POSITION**

forming or treating or major component (in the case of assembly) remaining in one fixed location. That is, hold the material at a fixed position.

**Examples: Forming and treating-speciality shoemaking; sculpturing; any artisan making a complete unit; some tool making.**

**. Assembling-hand-embroidery work; building a battleship or constructing a large building.**

## 2.5.2 LAYOUT BY PROCESS (function).

All operations (processes) of the same type are performed in the same area; like machines or similar assembly operations

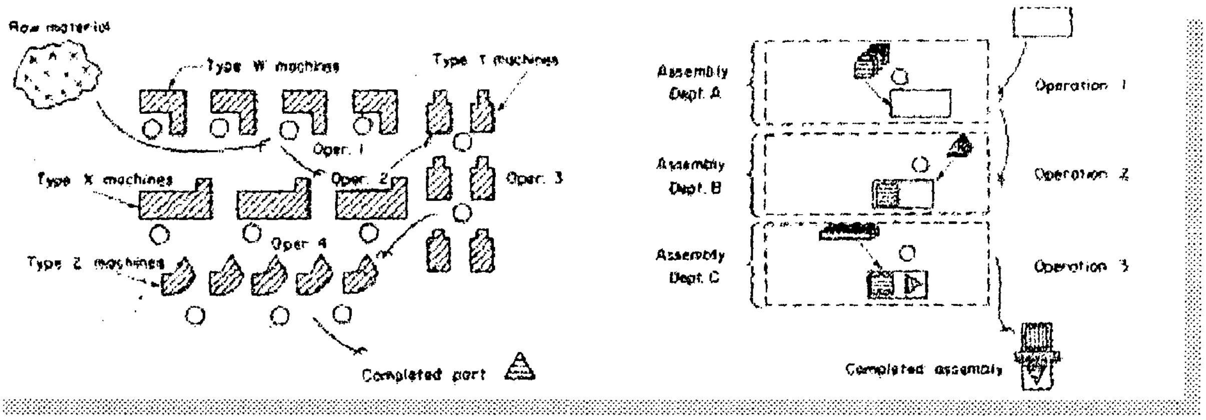



**Figure III LAY OUT BY PROCESS**

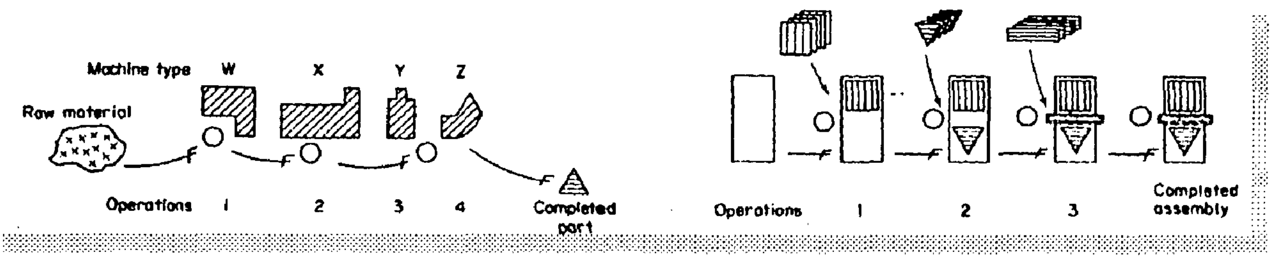
are grouped together. That is, move the material through process departments.

Examples: Forming and treating-normal machine shop work; most textile and cloth making.

**Assembling-sheet-metal assembly by spot welding, riveting, stapling, and soldering.**

### 2.5.3 Layout-by-product (line production)

Machines or assembly workstations are arranged in the sequence of operation, successive operations being performed immediately adjacent to each other. That is, move the material from one operation to the next.




| Figure IV | LAYOUUT BY PRODUCT |
|---|---|

**Examples: Forming and treating-machining a motor block; quick car washing line.**

Assembling-automobile assembly line; assembling a tray of food in a cafeteria.In industries we do not find these layout in pure form. They are usually found either in combination or line of demarcation between one type is not clear.

***Break-Even chart***

**It's a useful aid in estimating what amounts of capital outlays are economically justified for an anticipated volume of sales. the chart can indicate over investment or when the plant is too large ,by showing that the anticipated revenue from the sales.**

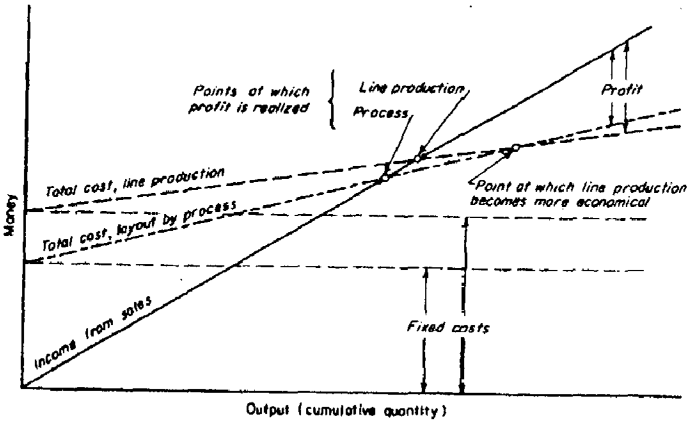



**Figure V Break Even Chart**

## 2.6 Factors influencing any layout break down into eight groups

**1. The material factor**, including design, variety, quantity, the necessary operations, and their sequence.

**2. The machinery factor**, including the producing equipment and tools and their utilisation

**3. The man factor**, including supervision and service help as well as direct workers.

**4. The movement factor**, including inter and intradepartmental transport and hand handling at the various operations, storage, and inspections.

**5. The waiting factor**, including permanent and temporary storages and delays.

**6. The service factor,** including maintenance, inspection, waste, scheduling, and dispatching

**7. The building factor**, including outside and inside building features and utility distribution and equipment.

**8. The change factor**, including versatility, flexibility and expansion.

Each of these factors breaks down into a number of features and consideration though not every feature or consideration will effect the layout.

1. **The material factors-** This includes raw material, material in process, finished product, rejects, salvage material, wastes, packing and materials for maintenance.

**The considerations that effect the material factor are:-**

a) Design & specification of the product.
b) Physical or chemical characteristics of material.
c) Quantity &variety of product.
d) The component parts or material.

**1) Each product**, part or material has certain characteristics that may affect a layout, these may be size, shape, bulk, weight, condition and special characteristics etc.

The quantity of products, variations in out put, a plant making only one product has an entirely different layout then one making a large variety. A one-product layout should come very close to the goal of line production. A large variety of products will call for layouts will call for layout by fixed position.

2) **Machinery** – Second in importance to the product or material itself is the process or operating machinery and equipment. The features to consider include the process, machinery, tools, and equipment, machine utilisation, requirement of machinery & process

**Movement**

Movement as stated before is at least one of the three basic elements of production – material, men or machinery. Usually it is the material – raw, in process, or finished products. It is reported that material handling is responsible for about 90% of all plant accidents, 80% of indirect Labour changes, a large percentage of product damage.

The point to be noted is that handling is not an end in itself. The mere movement does not change its form or characteristic or add other material to it. The relation of quality to type of layout can best be seen from the list.

## 2.7 .Psychological and Personal Considerations

Psychological effects have to be taken e.g. fear of potential injury; spaces around them, social contact, monotonous job etc. have to be considered.

Organization & Supervision Layout must be tuned with the organization of the Company. In relayout work, reassignment of duties and responsibilities must be considered carefully. It must not be assumed that men involved can adjust themselves to a new layout without any difficulty. Also in case of conversion from one basic type of layout to another the layout may call for a complete change in the state of mind of entire organization. Participation in planning, be it only of minor detail, leads to more ready acceptance of the new plan. The success of a layout often depends as much on how well it is accepted as on how efficient it is.

**Relation of Quality to Type of Layout**

| *Type of Layout* | *Relation to Quality* |
|---|---|
| **Layout by fixed position** | Quality is a fixed responsibility of individual workers. More skilled workers requiring fewer inspectors. |
| **Layout-by-process** | Interdepartmental inspection and friction over quality, for each operation is done in a different department. Good possibilities for centralized or semicentralized inspection.First piece and setup inspection,and floor inspection during runs |

| | |
|---|---|
| | are usual. |
| **Line production** | Hard to pin down quality responsibility. Bad work will interrupt continuity and "starve" subsequent operations. This usually means better receiving, inspection, and repair stations on the line are required. Inspection of tools and gauges before production is far more important. Less skilled workers, but fewer errors because of standardized work and job specialization. Decentralized inspection with inspectors holding the |

rate-of-Flexibility of

Layout

## 2.8 Flexibility

Flexibility is a basic part of one whole concept of improvement and its frequency and rapidity and ever becoming greater.

Need for flexibility may be due to:

Material changes, i.e. product design, materials, demand, variety,

Machinery changes – processes and method

Man changes – working hours, organization or supervision skill

Supporting activity changes – handling, storage, services

External changes and installation limitations

### 2.8.1 Flexibility can be obtained by:

**a**. Mobile or movable machinery and equipment, which is achieved by keeping machinery free of all fixed foundations.

**b.** Self-contained equipment – independent of general plant services i.e. machine has its own motors, dust collector, supplementary lighting etc.

**c.** Readily accessible service line – Services can be planned in advance with frequent outlets, quick disconnects, or plug in type of connections.

**d.** Standardized equipment - Standard size stock rack, assembly benches, conveyor sections, motors, all lead to saving in both planning a relayout and executing change over. Along with these large and unobstructed floor areas are most suitable i.e. large spans, wide column spacing, few walls or partitions, and minimum obstructions like stair ways, furnace stack, fixed conveyors, walls may be mere partitions made in standardized sections for quick erection and remove.

## 2.9 Operations Planning

### HANDLING OF MATERIALS AND PRODUCT

Material handling emerged as a technology during second wOrld war when acute shortage of manpower was felt. It might be defined as the movement of everything.

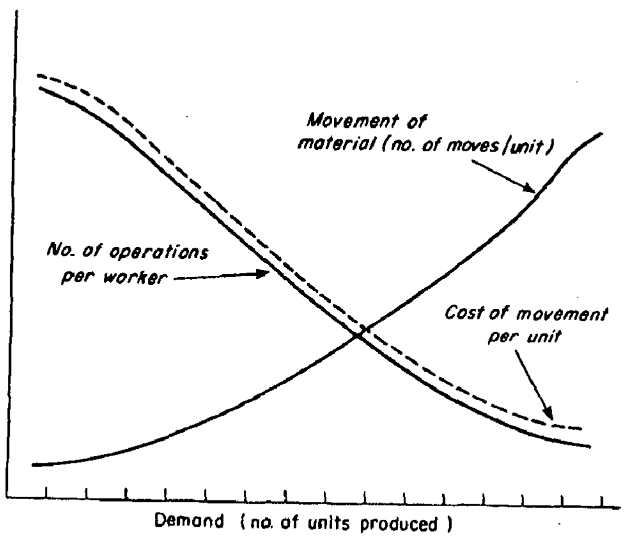



**Figure VI DEMAND CHART**

Scientific Material handling is now recognized as a vital factor in end cost of all the products and services. It is therefore essential that every new factory should be so designed that the structure and layout do not inhibit the application of the most efficient handling method compatible with the work to be performed.`"Handling considerations "do not apply only to workshop s but equally important in respect of raw materials, finished products storage, transport, and dispatch. Materials and dimensions, though important, depend heavily on several significant principles of inventory and work organization. As is known labor cost rises with distance and tonnage. The time honored likeness grouping of goods is now outdated the new concepts of departmentalization is built on such factors as fast and slow movers, shelf stocks etc.

| *Suggested Aisle Widths:* | |
|---|---|
| For personnel only (2 persons to pass) | 30 inches minimum |
| For two-wheel hand truck (no passing or turning with load) | 30 inches minimum |
| For stock truck (where trucker must pass around it) | 20 inches plus width of truck |
| For stock truck (where other trucks and workers must pass) | 36 inches plus two times width of trucks |
| For hand-operated fork truck, pallet transporter, semilive skid and jack | 5 to 8 feet, depending on nature of load |
| For 2,000-pound fork truck | 8 to 10 feet |
| For 4,000-pound fork truck | 10 to 12 feet |
| For 6,000-pound fork truck | 12 to 14 feet |

Figure VII AISLE WIDTHS

**By these means inventory is organized to minimize walking and hauling. Daily tonnage is moved in and out of the warehouse with fewest steps turns of wheel and man hr.**

## 2.10 Proportion of Buildings

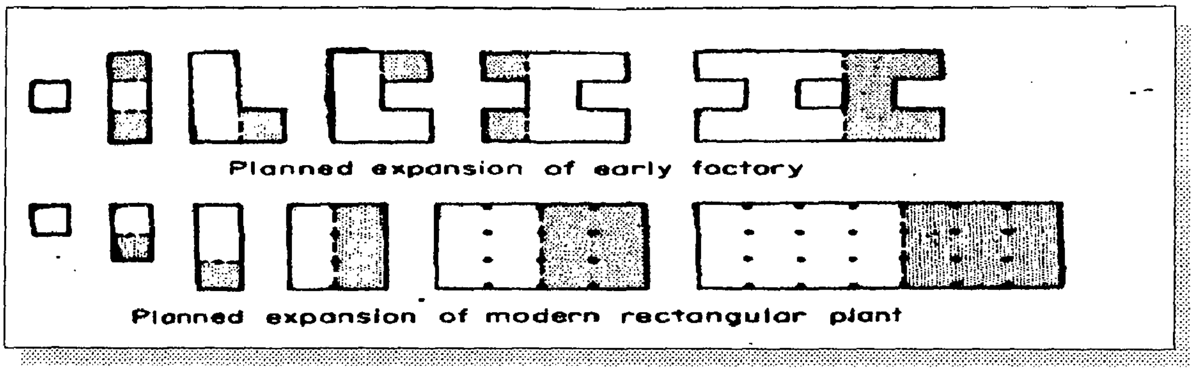



**Figure VIII PLANNED EXPANSION OF BUILDING**

Proportions of building are again an important factor, as is well known that square buildings are cheaper because the perimeter is shorter and less wall is needed for a given footage and cubage. But most important than any saving in building cost is the lower cost of labor when the warehouse is well proportioned

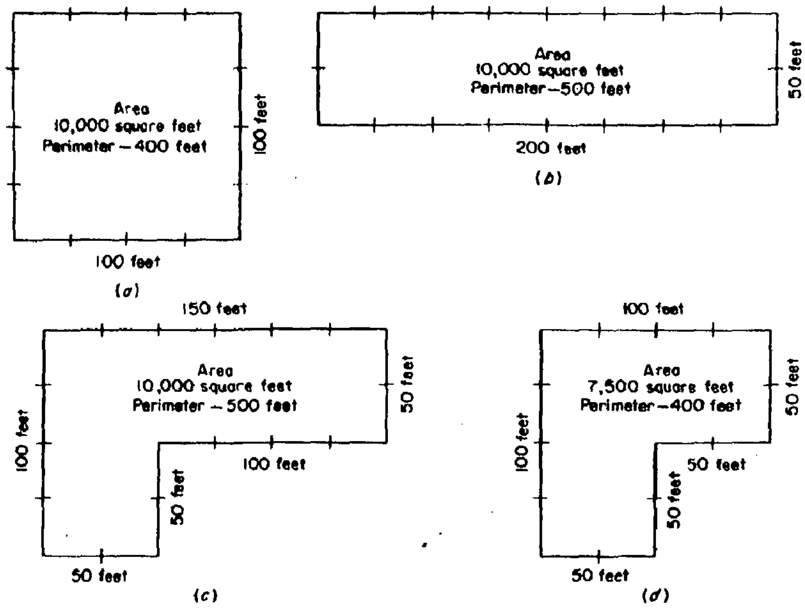



**Figure IX EFFECT OF SHAPE ON PERIMETER**

Walks and hauls are greater as the ratio of length of width of structure increases. Ratio of 3:1, is optimum and generally not to be exceeded. Of course contiguous and related though separate functions can be set up in warehousing of any L-W ratio as long as no unified function occupies space exceeding the 3:1 proportion.

Odd shapes like the 'V' and 'L' should be avoided, these are hard to organize for economy and require more wall to enclose a given footage or cubage.

**Floor – Type of Floor**

Expansion joints, details to be given special attention. In time 80% complete automation in distribution warehouses will be the rule, goods will be handled by machines, activated by magnetized tape machines will detect odors, read numbers, appreciate dimensions, work in the dark in one storey warehouses of towering heights. Instead of labour forces we shall have small corps of technicians to keep pant operative. Supervisory staff should be located between the making and the administrative departments separated from both as this system has following advantages.

1. Walls are kept free for openings.
2. Future expansion is possible in any direction.

3. Supervisory staff when placed together establish better rapport and can jointly solve problems and interact with each other more freely All can share certain common facilities like reading, tea or restrooms.

4. Double storied development is possible within single height of main work areas and observation galleries at the first floor that permits a better view of the department.

## 2.10 Environment & orientation

A factory building is a shell to protect and run a process. But the process needs workers who are increasingly demanding better conditions; good management practice now has its constituents as the provision of pleasant and efficient working conditions. Over the last few decades, changing social attitudes, hygienic requirements, mental satisfaction and psychological aspects have emphasized the fact that workers have got to be considered.

Good and efficient work demands good conditions, in factories, one of the essentials will be to provide a working environment which is optimal both for work and satisfaction rather than marginally acceptable. It is created by the space within the buildings, its envelope and the equipment the process and the people concerned.

The main constituents for the physical environment are as follows : -

1) Dust free and hygienic atmosphere.
2) Noise control and reduction
3) Lighting (daylight & artificial)
4) Colors
5) Safety
6) Fire

7) Pollution

8) Ecological balance

## 2.10.1 Noise control

Noise is often defined as unwanted sound. The degree of 'unwanted ness' is however a physiological and psychological question and may range from moderate annoyance to various degree of permanent hearing loss, and will further more be rated to differently by observers. It is generally recognized that the overall efficiency of human beings is considerably higher when they are less irritated or annoyed by the surroundings. Also a certain degree of quietness is a desirable quality in itself. Control of noise is therefore important from all points of view, as it affects the very efficiency of man.

High noise levels are prevalent in industrial buildings, the amount of noise depends on the way the power is applied and transmitted. "Noise control" is very pertinent to industries because the noise -tolerance is particularly reduced with lack of oxygen and with action of fumes or dust interfering with oxygen consumption and its transportation to the brain cells for purpose of study of industrial noise the frequency region of interest is 20 to 20,000 cps. Noises encountered in factories are complex and they are composed of a large number of sounds of different frequencies, which often extend over the entire frequency region. The ear is most sensitive to damage between range of 2000-4000 cps (Hz).

## 2.11 Day lighting

**Maintenance of Illumination**

It is recommended that an illumination check be made with a foot-candle meter periodically, and when illumination has decreased to 75% of its initial value, the lighting equipment should be cleaned. In addition to cleaning of lighting units, the frequent painting and maintenance of the of the surroundings - side walls, ceilings, machinery etc. will help keep lighting efficiency near original value.

### 2.11.1 Roof Glazing

North light is not always advantageous, as light coming from one direction only allows one layout arrangement for machinery as the production line must run at right angles to the glazing and hence restricts machinery layout and also flexibility of plant layout.

- Unequal nature of the day lighting over a large floor area
- For comfortable working the glare of large areas of sky in view of operative should be avoided
- Roof-light glazing bars are painted white to avoid an irritating pattern of dark lines against a
- bright background

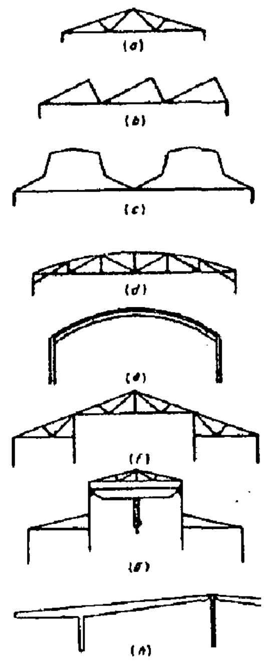



Figure X Typical Types Of Roof

- Small areas of glass distributed over the entire area of roof surface must be avoided as they create sharp pattern of high contrast of light and dark areas.

## 2.12 Colour:

Improvement in standards of cleanliness and appearance. The correct use of colour in conjunction with a good standard of lighting both natural and artificial can reduce eyestrain, glare, and visual discomfort.

**Industrial Colour Planning**

## 2.12.1 Background Colour

Background colour must be in relation to work carried out in the room. The walls and ceilings which form this background should not give rise to glare, should be restful and provide a neutral light surround adapted to the lighting conditions

- Background colour should be complementary to that of material being worked and at same time provide a suitable contrast in line with the task.
- Colour from middle of the spectrum e.g. yellow, green, which provide suitable hue contrasts with most materials can be used as background colour
- White is generally unsuitable as it causes destruction and gives glare.
- Bright colour must be avoided in favour of pastel tones which afford relief to the eyes and assist speedy readjustment of vision
- Colour can be used to vary the apparent temperature "cool

colour such as green, blue give impression of reduced temperature in boiler rooms foundries and other necessarily hot places while colour such as yellow can create an effect of warmth in cool areas.

### 2.12.2 Machinery colour

The colour selected for machinery must provide a suitable brightness contrast with both the task and the immediate background. The working area of machine must be the brightest spot in field of vision.

- Must harmonize with surrounding decorations
- Must not act as camouflage but should be easy and automatic perception of different parts of machine
- Must provide contrast lack

### 2.12.3 Artificial Lighting

- Unduly bright sources of light causing discomfort through glare, and visual discomfort resulting from bright light points against dark background
- Identification of Colour – pipes, conduits for air, gas, steam, electricity hazards should be marked with an arresting colour, e.g. orange

Some peculiarity of vision which must be taken into account by an architect.

### (1) Simultaneous Contrast

The eye sees no colour within its field of vision as a fixed quantity, but only as modified by simultaneous perception of adjacent colour. The colour seen is modified as to hue, value and intensity.

**As to hue** – each colour seen will tend to cast a ting of its complementary colour upon adjacent colour.

**As to value** - Dark colour will make adjacent colour appear lighter and vice versa

**As to** intensity – strong colour will weaken adjacent colour

In industrial plants the phenomenon may be advantageously used to emphasize work in hand, to separate machine from background and enliven a general colour scheme for psychological effect.

**(2) After Image**

The eye tires quickly of any colour upon which it is focussed and tends to reward immediately afterwards, the complement of that colour. If one gazes intently at an orange spot and then looks quickly at white paper, an afterimage of pale blue will appear. One of three effects will result from this phenomenon of vision.

- The second colour viewed may be enhanced by the after-image remaining from first colour
- It may be weakened
- It may be influenced towards a different but not necessarily unpleasant colour

The first effect can be used favorably, the second effect mentioned i.e. weakening of the second colour is to be avoided in planning colour, the third, the changing, must be estimated for its probable good or bad result

**Application**

Application depends upon the answer to the question

- What effect will after-image produce upon the particular problem under discussion?
- Will a warm or cool after image be desirable or not, e.g. if a large interior should look cool and spacious, a strong orange in the vestibule to that space will help accomplish the effect.

### 2.12.4 Warm and Cool Colour

**Psychological Associations**

We note moving around the spectrum, yellow, the colour of sunlight, brings good cheer, green has little effect upon human emotion, blue is definitely calming, purple is depressing, red excites to courageous endeavor, and orange is most powerful stimulant of all.

Theoretically, some 150 hues are discernible by the eye in the spectrum of sunlight, multiplied by 10 for variation of value in each hue and again by 10 for variations in intensity at each value level it figures 15,000 possible colour. In practice, 1000 colours are probably the maximum required by an architect.

The selection of colour for an architect's thinking must be based on outward from man at the machine, through the man's immediate surroundings, to the surfaces farthest away.

The first consideration is eye comfort at the machine

1. Brightness contrast shall be greatest within the confines of the work in hand
2. Brightness contrast shall be less between work in hand and its background
3. That no contrasts farther away shall be permitted to interfere with the first two relationships, i.e. brilliant illumination upon the object in work is required slightly less upon the object is seen and successive small contrast against the floor, walls or other surfaces with view,.

For prolonged concentration in seeing, brightness ratios between task and surroundings should be smaller than 5 to 1, ratios greater than 10 to 1 should be prevented i.e. value of colour.

**2.12.5 Floor** -which is often glimpsed beyond the working area of machine, should obviously be light in value in order to minimize brightness contrast. The fact that less light falls upon the floor than upon the machine permits the specification of light colour. The colour of the floor will approach neutral as a concession to maintenance.

**2.12.6 Walls** - These should be of such a value, taking into account their distance, height, orientation and illumination, that slight brightness. Contrast between them and machine is maintained. Yet a conflict arises from the fact that as much reflectance as possible, is desirable from upper part of walls. Thus in some cases of lofty interiors upper part of walls may well be white and lower pacts in colour.

**2.12.7 Dado** are of great value for industrial plants, a problem of good seeing for the worker can be solved by appropriate dado colour as background and as rest area for the eye.

**2.12.8 Ceiling** – as are usually situated above the horizontal field of vision and because they usually should reflect all possible light from sky and interiors, should be handled differently from any other surface.

## 2.13 DESIGN IMPLICATIONS OF INDUSTRIAL PROCESS

The reasons for generating problems in industries are many and they varies according to the type of industrial process. The reasons, in general, are the scale of industry has changed from domestic to institutional[7], especially after industrial revolution. (The earlier proximity of work place and rest-place has lost since then more and more separation between them is inevitable). The inter-mixture of life and pursuit was well knitted in the earlier design and utilization of the same space for domestic and industrial purposes was common. Due to the passage of time, there is a clear cut separation of domestic and industrial space in contemporary requirements and lost the intermixture. After begin lost the intermixture and closeness of work place and rest place, the problems like security, safety, means of transportation, communication etc. has given rise to high investments of money for industrial structure and labour for industry. This very concept has given the temporary look to the industrial structures due to bad economic conditions.

Soon after the industries were separated from house, its sphere of influence, extended to larger and larger areas. It was

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[7] 'The Encyclopaedia Britanica', Vol. 12, pp. 288

possible only because of the urge to explore new sites, link them with efficient and safe transport, serve with better technical advancement, commerce, employment, and competitive spirit of the business.

## 2.14 DESIGN CONSTRAINTS FOR ENGINEERING INDUSTRY

The reasons for generating the problems in industries are many and vary according to the type of industrial process. According to scope, set for the dissertation, attempt has been made to study the problems of engineering industries. They come under the manufacturing industries. Their range is from **small scale to heavy industry.** They are capital **intensive and labour intensive** by which employment is provided to number of skilled, semi-skilled and unskilled workers.

The category of engineering industry for classification of industry comes under `**Factory'**.[9] In the factory envelope has no direct relationship with the manufacturing process. It may consist of combination of number of processes having separate identity and should have sequential movement of material the product is a tailor made. In case of `Mill' single envelope

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[9] Crube, O.W., 'Industrial Building and Factory', Architectural Press, London, 1971, pp. 10.

follows the process and movement of material is strictly sequential and no change in the product expected.

The major problem, one is likely to face in the engineering industries, is space requirement.It is very difficult to assess the physical space requirement as the product to be produced may change. (The flexibility is maximum in this type of industry. The subdivision of processes, in different separately identified, compartments creates problem in achieving sequence and flow in the overall process.) This is one of the major hurdles. The area or physical requirements of engineering industries depends upon the production capacity, work centers, delay locations, and flow of production assemblies. As the people started realizing the capacity and contribution of industries and its impact on economy and development of the nation, as a result following factors emerged out for understanding industrial problems. They are[10]

(a) Economic factors,

(b) Service factors,

(c) Climatic factors,

(d) Statutory factors

Each factor is illustrated below for it influence on industries and its planning.

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[10] Grant, I.W., and Grant, E.L., 'Handbook of Industrial Engineering and Management', Prentice-Hall of India (P) Ltd., New Delhi, 1969, pp. 557.

**2.14 (a) Economic Factors**

Economic factors are related to raw material, labour market facilities and transportation network. The location, accessibility, quality and quantity of raw material, market infrastructure and economic transportation are the factors by which problems are generated. According to labour factor it generates problem like migration, rehabilitation, education and training facilities etc. For better economic uplift provision or modification of market system, banking post and communication facilities are essential factors of problem. In the transportation network, haul length from source to site, ratio of weight to volume and time and cost taken during transit are important and problems for industrial design.

**2.14 (b) The service factors**

They are mostly the developmental factors such as

(i) provision of basic services like water, power and various fuels required for industrial process,

(ii) The availability and provision of external service such as disposal system, repairs and replacement system, provision of protection systems (like fire and medical),

(iii) The availability and provision of ware-housing of facilities for efficient dispatch and circulation of goods produced,

(iv) The availability and provision of housing and related social, cultural and habitations infrastructure.

**2.14 (c) The Climatic Factors**

The climatic factors generate problems to withstand natural hazards and calamities. They are wind, rain, quakes, floods and severness of climate. The unpredictable character of the climate increases stoppage of work due to absence or labour, problems for storage of material, in its raw stage, as well as, in its finished stage.

**2.14 (d) The statutory factors**

The statutory factors are of preventive nature and are based on statistics and long experiences. They are meant for achieving safe, sound and healthy personal working conditions and handling. These factors are like 'cautions' and 'directions' for the provision of better physical working conditions. The statutory power provides direction to an architect to provide solutions to industrial problems. They cover environmental control, pollution control, health and hygiene requirements and safety of structure. The statistical information[11] is also, collected under statutory powers, provides clues for industrial problems. It mainly gives basic assumption regarding work force relationship to production capacity, production capacity to space utilization, workers facilities as per various types of industries, distribution of factories as per size and employment and its number of units, occurrence of accidents, and nature of accidents.

## 2.15 Design Constraints due to rules and regulations

Whenever an architect is entrusted with the design of a building, he is required to do so within a certain framework of act, rules, regulations and bylaws. In Industrial context, apart from the requirements of process, he has to provide minimum standard in terms of height, floor areas related to number of occupants, safety measures, fire precautions, worker's facilities etc.

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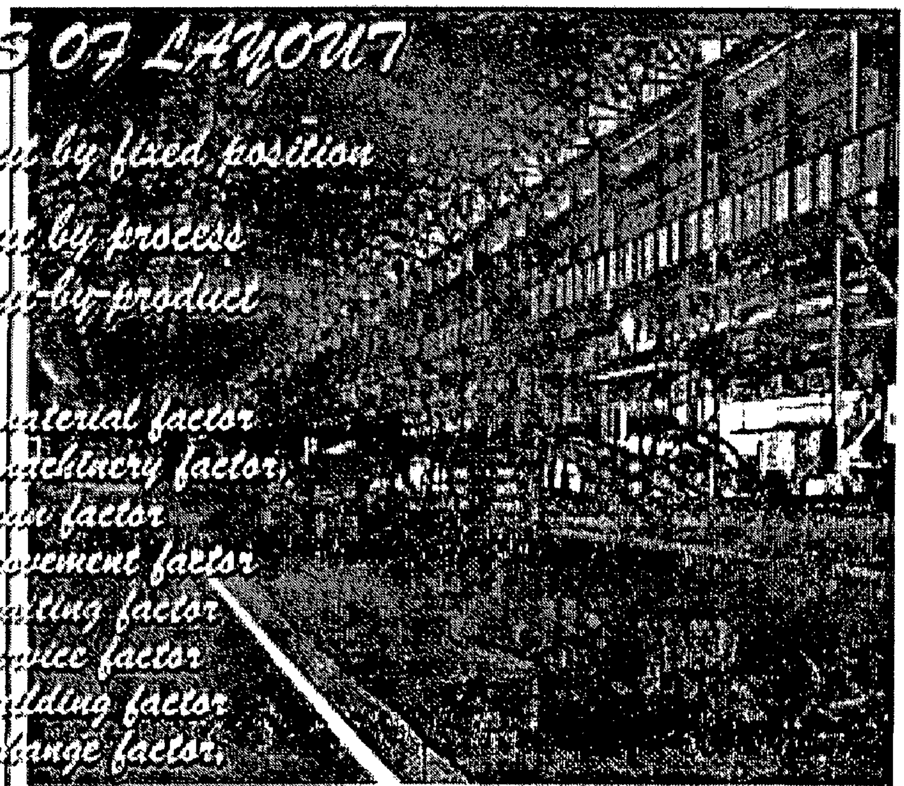
[11] Labour Bureau, 'Statistics of industries 1959', Ministry of Labour and Emplmoyment, Government of India, Simla.

# factors influencing plant layout

plant layout embraces the physical arrangement of industrial facilities. this arrangement either installed or in plan, includes the spaces needed for material movement, storage, indirect laborers, and all other supporting activities or services, as well as for operating equipment and personnel.



## TYPES OF LAYOUT

a). Layout by fixed position

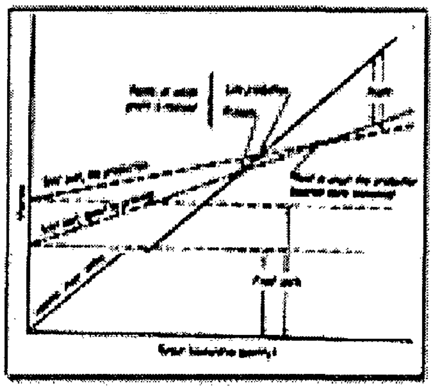
b). Layout by process

c). Layout by product

1. The material factor
2. The machinery factor,
3. The man factor
4. The movement factor
5. The waiting factor
6. The service factor
7. The building factor
8. The change factor,

## Break-Even chart

It's a useful aid in estimating what amounts of capital outlays are economically justified for an anticipated volume of sales. the chart can indicate overinvestment or when the plant is too large, by showing that the anticipated revenue from the sales.



# Factors influencing plant layout

The main objectives of Plant layout may be summed as the most economical to operate and yet safe & satisfying for employee .It is the integration of all the facilities into one big operating unit.Plant layout embraces the physical arrangement of industrial facilities

## Seven types of movement

1). Move the material
2). Move the man
3) Move the machinery
4).Move material and men
6). Move men and machinery
7). Move material, men, and machinery

## FACTORS INFLUENCING PLANT LAYOUT

1.The material factor
2. The machinery factor.
3. The man factor.
4. The movement factor
5. The waiting factor.
6. The service factor
7. The building factor.
8. The change factor

# LIGHTING IN INDUSTRIAL BUILDING

Once the general requirements of the lighting Installation and the room to be lighted are known. An analysis of the visual task may lead to more special requirements for the illumination of the interior. This will determine the choice of lighting system to b used and the location and arrangement of the luminaries.

General lighting produced by a regular array of luminaries with or without an Indirect component results in a specific horizontal illuminance with a certain uniformity.

- Localized General Lighting
- Local Lighting
- Choice of lamp

The designer shall choose appropriate types of lamp(s) suited for the specific application and satisfying the design objectives.

The designer shall choose appropriate types of lamp suited for the specific application and satisfying the design objectives

Local lighting is recommended for:
- The work involves very critical visual task.
- Perception of forms and textures requires strongly directional light.

## COLOUR IN INDUSTRIAL BUILDINGS

Color is an important aspect:not only due tothe aesthetic reasons but functional reasons as well. Proper use leads to improvement in standards of cleanliness and appearance. The correct use of colour in conjunction with a goodstandard of lighting both natural and artificial can reduce eye strain, glare, and visual discomfort.

## INDUSTRIAL COLOUR PLANNING

### BACKGROUND COLOUR:

Background colour must be in relation to work carried out in the room. The walls and ceilings which form thisbackground should not give rise to glare, should be restful and provide a neutral light surround adapted to the lighting conditions.

### MACHINARY COLOUR:

The colour selected for machinery must provide a suitable brightness contrast with both the task and the immediate background. The working area of machine must be the brightest spot in field of vision.

Colour should be complementary to surrounding are

Colour must provide a suitable contrast from work

Colour must provide rellief to the eyes and assist sp readjustment of vision from work areas.

Colour can be used to vary the apparent temperatur

Colour of machine must not act as camouflage of p

Identification of Colour - pipes, conduits for air, gas, steam, electricity and other hazards.

Easy and automatic perception of different parts

# CHAPTER – 3

## "ARCHITECTURAL INTERPRETATION OF DESIGN CONSTRAINT THROUGH ANALYSIS"

"Eliminate the impossible, and what remains, however improbable, must be the solution". These words by Sherlock Holmes describe the essence of his method; and is a very good general description of the method of establishing a problem space.

## 3.1 Categorization of Design Constraints due to Industrial Process

To identify and analyze the design constraints these have to be simplified and categorized in suitable format so as to understand them, though, again there may be different interpretations, but considering the objectives of the dissertation the interpretation has been done as given below:

1. **Constraints due to functional requirement**
2. **Constraints resulting out of occupational, interior and exterior environment i.e. physical environment.**
3. **Constraints due to ecological imbalance**

## 3.1 Constraints due to Functional Requirements

These constraints are well defined and clearly expressed in the basic principle of manufacturing process. It gives the correct concept of interaction between the various constituents of industries such as man, material and machine. The sequence of operation, positioning of labour and material at machine for process, waiting of material, handling capacity and location of such facilities gives the functional problems.

## 3.2 Constraints resulting out of occupational, interior, exterior environment i.e. physical environment

The physical constraints can be ascertained from the various machines used, quantity of labor and material required areas required for housing them. It is helps to understand building

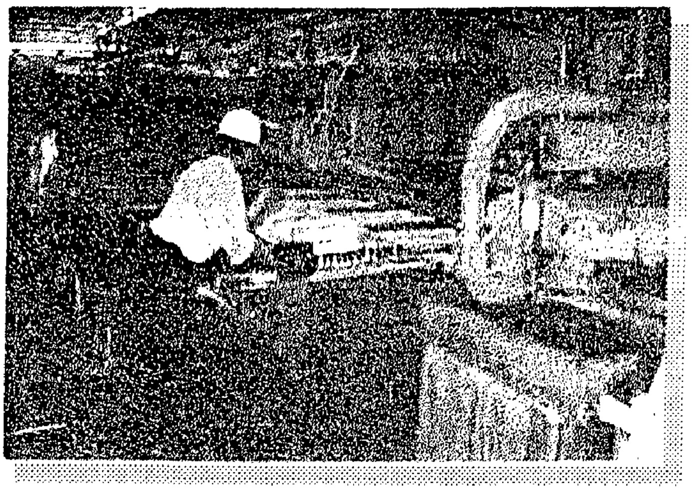


Figure XI PHYSICAL ENVIRONMENT

requirements, I Loading factor and facilities to achieve the smooth function of industry.

The problem of dust particles, emittance of fumes, and gases, which may be poisonous or irritant are to be taken care of in the design of the building enclosure, types of ventilation systems, lighting, safety measures, acoustics etc. have to be incorporated.

### *3.2.1 CONTROL OF INDUSTRIAL ENVIRONMENT*

Control of industrial environment is concerned with the design and application of equipment for providing the necessary conditions within the design and application of equipment for providing the necessary conditions within industrial areas for maintaining the efficiency, health and safety of workers.

### *HEAT CONTROL IN INDUSTRIAL WORK AREAS*

In certain work situations there is considerable release of heat from the process equipment to the environment. It is not economically feasible to stop the escape of all this process heat. Distinction must be made to control needs for hot dry industrial areas and warm-moist conditions. In the first case, the process gives off only sensible and radiant heat without adding moisture to the air. The heat load on exposed workers is thereby increased but the ratio of cooling by evaporation of sweat is not reduced. Heat balance may be maintained although this will be at the expense, perhaps, of excessive sweating. In the warm moisture situation, the wet process gives of principally latent heat. There may be no significant rise in heat load but the increase in moisture content of air will seriously reduce the heat loss by evaporation of sweat.

Examples of hot dry work situation are seen around hot furnace, forges, metal extruding and rolling mills, glass forming machines. Typical of warm moist operations are laundries, dye houses, and deep mines where water is used. The industrial heat problem varies in magnitude with local climatic conditions. Solar heat gain and an elevated outdoor temperature will increase the heat load at work place

In certain industrial work situations there is considerable release of heat from the process equipment to the environment. It is not economically feasible to stop the escape of all of this process heat or to offset it completely by the usual methods of comfort ventilation and air-conditioning. In the design and operation of control measures it frequently necessary to accept some heat exposure in excess of simple comfort requirements.

The engineer must distinguish between the control need for hot-dry industrial areas and warm-moist conditions. In the first case, the process gives off only sensible and radiant heat without adding moisture to the air. The heat load on exposed workers is thereby increased but the rate of cooling by evapo-ration of sweat is not reduced. Heat balance may be maintained although this will be at the expense, perhaps of excessive sweat-ing. In the warm-moisture situation. The wet process gives off principally latent heat. There may be no significant rise in the heat load on the worker but the increase in moisture content of the air will seriously reduce the heat loss by evaporation of sweat. The warm moist situation is potentially more hazardous than the hot-dry.

Examples of hot-dry work situation are seen around hot furnaces, forges, metal extruding and rolling mills glass-forming machine and the like. Typical of warm-moist operations are laundries, dye houses, and deep mines where water is extensively used for dust control.

The industrial heat problem varies in magnitude with local climatic conditions. Solar heat gain and an elevated outdoor temperature will increase the heat load at the work place but these contributions may not be very important compared with the locally generated heat of the process itself. The moisture content of the outdoor air, on the other hand, is a most important climatic factor affecting hot-dry work situation. For the warm moist job, in contrast, solar heat gain and elevated out door temperature are the more important, since, compared with the moisture release on the job, that contributed by the outdoor air will be of little significance.

### 3.1.3) Constraints due to ecological imbalance

The problems resulting due to ecological imbalance are generally those which are covered under all types of pollution. The dust, as contaminant, emitted out, by the industry, from its chimney stack is carried away from the wind and is dispersed on the leeward side of the stack over a larger area. The solid and liquid waste generated during the industrial process may also contaminate the environment. It must be disposed or recycled so as to have minimum effect on the environment. The positioning and height etc. of the chimney stack must be considered at the design stage.

In general, the expansion cum modernisation is designed to the meet the following requirements.

Low consumption of fuel, water, chemicals, steam and power

Low annual maintenance

Adequate instrumentation and automatic controls to ensure consistent quality and ease of operations.

Adequate environmental protection measures to minimise pollution problems/hazardous

Adequate facilities to ensure safe operation of the plant.

## .3 a)AIR POLLUTION & ITS ORIGIN & EFFECT

**Air pollution can be defined as the presence of any foreign matter in atmosphere either in the form of particulate or gas in sufficient quantities and duration, which are detrimental to mankind vegetation & materials.**

According to WHO air pollution define as limited to situations in which the outer ambient atmosphere contains material is concentrated which are harmful to man and his environment. Ambient air is a mixture of gases containing about 78% nitrogen, 21% oxygen, 1% argon, 0.03% $CO_2$ and have other gases like neon, helium, methane, krypton etc in very low proportions. Water vapours are also present ranging from 1 to 3% on volume basis. In addition to their component certain constituents which are known as air pollutants are also present at very low background levels.

Air pollution is an atmospheric condition in which polluting constituents are present in high concentration enough above their normal levels to produce detachable harmful impact an different receptacle like flora, fauna, materials etc. These constituents are air borne and generated through natural & Anthropogenic.

**COMMUNITY AIR POLLUTION**

Outdoor air is the community property; maintenance of acceptable air quality requires complex governmental initiatives affecting industry, ısportation and even personal life styles. The ultimate objective of there tive is to protect human health and prevent degradation of the onment. The origin of the air (Prevent and Control of Pollution) Act 1981 l be traced to the United Nations Conference on the human environment in Stockholm in June 1972 in which India also participated

### 3.1. 4 Classification of pollutants

Pollutants are the main creators of pollution, which causes damages to the target or receptor. Target is always adversely affected by pollutant. It may be man,,animal , plant building or material etc. . Pollutants can be classified in a number of way

**a) According to form basis**

**1) Primary pollutants:**

These substances emitted directly from an identifiable source . These pollutants exist as such after being added or released into the environment e.g. SO2, nitrogen oxide

**ii) Secondary pollutants**

These are substances derived from primary pollutants by chemical reactions e.g. primary pollutants such as hydro carbon s & nitrogen oxide , particularly in the environment , react in presence of sunlight to form a group of nitrous compounds like PAN (peroxy acetyl nitrate) as the secondary pollutants

**b) According to charcteristics**

**1) Gaseous pollutants**

these pollutants are gaseous in nature at normal temperature and pressure . these also include vapours of compounds whose boiling points are below 200 °C .These pollutants include a variety of inorganic & organic gaseous materials

**a) Inorganic gaseous pollutants**

These include noxious gaseous pollutants like oxides of nitrogen , oxides of sulphur , oxides of carbon , hydrogen sulphide ,ammonia chlorine etc. These primary pollutants are emitted & as such are not found in the atmosphere .Secondary pollutants are also formed in the air and are mainly generated by exhaust of automobiles and industrial emission e.g. O3 is not emitted as such in the atmosphere but formed from primary pollutant by the interaction of atmospheric oxygen when it under goes photo chemical reactions

**b) Organic gaseous pollutants**

These pollutants include hydrocarbons such as CH4, C3H8, C2H2, C6H6, C8H18 and other compounds such as formaldehyde, acetone

/apours alcohols, organic acids, chlorinated hydrocarbons etc.

**i) Particulate matter**

Small solid particles and liquid droplets are collectively known as )articulates These are present in atmosphere in fairly large ıumbers and pose serious air pollution problem. Particulate )ollutants are classified according to particle size and nature into 'umes, dust, ash, carbon, smoke, lead, asbestos, oil, gases etc.

**ii) Aerosol pollutants**

These air pollutants remain suspended in air and consist of fine )articles of different organic and inorganic compounds having liameter less than 100 $\mu$.

***iii) Biological contaminants***

Biological contaminants deteriorate the atmosphere and their effects on human health are still worst. Their exist numerous air )orne micro –organisms, pathogens, bacteria, viruses and )arasites which are added as air pollutants in the atmosphere. Their effects on living organisms are obviously undesirable

### 3.1.5 Effects of particulate pollutants

Particulate pollutants are present in troposphere and stratosphere where they stay for a long period

**I) Effects of particulate pollutants on human beings**

The effects of particulate pollutants are largely dependent on the particle size. Air borne particle i.e. dust, soot fumes and mists are potentially dangerous for human health.

- Particular pollutants have a bearing on the penetration of particles beyond the respiratory passages in to lungs. Nasal passage prevent coarser particulate bigger than 5 u from entering in to the respiratory system
- Fine particulate less than 2 u are the worst source of lung damage while the larger particles (3 u) are trapped in the nose and threat. These particles create various breathing troubles by nasal tract blockage and irritation of the lung capillariess inhibiting the rate of minerals from the soil.
- . Particulate fumes and cause cracks in it.
- Particulate accelerate corrosion of metals, which is maximum in urban and industrial areas
- Particle including fumes, duct, soot, mists and aerosols can being about serve damage to soil building, sculpture & monuments

## 2) Effects of particulate pollutants on plants

- Gaseous pollutants and deposition of particulate on soil adversely affect plants. This deposition of toxic metals on soil makes the soil unsuitable for plant growths.
- Particulates such as dust, fog, soot deposited on plant leaves block the stomata of plants, thus inhibiting the rate of minerals from the soil .

### 3) Effects of particulate pollutants on Materials

Particulate affect a variety of materials in various ways. They cause damage to building ,paints and furniture etc. . Painted surfaces are very susceptible to damage in the wet condition

- Particulate affect a variety of materials in various ways .They cause damage to building ,paints and furniture etc. . Painted surfaces are very susceptible to damage in the wet condition .Particulate fumes and cause cracks in it .
- Particulate accelerate corrosion of metals ,which is maximum in urban and industrial areas
- Particle including fumes ,dust ,soot ,mists and aerosols can being about serve damage to soil building , sculpture & monuments
- Plants are adversely affected by gaseous pollutants and deposition of particulate on soil. This deposition of toxic metals on soil makes the soil unsuitable for plant growths.

## 3.2 Design Implications due to rules and regulations

The various factory laws, codes and bye laws stipulate the standards for various physical conditions, demanding definite working conditions, safety norms for cleanliness, housekeeping, Indoor environment, ventilation, temperature, lighting pollution norms, fire, plumbing, toilet facilities, safety and avoidance of injury and accidents, type of floors, minimum size of escapes doors and various workers welfare activities.

## 3.2.1

## LEGISLATIONS RELATED TO AIR POLLUTION & PRESCRIBED STANDARDS

### Legislation

Today environmental legislation is becoming an integral part of management of pollution. India is the first country, which has made provisions for the protection & improvement of environment in its constitution.

The article 51-(g) of the constitution states:

*"It shall be the duty of every citizen of India to protect & improve the natural environment including forest, lakes, rivers & wildlife to have compassion for living creatures."*

The directive principle of state policy, an integral & significant element of our democratic order, also contains specific provisions regarding the state commitment to protect the environment.

These constitutional provisions have been given effect though a well-placed system of environmental protection laws in India.

### 3.2.2 LIST OF APPLICABLE ENVIRONMENTAL REGULATIONS

The Water (Prevention and Control of Pollution) Act, 1974 as amended upto 1988.

The Water (Prevention and Control of Pollution) Rules, 1975

The Water (Prevention and Control of Pollution) Cess Act, 1977 as Amended upto 1991.

The Water (Prevention and Control of Pollution) Cess Rules 1978 as

The Environment (Protection) Rules, 1986.

The Hazardous Waste (Management & Handling) Rules, 1989.

Manufacture, Storage and Import of Hazardous Chemicals, 1989 as amended upto 1994.

The Public Liability Insurance Act, 1991.

The Public Liability Insurance Rules 1991.

Environmental (Protection) Rules, 1992 and 1993 – " Environmental Standards."

Environmental (Protection) Rules 1994 – "Environmental Clearance" as amended upto April 1997.

The National Environmental Tribunal Act, 1995.

Environmental (Protection) Rules, 1996 – "Public Hearing Notification."

The National Environment Appellate Authority Act, 1997

Environment (Protection) Second Amendment Rules, 1998- "Environmental Standards."

In above applicable laws & regulation following are related to air pollution only

- The Air (Prevention and Control of Pollution) Act 1981, as amended Up to 1987.
- The Air (Prevention and Control of Pollution) Rules 1982 and 1983.
- The Environment (Protection) Act, 1986.
- The Environment (Protection) Rules, 1986.

We are going to discuss only legislations related to Air

These acts & rule have commanding & controlling power in this way:

Enforcement of pollution control norms in various types of industrial units depending on their production processes / technologies & pollution potential particular attention is given to highly polluting industries.

By introduction of environmental audit.

Environmental impact assessment from the planning stage & selection f sites for location of industries.

Clearance of MOEF of all projects above a certain size & in fragile areas.

### 3.2.3 Air (Prevention and Control of Pollution) Act

Measure for prevention & control of Air pollution

- Declare Air pollution control areas
- Prohibit the use of any fuel in Air pollution control areas
- imposing restriction on use of certain industrial plants
- not to allow emission of air pollution in excess of the prescribed standards
- give instruction for measuring standards for emission from automobiles

ii)Environment (protection) act, 1986:

Measure for environmental protection & improvement

- Laying down standards
- Restriction of industrial activity in certain areas
- Regulating the handling of Hazardous substances & wastes
- Not to allow emission / discharge of environmental Pollutants & excess of standards
- Rules to Regulate environmental Pollution

# CHAPTER IV

## "CASE STUDIES"

# CHAPTER – 4

# CASE STUDIES

## 4.0 ABSTRACT

In order to study the design apart from the various literatures, case study is definitely the most potent source of information. For the present study case studies taken are from (1) Literature and (ii) Personal visit to factory, In case of personal visit a questionnaire is prepared and survey work is carried out at Hindalco Industries, Renukot.

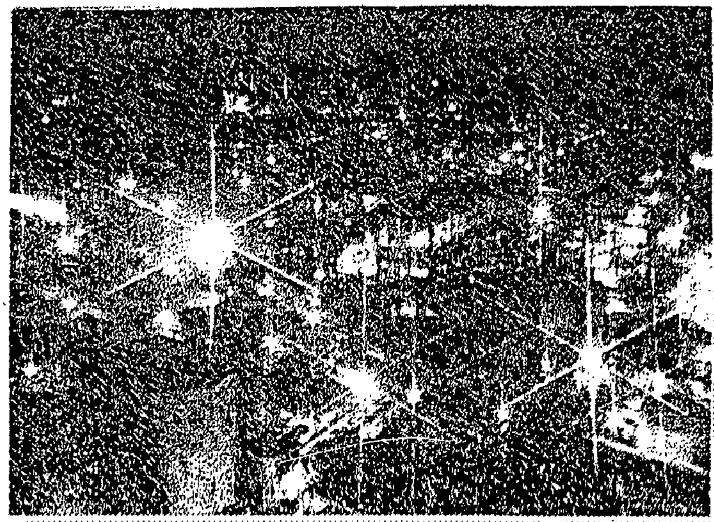


Figure XII VIEW OF HINDALCO, RENUKOT

## 4.1 Personal Survey of Factory

In order to understand the physical environment conditions a questionnaire is prepared based on the objectives given below:

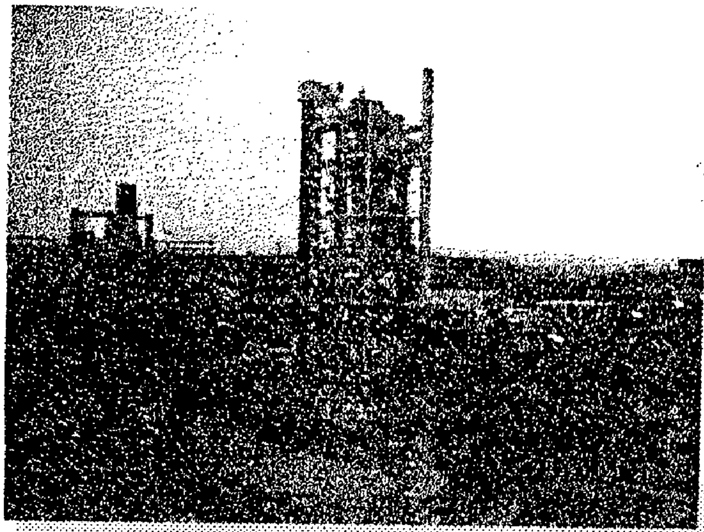
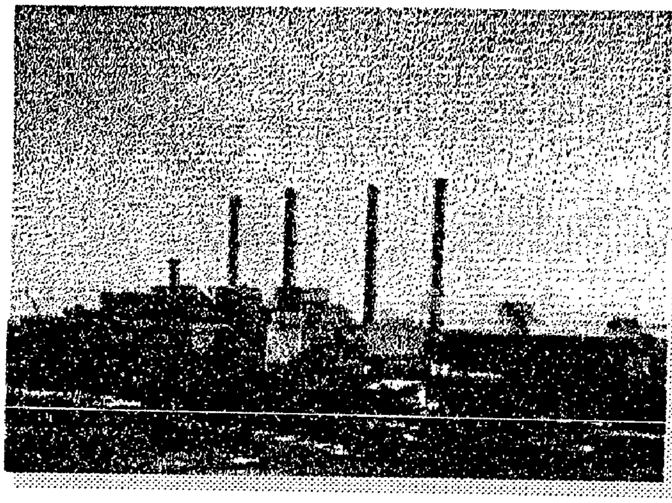


Figure XIII VIEW OF HINDALCO,RENUKOT

1. To study the problems faced by Industries while performing industrial processes

2. How they are generated and their effect on physical working conditions and building envelope



3. To collect information regarding the factors which influence space utilization, sequential arrangement and service factors

Figure XIV VIEW OF HINDALCO,RENUKOT

The methodology adopted for conducting survey is based on personal interview with the manager, supervisor and workers selected as random sample.

### 4.1.2 Survey Conclusion

Figure XV VIEW OF SLITING LINE

The data which are collected are analytical with the help of relevant statistical tools, i.e. software package which include Microsoft excel various analytical techniques (statistical techniques) are employed different factors or parameters are attributed weight and the result evaluated. Thus the result obtained will be helpful to evolve proper guidelines.

## 4.2 CASE STUDY: HINDALCO INDUSTRIES, RENUKOOT

### 4.1 LOCATION

Lying in the foothills of Vindhya Range, renukoot is about 160 km from mirzapur. It is well connected to both these cities by road. There are direct trains between amritsar to tatanagar and Ranchi via renukoot. The nearest airport is about 180 km by road from renukoot.

## 4.2 GROUP OVERVIEW

The Aditya Birla Group is India's second largest business house.it has a leadership position in India in aluminum. It is India's largest integrated aluminum producer and among the worlds lowest cost producers.

## 4.3 HINDALCO OVERVIEW

"HINDALCO" was setup in collaboration with **Kaiser**

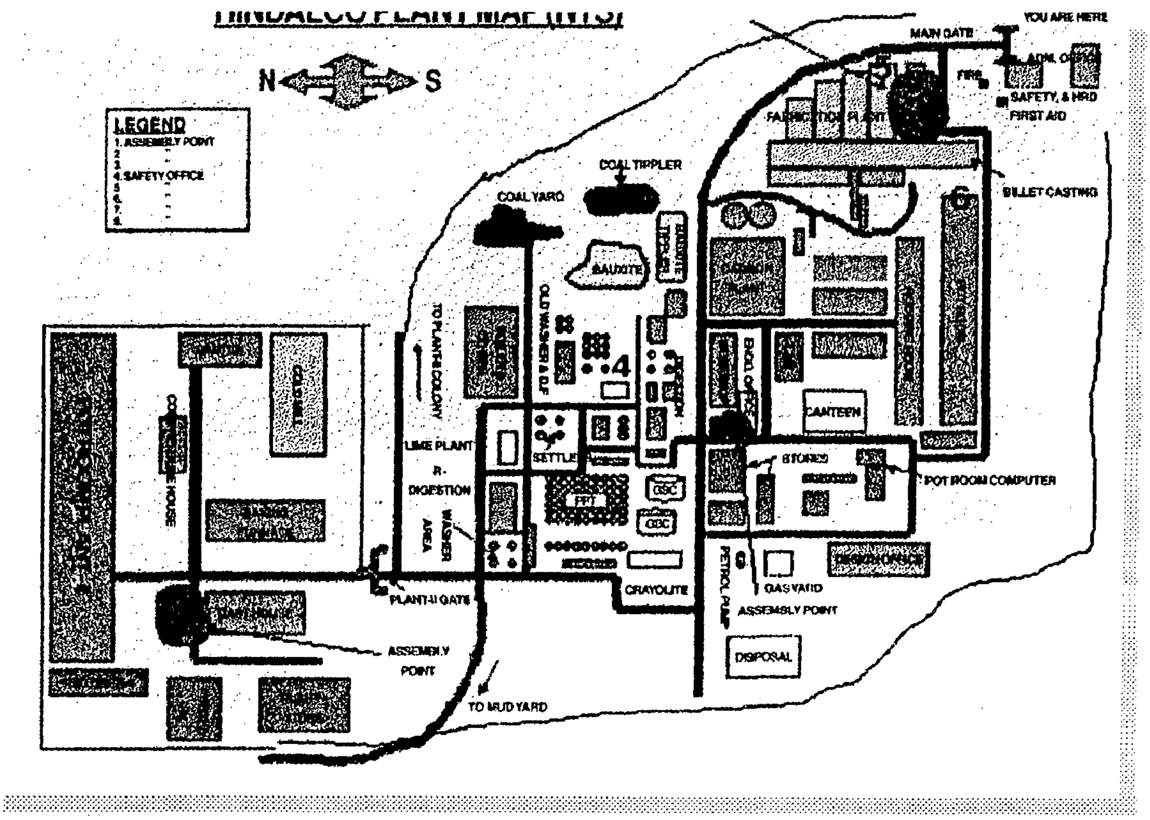



Figure XVI SITE LAYOUT

**aluminum & Chemicals Corporation U.S.A.** The plant started functioning in year 1962 with capacity of 20,000 tons per annum. Aluminum has turned out to be a wonder metal, no other single metal can do so many jobs, so well and so economically.

Handclap ranks as the largest aluminum producer in India and contributes about 44% share in total production of the country . The company's fully integrated aluminum operations consists of mining of bauxite, conversion of bauxite into alumina, operations consists of the mining of bauxite, conversion of bauxite into alumia,production of primary aluminium from alumina by electrolysis and production of properzi redraw rods, rolled products, extrusions and value added products like foil and wheel. Hindalco's integrated operational efficiency have enabled the company to be one of the worlds lowest cost producers of aluminium. Hindalco also

Figure XVII ' HOT MILLS

owns a large captive thermal power plant at Renusagar, that meets the power requirements of the company.

Hindalco currently has Primary aluminium capacity of 242,000 MTPA. The capacity is being increased further by 100,000 MTPA, and is expected to achieve by 2002-03, the project entails a capital expenditure of approx. Rs. 1800 crores.

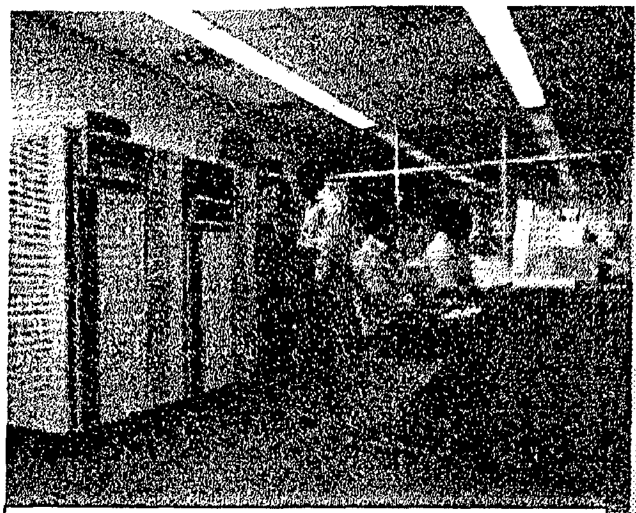


**Figure XVIII CONTROL ROOM**

| PARTICULARS | PRODUCTION (FOR 19999-2000) |
|---|---|
| 1. Power generation | 4,050 MU |
| 2. Alumina | 453,305 MT |
| 3. Aluminium Metal | 248,930 MT |
| 4. Rolled Product | 58,594 MT |
| 5. Extrusions | 14,959 MT |
| 6. Wire rods | 49,018 MT |
| 7. Foils | 7,537 MT |
| 8. Co-generation | 246 MU |

| MU - Million Units | MT - Metric Ton |
|---|---|

## 4.4 ENVIRONMENTAL POLICY

The Hindalco Industries Limited are committed to resource conservation and control of environmental aspects of our *activities* interalia, relating to producton of Alumina, Aluminium, Fabricated product, in order to serve the cause of sustainable development.

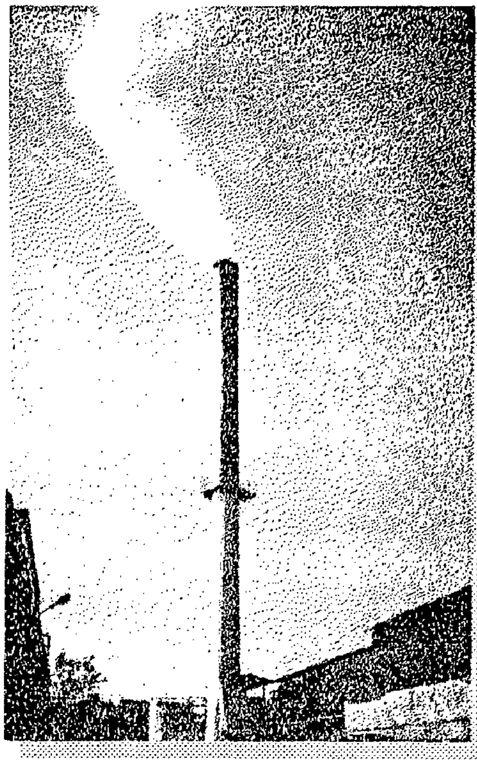


Figure XIX STACK

This is achieved by

- Innovation and improvement of processes, equipment's, operation maintenance and other practices continuously for pollution prevention.

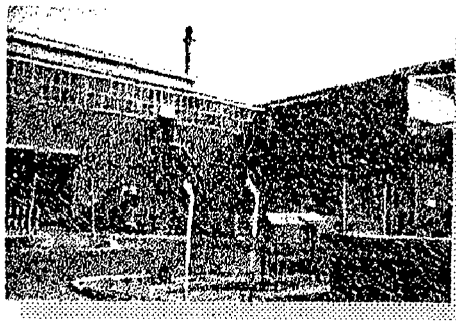


Figure XXI INSIDE VIEW

- Adopt cleaner technologies.
- Conserve key input resources such as bauxite, coal, power, water etc. Keep exploring the feasibility of recycling and

utilization of inevitable wastes e.g. Water, lube oil red mud. and fly ash.

- Remain in compliance with all applicable environmental laws and regulations and also strive to go beyond.

Alumina is produced from Bauxite in two stages by Bayer's process,using caustic soda at high temperature (243 C) and 36 KG/SQ CM pressure and process is carried out in the digesters. Alumina, required for the electrolytic reduction in reduction plant, is supplied by Alumina plant. Reduction plant has 8 pot lines having 1468 prebaked pot cells. Each pot is linked with carbon cathode and has 24/26 anodes. The entire

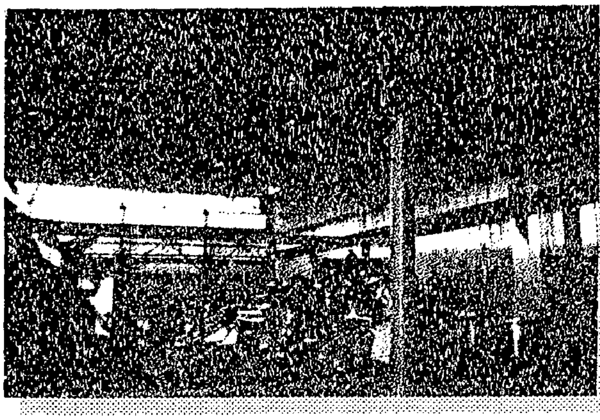


**Figure XXII SCRAP LYING ON FLOOR**

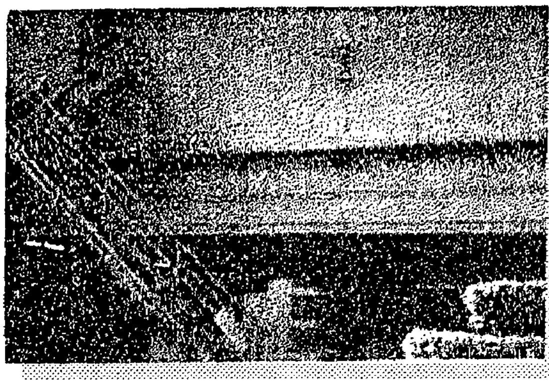


**Figure XXI VIEW OF INSIDE AREA**

process is controlled by microprocessor based pot controllers called CELTROL. To control pollution due to emission of fluorine gas, dry scrubbing system have been installed.

## 4.4 PROCESS DESCRIPTION OF FABRICATION PLANT.

### EXTRACTION OF ALUMINIUM

Alumina, required for the electrolytic process in Reduction Plant, is supplied by Alumina Plant. Reduction Plant has 8 Potlines having 1468 prebaked pot cells. Each pot is lined with carbon cathode and has 24 / 26 anodes suspended from the top. Alumina is converted to melallic aluminium in these pot cells by the `Hall Heroult' fused salt electrolysis. The pots operate on DC current of 58 / 63 kA at 4.3 volts. Electrolysis of the alumina takes place in the molten bath of cryolite at a temperature of 955-960°C. The molten aluminium which collects at the cathode is siphoned into the crucibles periodically (760 Kg / tap every 40 hours). The entire process is controlled by microprocessor based pot controllers called CELTROL To control the pollution due to the emission of

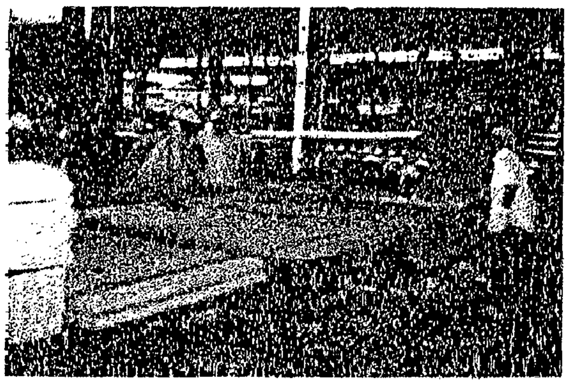


Figure XXIII PACKING

fluorine gas, dry scrubbing system has been installed on these pots. The emitted fluorine is collected and passed through the reactors where alumina gets enriched with fluorine and is fed back into pots. Daily production of aluminium is about 672 MT. Anodes used in Potrooms are manufactured in Carbon Plant. The raw materials for anode manufacturing are C.P. Coke and hard pitch. These are mixed together to form green anodes, thereafter the green anodes are baked and then sent to rodding room where a stub welded to copper rod is fitted. The baked anodes are then sent to Potrooms for use in the pots.

PROCESS DESCRIPTION OF FAB**RICATION**

### 4.4.1 PROPERZI

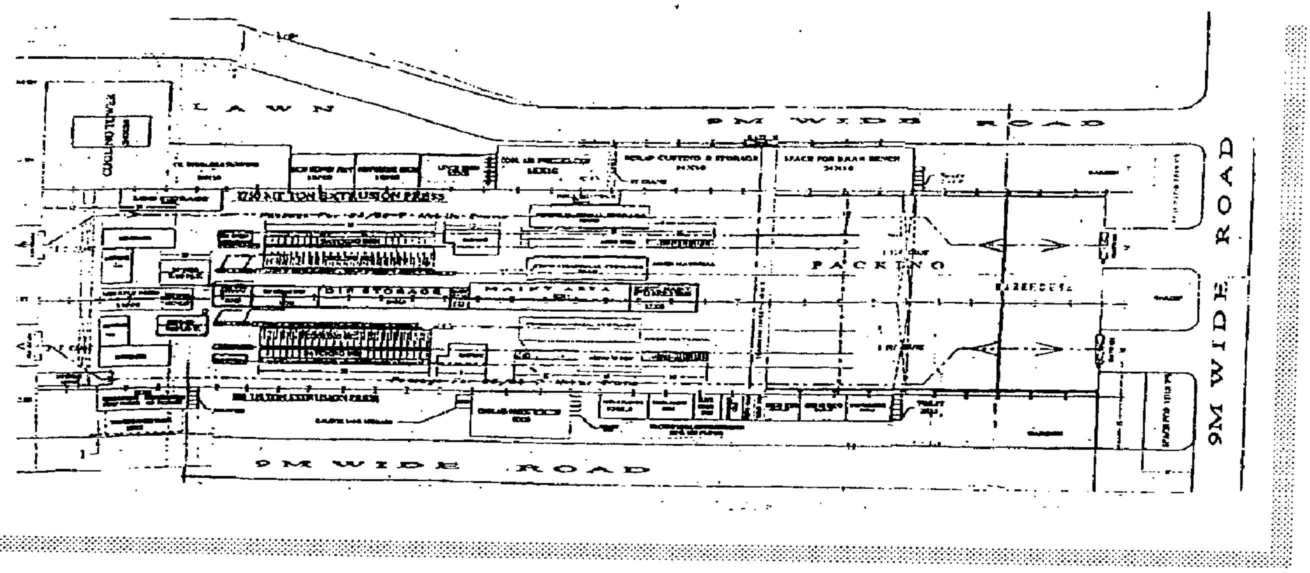



**Figure XXIV PLANT LAYOUT OF EXTRUSION**

This is a continuous casting and rolling process. It is used for production of Atuminium EC / Alloy Conductor redraw rods. Molten metal from Potroom is poured in the melting cum holding furnace. After fluxing and degassing molten metal is fed into peripheral groove of water-cooled circular casting wheel, which keeps rotating at a constant speed. An endless steel belt covers the lower half periphery of this wheel. During one half rotation af wheel, the molten metal assumes typical shape conforming to the configuration of the peripheral groove of the rotating wheel. The bar has cross sectional area of 12- sq. cm. at 450-500°C temperature and it comes out continuously. This bar is fed into the Properzi machine that has 13 sets of rolling stands. Each stand has three rolls set 120g apart and has difterent cross sections of rolls starting from the biggest section at stand No.1 to the smallest stand No.l3. These stands are driven by a gear train which gets its drive from 200 / 250 H.P. Motor. The rod coming out of stand No.l3 has size of 3/8" or.9.5 mm dia. The rod thus produced is fed to a coiler to make coils of 1 .5 to 2 M.T. weight. Aluminium Rolling ingots (slabs) and Aluminium Extrusion ingots (billets) are

produced through the D.C. Casting as well as newly installed State of the art Slab andBillet Casting facilities.

## 4.4.2 D.C.CASTING

The direct chilled casting commonly known as D.C. Casting process is followed for the manufacturing of Rolling Ingots and Extrusion Billets. The Hot Metal from the Pot Room, process serap in plant, scrap fram Extrusion / Rolling Mills are charged in oil fired reverberatory type melting furnaces. Necessary alloying, if required is done after fluxing and degassing. The

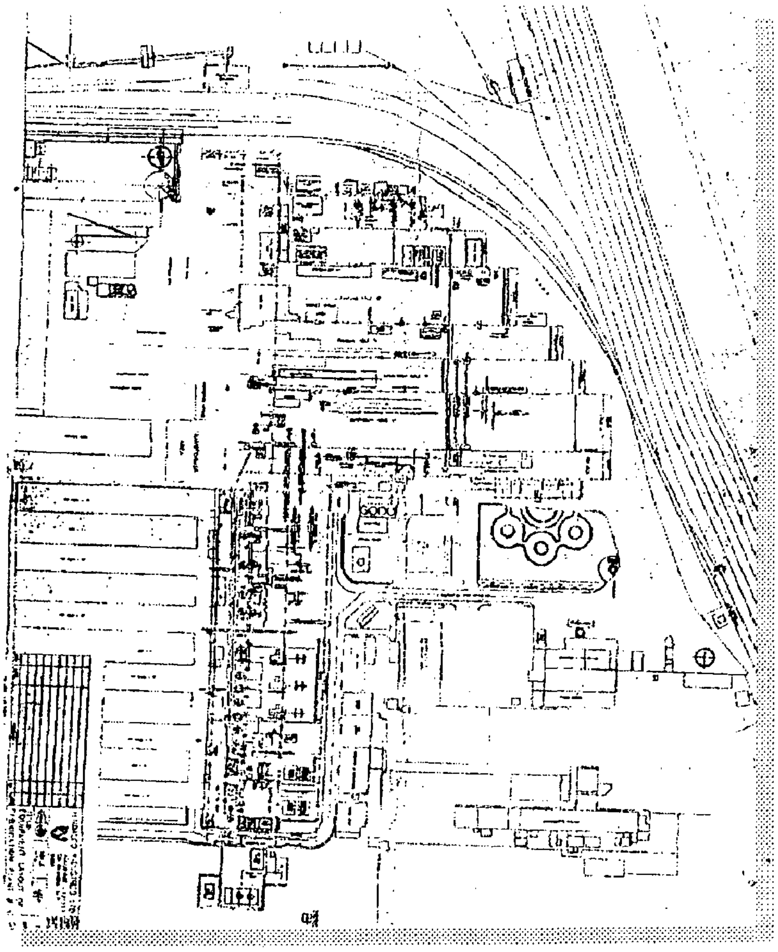


Figure XXV FABRICATION PLANT

molten metal is then tr[illegible] metal treatment is done [illegible] casting. The casting machine is placed in deep floor excavation lined with concrete, the metal flows from the holding furnace in an open launder, through a fibre glass screen and distributor, into bottomless short water cooled moulds made of aluminium.

To attain non- turbulent under pouring condition, the metal flow, float control metering pins made of refractory are used. Before starting the casting, bottom block carried by the platen fixed to the hydraulic cylinder is inserted in to the mould. When the metal flowing into the mould reaches proper level, the cylinder begins its downward travel. The rate of flow of molten metal and descent of cylinder ram reaches its bottom most position or depending on the cast length required, the furnace tap hole is closed. The runner and station are moved and the cast product is lifted.

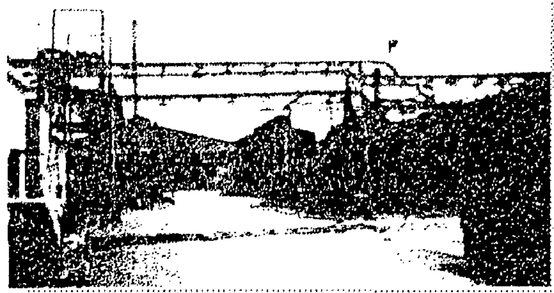


Figure XXVI OVER HEAD BRIDGE

### 4.4.3 CAST HOUSE

To meet the demand of overseas market, Hindalco has installed an ingot casting plant at Plant-II. This facility has contributed substantially in broadening the range of Rolled Products and improving their quality. It has also enabled higher value addition and higher volumes.

### 4.4.4 BILLET CASTING

A state of the art Vertical Billet Casting facility has been commissioned to ensure increased volume of quality feedstock for the Extrusion Presses besides enabling increased export of value added Billets.

### 4.4.5 EXTRUSION PROCESS

Extrusion in brief is a process for making desired shape of a metal or its alloy by forcing the metal to flow through desired die under pressure in plastic stage. Our Extrusion shop has three presses on each of 2240 tons, 1800 tons and 1250 tons, hydraulic pressure. During process of extrusion, aluminium alloy billets (6" to 9" dia and 35 to 75 cm long) or logs 6 meter long and 7" dia received from

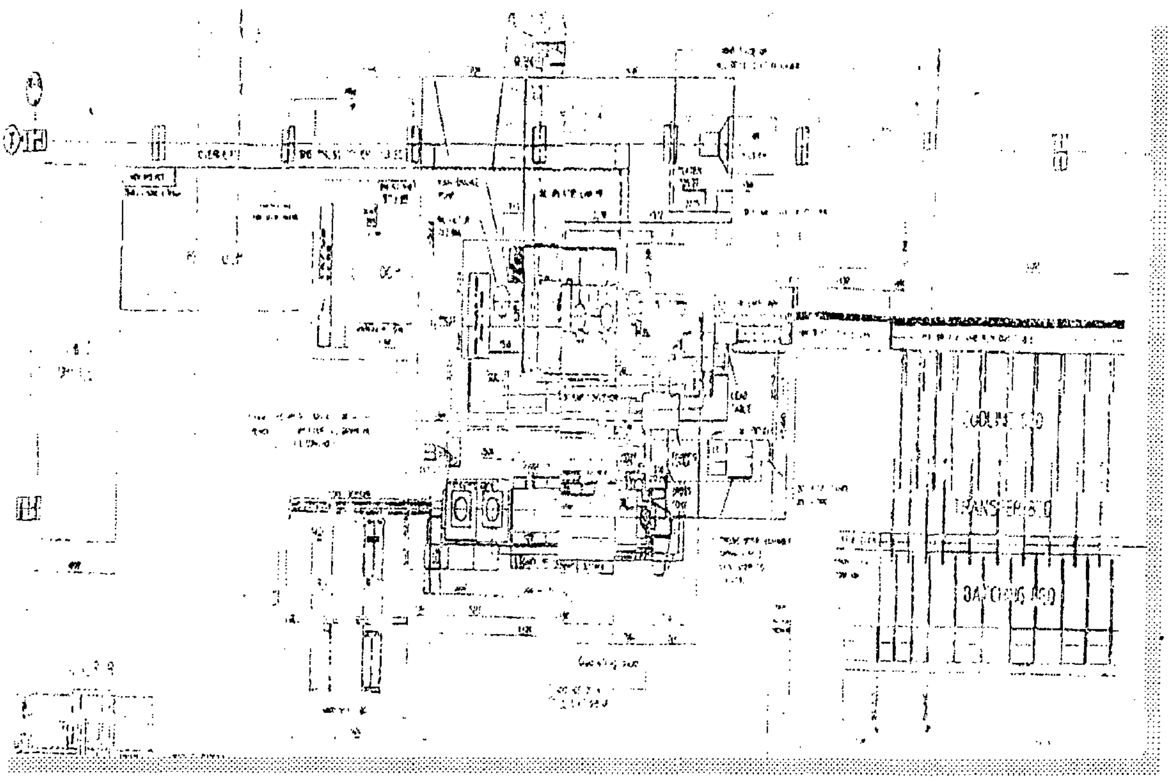


**Figure XXVII EXTRUSION PRESS**

Remelt shop are heated in an induction billet heater or log heating furnace to about 500 degree centigrade. The hot billet passes through a conveyor to the billet loader, which takes it to the feed line of the extrusion press. The ram of the press pushes the hot billet into a heated container against a die (at a temperature of about 800°F) made of special steel. When pressure on the billet is applied by the hydraulic ram through a steel dummy block, aiuminium flows through the die opening taking the shape of the die.

Extruded profile is hand(ed by down line equipment installed at each press which consists of a putter, a stretcher for profile stretching, a finish saw machine for final sawing operation and a belt conveyor system. Profiles are then heat treated in an Ageing oven and then sent to Packing fior onward dispatch to the customer.

### 4.4.5 ROLLING PROCESS.

The Rolling ingots produced by D.C. Casting process are rolled into sheets, coils, plates, and circles. The Company has a Hot Rolling Mill and 2 Nos. Cold Rolling Mills. The rolling process can be divided into two parts i.e. Hot Rolling and Cold Rolling. The Rolling ingots after scalping (wherever necessary) are charged into electrically heated soaking pits. After the Ingots are heated

to about 5o0°C and soaked for 12 hours depending upon the alloy, they ate hot rolled in 2 High reversible Hot Mill. The 305 mm thick ingots are reduced to
3.0 - 9.5 mm thickness. It is then coiled or cut to plate length depending on the requirement.

After the coils have cooled down to ambient temperature, their thickness is further reduced by cold rolling as per requirements. Based on final thickness and temper the coils are annealed at intermediate stage. The finished coils are then cut into sheet / coils of required length and width. The thickness of the finished product depends on requirement. The scrap generated is recycled for reprocessing of Rolling Ingots in the melting and casting shop.

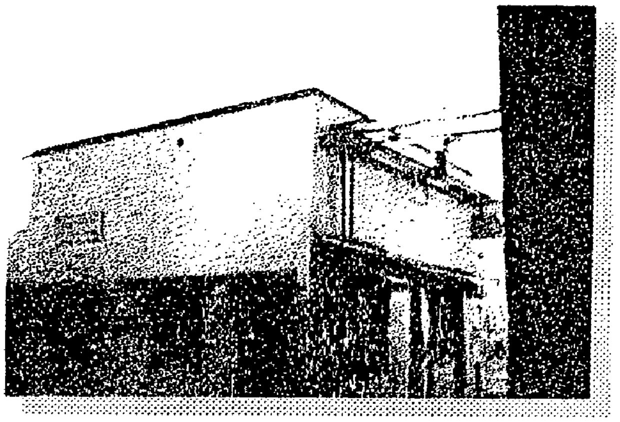


**Figure XXVIII SERVICE DUCTS**

### 4.4.5 CONTINUOUS STRIP CASTER

An alternative to hot rolled coils, the strip is cast directly from molten metal in this plant supplied by M/s Pechiney Aluminium Engg. France. This eliminates all intermediate processes like DC Casting, Scalping, Soaking etc. and thereby reduces the cost of end product.

### 4.4.6 FOIL PLANT

As a part of strategy to diversity into downstream high value products, an Aluminium Foil plant of 5000 TPA capacity has been set up at Silvassa (U.T.). The production of Foil during 1999-2000 was 7537 MT which was way above the installed capacity of 5000MT.

**ALUMINIUM ALLOY WHEELS**

Aluminium Alloy Wheel Plant at Silvassa was commissioned in September'99. Alloy wheels being a hi-tech product, with the stabilization of the Plant, production is slated to increase progressively. The initial market feedback has been encouraging. The Company is moving forward in establishing a customer network.

**DIVERSIFICATION**

Aluminium has excellent prospects, both in the domestic and international markets. The Company's expertise in the Aluminium business is well establi-shed. In order to capitalize on its inherent strengths and opportunities. Hinda-ko is also examining venture into related value added products such as manufacturing of Aluminium Cans and Hi-Tech Aluminium Casting.

The company has 1278 pots spread over an area of 17405 sq.m. in 7 pot line (each pot line has 2 rooms). Out of these 7 pot lines, 3 are in the main plant and other 4 one km away thereby ensuing effective dispersion and dilution. The industry has air mover arrangement in the pot room all along the length of the pot lines and the system is specially designed to entrap the dust particles. The pot lines are open from the sides and the gases moving out of operating pots are at a higher temperature than ambient. The gases move up continuously through air movers.

The gas suspension calciner with efficient electrostatic precipitates has been installed. Stack height and exit velocity for stacks have been designed on the basis of sulphur dioxide emission.

he daily requirement of water of about 30,000 $m^3$ is met from Rihand river. Out of which 16000 $m^3$ is used for plant purpose.

Three types of solid waste are generated during the process. The red mud, fly ash, spent pot living are reused.

**NOISE SOURCES:**

Figure XXIX CALCINER

Major stationery sources include fabrication plant, gas suspension plant, reduction plant, alumina plant etc. The other major sources are trucks, railway wagons and vehicular traffic.

1. Fabrication Plant
   (a) Quenching area
   (b) Rolling mill
   (c) Extrusion Press
2. Carbon Plant
   (a) Anone press
   (b) Ball mill
3. Gas suspension caliner
   (a) Blower room
   (b) Oil heating unit
4. Alumina plant
   (a) Digestion unit
   (b) Ball mill

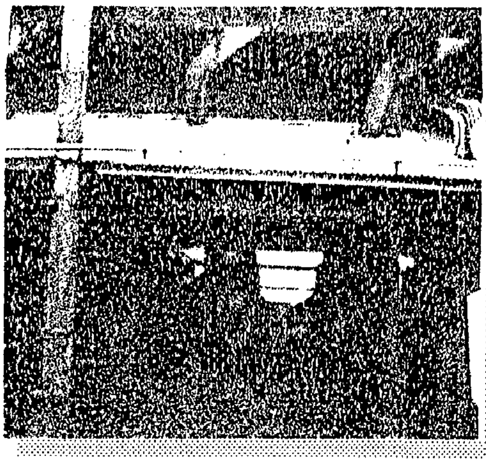


Figure XXX EXHAUSTS

(c) Compressor House

5. Cryolite Plant

(a) Ball mill

(b) Crusher

(c) Vacuum pump

6. Calcium plant

7. Caster plant

(a) Blower furnace

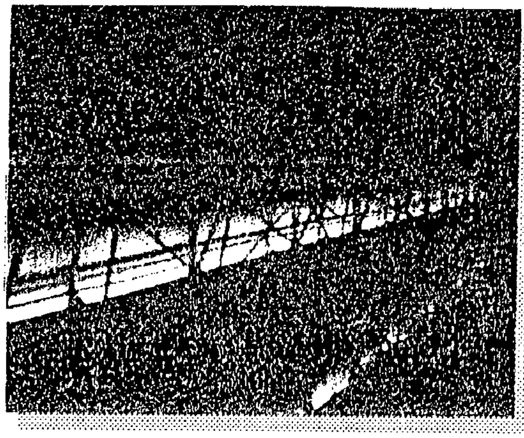


Figure XXXI ROOF VENTILATION

## 4.5 Personal Survey of Factory

The plant constitutes both old and new plant which developed and evolved over a long time. Plant extension has been done to increase the production capacity. Latest machines and equipments have been brought and installed. The company is very conscious of the environmental issues and has bagged many environmental awards and ISO certifications.

As stated before, entire process, starting from extraction of Alumina to production of different forms of metal by different processes i.e. carried there only itself. Again due to inherent problems due to different process and due to different needs and requirement, the envelop has to cater to specific needs by function and for different other considerations.

**Survey Conclusion**

1. The plant is situated on a difficult undulating terrain, but due to governmental policy, the land available was very cheap, and hence expansion was considered adequately while planning the pant.
2. The means of transportation of material consists of raw bauxite, coal, and finished products. Thus the plant is adequately connected by railway lines and road transportation. But road traffic has not been planned properly and leads to congestion and jams at peak time.
3. Though the older plant is still efficient but no specific planning was done to upgrade or revitalized it in its individual capacity.

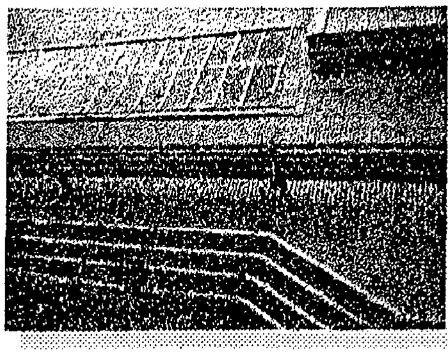


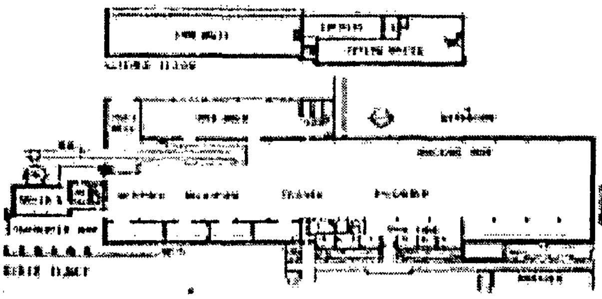
Figure XXXII SERVICE CABLES

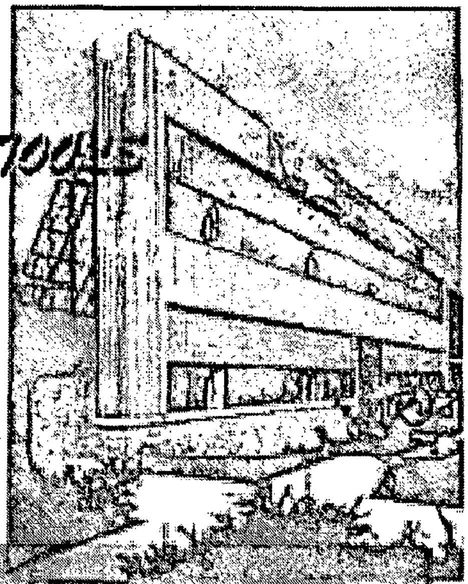
4. The additions that have been done through the years have not been planned but done as and when required which is a haphazard development
5. The new plant, i.e. plant II which has been commisioned has been placed at a distance of 1-2km from the plant which could have been incorporated there in if it was envisaged earlier and provisions given.
6. The different metal products obtained from Aluminum are placed at a centralized point which improves efficiency
7. On the building plant, though the technical or structural efficiency is seen, and in some plants special focus on natural lighting has been placed. Different types of roof light, mumtor light have been used.
8. The artificial lighting has been generally done by sodium vapour lamps, placed on a grid for adequate illumination.
9. Rarely any lighting to cater for specific tasks have been used. Even though required.

10. Ventilation is generally adequate with air-cooled ducts running in plants. Also special air fans, have been installed at the entry points to check the dust.
11. Storage of scrap has not been provided adequately, and it creates problem of transportation and communication at plant level.
12. Warehousing is properly planned, state of art material handling equipment are used which include conveyor belts, trolleys, rails, cranes and fork lifts have been used.
13. Flooring is in general of cement concrete to resist the heavy overflow traffic, the scrap is often melted and tiles of aluminium are used where the surface needs more resistance.
14. Electricity obtained from power plant is distributed from rectified areas to different plant areas. The lines are both overhead and underground.
15. Inside services are placed along the columns and trusses on rails, which have colour marked on them for easy identification

# CASE STUDY

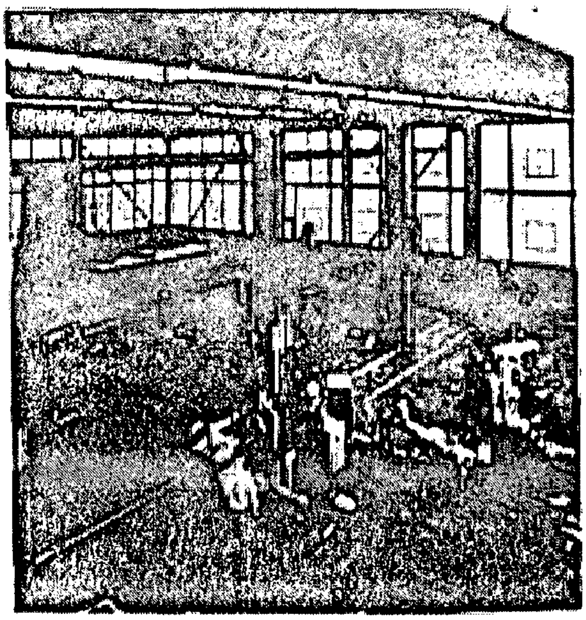
## BUILDING FOR MACHINE TOOLS





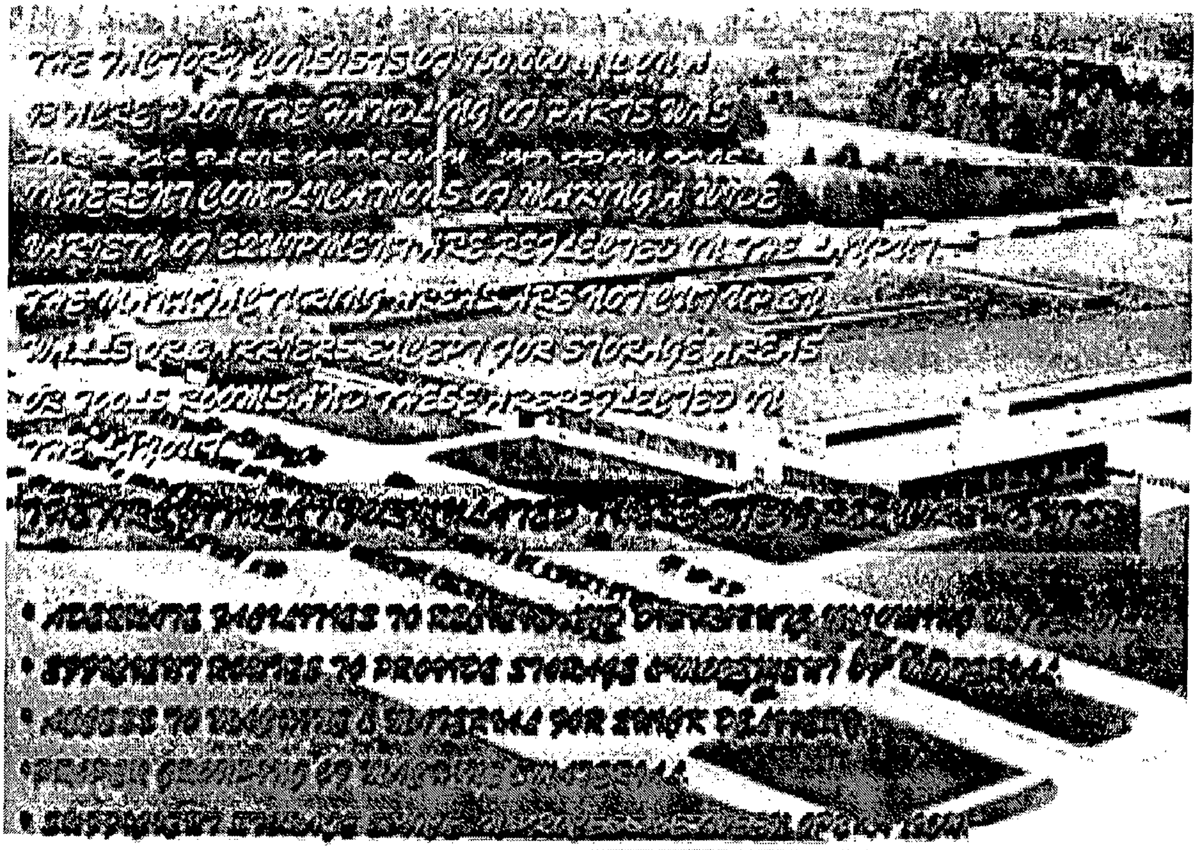
SPECIAL PROBLEM HERE WAS HANDLING EQUIPMENT .BECAUSE OF VARIETY OF LOADS & OPERATION.A 25-TON OVERHEAD CRANE TRAVELS AND SERVICES THE BUILDING'S ENTIRE 30-FT LENGTH. FOUR POWER REEL TYPE JIB CRANES

THE GUIDING DESIGN PRINCIPLE WAS OPEN WELL LIGHTED SPACE.FOR VARIETY OF MACHINERY. RATHER THAN SOME SIMPLE LINE OPERATION.



# CASE STUDY :-

## MATERIAL HANDLING PLANT AT PHILADELPHIA

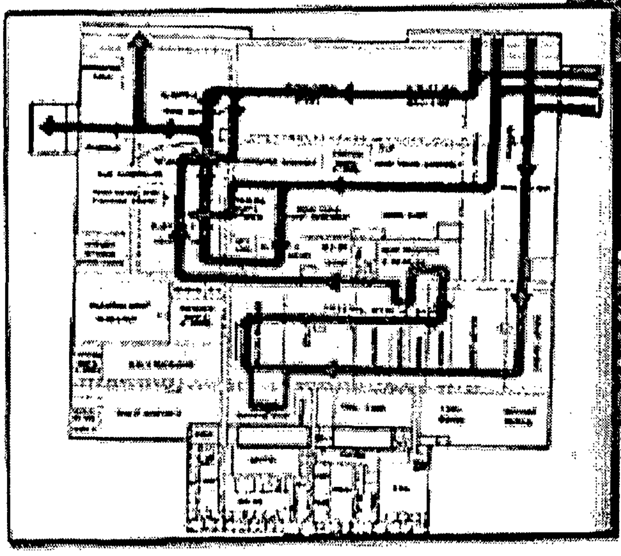


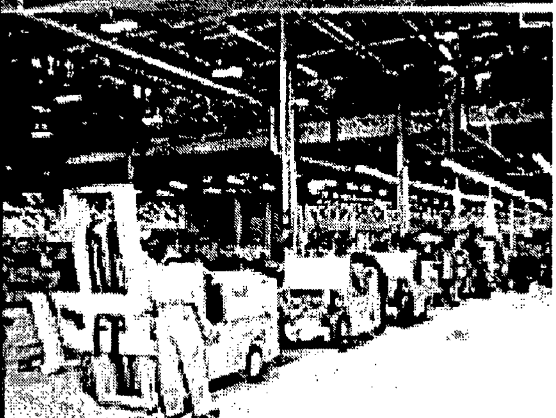
THE FACTORY CONSISTS OF 750,000 SQ. FT IN A 93 ACRE PLOT. THE HANDLING OF PARTS WAS [illegible] INHERENT COMPLICATIONS OF MAKING A WIDE VARIETY OF EQUIPMENTS ARE REFLECTED IN THE LAYOUT. THE MANUFACTURING AREAS ARE NOT CUT UP BY WALLS OR BARRIERS EXCEPT FOR STORAGE AREAS OR TOOL ROOMS AND THESE ARE REFLECTED IN THE LAYOUT.

[illegible]

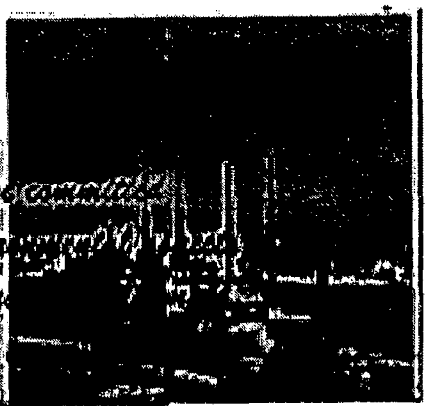
- ADEQUATE FACILITIES TO RECEIVE [illegible]
- SUFFICIENT SPACE TO PROVIDE STORAGE [illegible] OF MATERIAL
- ACCESS TO [illegible]
- [illegible]
- [illegible]
- FACILITIES TO PACK OR CRATE AND SHIP BY ALL CLASS CARRIERS.

LOCKERS & TOILETS ARE LOCATED ON MEZZANINE FLOORS, LOCATED NEAR PRODUCTION LINE. MOST OF THE PLANT HAS A CLEARANCE OF [illegible] FT BELOW GIRDERS. THUS PRODUCTION LINES ARE FREE TO CHANGE WITH LITTLE DIFFICULTY.





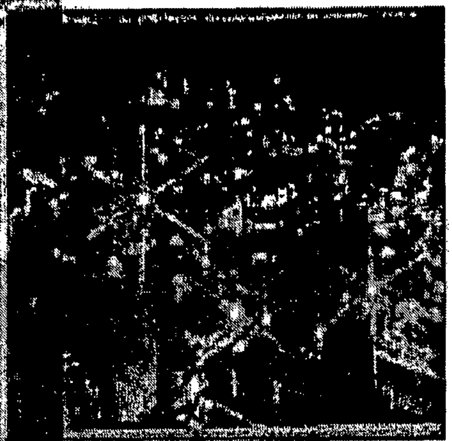
## ENVIRONMENTAL POLICY



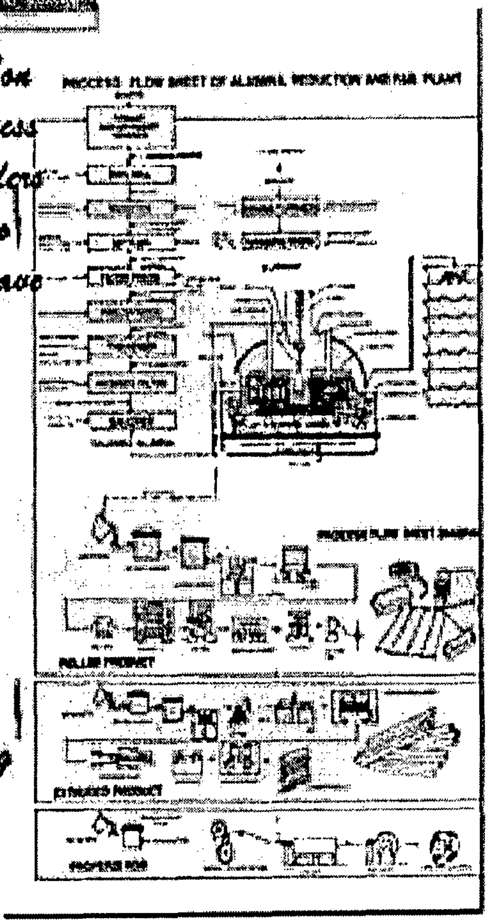
The Hindalco Industries Limited are committed to ensuring conservation and control of environ... of its activities interalia, relating to produc... Aluminium, Fabricated products, in order ... of sustainable development.

This to be achieved by:

- Innovation and improvement of processes, equipment & operation maintenance.
- Adopt cleaner technologies.
- Conserve key input resources such as bauxite coal, power, water etc.
- Keep exploring the feasibility of recycling and utilization of inevitable wastes.
- Remain in compliance with all applicable environmental laws And regulations and also strive to go beyond.



## PROCESS DESCRIPTION OF FABRICATION PLANT



Reduction plant has 8 pot lines having 1968 prebaked pot cells. Each pot is linked with carbon cathode and has 24/26 anodes. The entire process is controlled by microprocessor based pot controllers called CELTROL. To control pollution due to emission of fluorine gas, dry scrubbing system have been installed.

## PROPERZ

This is a continous casting and rolling process. EC/Alloy redraw rods. An endless steal belt The rod coming out has size of 3/8 or 9.5

## D.C CASTING.

Manufacturing of rolling ingots and extrus ion billets follows the direct chilled casting. The hot metal from pot room is transferred to casting machine placed in deep floor excavation lined with concrete, the metal flows from furnace in open launder, through fiber glass screen and into bottomless short water cooled moulds.

# CHAPTER V

# " INCORPORATION OF DESIGN CONSTRAINTS AS ARCHITECTURAL SOLUTION "

# CHAPTER – 5

## "INCORPORATION OF DESIGN CONSTRAINTS AS ARCHITECTURAL SOLUTION'

## 5.0 ABSTRACT

The design constrains as discussed before provide an opportunity for a better design by incorporating & absorbing them and producing a comprehensive design. Again these can be categorized on basis of planning policy level, functional level and physical planning level.

Factory design offers a challenge to every Architect

Architects who undertake the design of factories are faced with considerations different in many respects from those to which they are accustomed.

These differences are perhaps more in degree than in kind, for the same fundamental principles apply to all types of architecture. In the industrial field they are simplified, are more clear cut and uncompromising than in most others. Here function is actually the predominant factor, followed closely by economy No aesthetic consideration can prevail unless it is completely consonant with the other factors.

There is no magic, which precludes the undertaking of industrial work by any competent architect. He has to work in

close co-operation with competent engineers, structural and mechanical, and this before he begins rather than after. He must also be prepared to do quite accurate estimating and business like accounting and managing. With this external equipment what he needs most is a great store of common sense and open mindedness, because industrial architecture demands complete freedom from cannons and prejudices which often govern other type of design. Economics take precedence over aesthetics.

The practice of consuming quantities of time in studying, often desirable in other fields, is out of place in industrial architecture. Speed and quick, unerring decision are vital. Promptness and precise fulfilling of promises are also essential. It is important to emphasize that these demands are equally applicable to architecture but it is important to emphasize them because in industrial work the necessity of heading them is crystal clear. On the other hand, it must not be supposed that these require leave no scope for design. In this field "form does follows function". As a matter of fact the very size of factory building is a challenge. Their long lives and their masses, when kept simple and well proportioned are beautiful. Architecture is here reduced to fundamentals. Industrial architecture provides an opportunity and an interesting one; that there is nothing inherent in the problem which a good architect cannot master, but it needs common sense and practical competence are necessary even more than in other fields.

## 5.1 POLICY PLANNING

In order to form clear concepts for architectural solutions, all the policies are to be brought down to local or micro-level, by which an architect may interpret them into problems first and try to provide solutions.

In most cases the policy demands flexible or expandable planning for economic or technical reasons and hence planning should also be adoptive and expandable.

The economic activities are geared up, as the industry needs various types of materials, people of various skills, auxiliary facilities and services, It generates speculative spirit in the region. The type of product accordingly requires skilled hands; thus it may also need the provision of special training educational and research facilities.

The very existence of industry may create ecological disturbance, by pollution. The present stage of problem may be insignificant but future may be unmanageable. Therefore, the policies at micro level provide adequate base for further functional and physical planning solutions, which are discussed below.

## 5.2 Functional Planning

The functional planning at micro-level determines the planning policy at local level to be adopted.

**5.2.1** It gives solutions in terms of long term requirement and short term requirements or priority of facilities.

**5.2.2** What direction should be of the solution like flexibility, expandability or demountability which will be best suited.

The expected movement of production determines the sequence, flow, and assembly line pattern of the industry. It also establishes the link between the receiving store and finished stores etc.

## 5.3 PHYSICAL PLANNING

### 5.3.1 ENVELOPE

The envelope is designed to satisfy the functional and physical planning criteria. The most common type of envelopes of engineering industry are large single flood construction with suitable roof and bay arrangements. The most common and ultimate goal of envelope is to provide protective skin to the production layout. The provision of opening for entry and exit of materials, admitting light and air and trapping the unwanted noise are the main function it has to perform.

Expert to ascertain its function and utility may check the concept of industrial building, during the planning stage. The sites physical conditions are taken into consideration for provision of area, formation level conducive to production. Therefore, topography, geographical, geological and climatic conditions are to be studied to link them suitably to industrial design.

- The shape of industrial building is generally rectangular, unless junction demands other shape. It series best for all types of material handling devices used during process.
- The size of the factory building is determined on the physical dimension of various components. In process of overall space assessment consider the physical dimension, circulation space, operational space, maintenance and executional space. The layout of machine prepared by mechanical engineer may be useful guide. This further leads to production bay dimensions and finally the column spacing.

The type of product and type of overhead installation govern the height of tructure.

- The structural system is final outcome of industrial process, production lines, resistance temperature differences, resistance to chemicals used in industrial process, free span bays, services and catwalks. The system so sketched be sound in construction, functionally suitable, and aesthetically pleasing. It may be easy directional extension, variation in height, directional and variation both and insertion possibility.
- Roofing in industrial building is meant to protect production line from sun, wind, rain, to keep off dust and dirt etc. The production line in engineering industries is very large, therefore, roofs in multiple bays, over large span trusses are required for industrial roofing. Roof also serves as a source for lighting and ventilation. It also serves as structural support for number of essential services of the factory. Roofs are also to be properly designed to allow penetration of stacks, pipes or equipment component without losing its protective quality.
- Cladding is outer most skin of the factory. It has to protect production line from sides. The cladding designed for

sound insulation dust collection, ventilation and to enhance appearance of the building. It has to accommodate various entry doors for material movement and provide windows for visual link form outside

- Flooring of industrial building is important for its size and loading factor. It should be leveled. Non skid, uniform and better resistance to wear and tear. It must be resistant to acids etc. where process involves these. The common constructional details are associated with flooring such as railway track in floor, machine foundation, service pit, ducts etc.
- Thus we see that from the above the design of envelope is the major field of architects contribution in industrial design.

## 5.4 Thermal Standards for Industrial Work Areas

The work situations considered here are those in which the attainment of simple thermal comfort; not always practicable. The heat stress must be kept below the level of outright hazard, but how much below? On what criteria should the specifications for control be based? How should the standards be varied in recognition of the differing demands and work rates from one kind of job to other? What differences exist between older and younger workers or between workers with differing degrees of physical fitness? These and other questions arise in the analysis of an industrial heat problem and must be considered by the designer.

The thermal relationship between man and environment is dependent upon four independently variable thermal characteristics of the environment : air temperature, radiant temperature, moisture content of the air, and air velocity.These may combine in various way: together with the rate of internal heat production, to create widely different degrees of heat stress. The need is to provide a rational basis for combining them into a single index that will predict the magnitude of the heat stress and will serve also a: a basis for fixing permissible limits of exposure.

A start is made with the heat balance equation:

$M \pm R \pm C = B + E \pm \Delta S$

where

M= metabolic rate.

R = rate of heat exchange with environment by- radiation.

C = rate of heat exchanges with environment by convection.

B = rate of heat loss from body in exhaled sir.

E = rate of heat loss from body- by- evaporation of sweat.

$\Delta S$ = rate of change in heat content of body.

Terms on the left side of Equation 1 represent the heat load; those on the right represent. The heat loss: together with the heat storage or withdrawal from the body. R and C are positive when the environmental temperature is above skin temperature and negative when below. In practice, B and $\Delta S$ are of small magnitude compared with the others and can be neglected. For a condition of heat balance, ~~therefore,~~ Equation 1 may be written:

$$M \pm R \pm C = E_{REQ} \qquad (1)$$

$E_{REQ}$ = required rate of evaporation of sweat to maintain heat Balance.

R and C can be calculated with reasonable accuracy by means of

standard equations of heat exchange:

$$R = K_R A_R (t_W - t_s) = 22 (t_W - t_s) \text{ ———— } (3)$$

$$C = K_C \sqrt{V} A(T_A - T_S) = 2\sqrt{V}(T_A - T_S) \text{ ———— } (4)$$

where

$k_r$ = coefficient of radiant heat exchange, Btu per (hour) (square foot) (Fahrenheit degree temperature. difference).

$A_R$= radiation area of body, square feet.

$22 = K_R A_R$ for average size man with moderately high mean radiant temperature, $t_w$.

$K_c$= coefficient of convective heat exchange, Btu per (hour) (square foot)(unit velocity)(Fahrenheit degree temperature difference).

A = surface area of body, square feet.

2 = Kr X :t, for average size man.

V = effective velocity of sir movement, feet per minute.

$t_w$ = (black-body equivalent) mean radiant temperatures of environment, Fahrenheit.

$T_a$ = ainbient air temperature, Fahrenheit.

$T_s$ = skin temperature, Fahrenheit.

This maximum evaporative cooling rate $E_{max}$ has been established experimentally and can be calculated by the equation :

$$E_{max} = CA\, V^{0.4} (P_s - P_a) = 10V^{0.4} (P_s - P_a) \qquad (5)$$

where

$K_e$ = coefficient of heat exchange by evaporation,Btu per(hour) (Square foot) (unit velocity) (millimeter of mercury vapor-pressure difference).

$10 = K_e A$ for average size man, fully wetted.

$P_s$ = vapor pressure of water at skin temperature, millimeters of mercury.

$P_a$ = partial pressure of Water vapor in ambient air, millimeters of mercury.

A combination of equations 4 and 5 yields equation 6 which is a statement of the maximum thermal conditions

$$M + 22(T_W - T_S) + \; = 10V2\sqrt{V}(T_A - T_S)^{0.4} (P_s - P_a) \qquad (6)$$

Equation (6) provides a rational basis on which to construct a heat stress index and to establish thermal standards for different industrial work situations.

Two physiological criteria are important in fixing the limit of sustained heat exposure:

I. The increase in body heat content must not exceed a certain level. This temperature may be limited to 95 F.

2. Thermal balance must be accomplished with a rate of sweating not greater than one liter per hour.

### 5.4.1 Control at source

The magnitude of heat exposure can be reduced by insulating hot equipment, locating such equipment most favorably (in zones of good general ventilation within buildings or even outdoors), covering steaming water tanks, providing covered drains for direct removal of hot water, and maintaining tight joints and valves where steam may escape. This method is obvious one and requires no particular comment other than to emphasize the benefits to be arrived from elimination of heat sources wherever possible.

### *5.4.2 Local Exhaust Ventilation*

The natural convection column of heated air rising from a hot process may be captured by means of ventilated enclosures or exhaust hoods and removed with a minimum of dilution by air from the surroundings space when local exhaust ventilation can be used.

### *5.4.3 Radiation Shielding*

In some industries, there are many hot objects and surface such as furnaces, ovens, furnace flues and stacks, boilers, molten material, and hot ingots of metal, casting, or forgings and, in consequence, the major environmental heat load is in the form of radiant heat. Since air temperature has no significant influence on the flow of radiant heat. Ventilation is of no help in controlling such exposures. The only effective control is the direct one of decreasing the amount of radiant heat impinging on the exposed worker.

Hot surfaces emit infra-red waves, which reach all objects within visible range. This is true not only if the hot surface is a primary one such as a furnace wall, a high temperature stack, or a hot ingot, but also if it is secondary in nature, that is, one which is reradiating heat after receiving it by direct radiation from a high temperature source. It may well be that all surfaces in a shop or build-ing are hot because of radiant heat received from a few primary sources. Under these circumstances, the ventilation air is heated rapidly as it circulates through the building. The result is a very unsatisfactory thermal environment, all stemming from the few primary heat sources. Consequently if the radiant heat load from these is reduced there will be a great improvement in the entire building.

### *5.4.4 GENERAL VENTILATION*

General ventilation ,which involves sweeping of the space occupied by workmen and process heat source with large quantities of outdoor air, may be used to limit the temperature rise within the space, if the outdoor air itself is not too hot. The method is particularly suitable. for cases where the heat sources are spread over the entire area, and for the removal of solar heat from the space.

### *5.4.5 Dilution Ventilation*

The principle of dilution ventilation furnish the basis for the design of the general ventilation system. The amount of air, which must be circulated, can be estimated as:

$$(cfm) = H/1.08\ \Delta T$$

Where

H = Heat to be removed from the space, Btu per hour.

$\Delta T$ = temperature rise of the air, Fahrenheit degrees.

Advantage. Should be taken of the chimney effect of the heated air within the space by· introducing the diluting air near the floor of the space and discharg-ing the heated air as near the top of the structure as possible. Regardless of whether natural or mechanical exhaust ventilation is used. Since the work Man ordinarily operate near floor level, the entering air temperature should be within acceptable limits as outlined earlier in this section. The leaving air temperature will have the effect on workmen through the radiant heat emitted by the upper parts of the structure, which are heated by the air. A higher leaving air temperature can be used with a high than with a low- ceiling, since the ceiling contribution to the mean radiant temperature will be less for the taller structure.

### *5.4.6 Roof Ventilators*

Roof ventilators are basically heat escape ports located in the high section of a building and properly enclosed for weather-tightness. Stack-draft effect plus some wind induction are the motive forces for several common designs. Of continuous ventilators and round ventilators. The latter can be equipped with fan barrel and motor, thus permitting gravity operation; or motorized high capacity operation, at will.

Two other main designs are available: one is the low-type ventilator which consists essentially of a stack fan with rain hood; the other contains a stack fan with a split butterfly closure that is floated to
open position by the discharge air-stream and is self-closing. Both employ minimal enclosures and have little or no gravity capacity.

Various types of roof ventilators may be listed in diminishing order of temperature differential and heat-removal capacity. Next to chimneys and stacks, the continuous ventilation monitor is most effective for removal of substantial and concentrated heat loads. This may be in the form of an elevated length of roof ridge with extended overhang and no rain louver. Such structures are commonly employed over open-hearth furnaces and soaking pit buildings but in practice they give uncertain performance. A more efficient type is a streamlined, watertight monitor constructed of non-corrosive metals or protected metals. Its capacity increases with wind velocity and it can be readily closed in winter to conserve building heat. Both types have tremendous capacity and are limited only by roof area and proper relation of low-level air inlets.

Minimum capacity ventilators of the gravity type are applicable to ware houses with light heat load and to manufacturing areas having high roofs and light loads. It is noted that efficient ventilator operation is generally obtained when difference in elevation between the average air inlet level and roof ventilation is not less than 30ft and the exit temperature is 25F deg. above the prevailing out door temperature.

To insure high level of performance it is essential that sufficient low-level openings be provided for the incoming air, otherwise the gravity ventilator becomes starved for air and capacity falls off. It must be 250fpm to450 fpm inlet velocity. Lack of adequate inlet area is the most common cause of failure. A positive supply of air to insure direct ventilation around the hot equipment may be necessary within buildings of considerable area where the external wall inlets are remote from the equipment.

## 5.6 EARTHQUAKE RESISTANCE DESIGN PARAMETERS

Equipment mounted in buildings is generally subjected to modified earthquake effects; this can mean amplification especially in the upper floors of buildings.

This amplification of the ground and building motions is worse when the building and the equipment resonate, i.e. when they have equal periods of vibration. Fortunately damping between the building and the equipment can be used to drastically reduce amplification, as it is not always possible to avoid the resonance effect. Table illustrates the effect of resonance and damping as obtained in a simple analysis. Any rule of thumb for seismic design should require all equipment

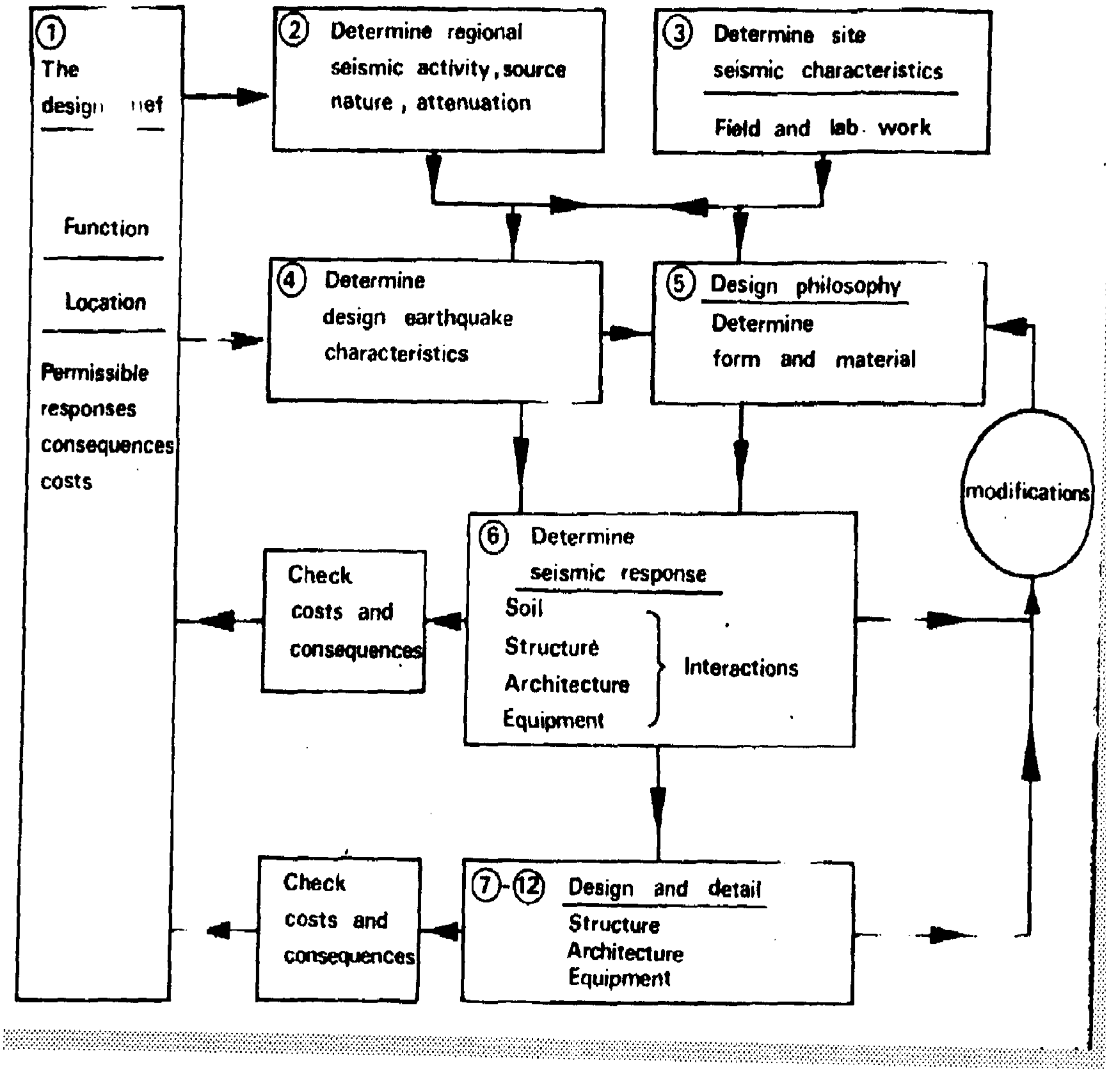



Figure XXXIII FLOW CHART FOR DESIGN OF EARTHQUAKE RESISTANT CONSTRUCTION

items in a building above ground floor to be designed and fastened for higher excitations than on the ground.

Equipment that would fail in a brittle manner in earthquakes

### 5.6.1 Response Of plant mounted in buildings.

| | | | | |
|---|---|---|---|---|
| Plant resonant with building with fundamental periods in range | | | 0.2-0. | 4 s |
| Fraction of critical damping for building | 0.07 | 0.07 | 0.07 | 0.07 |
| Friction of critical damping for plant item | 0.007 | 0.02 | 0.1 | 0.2 |

Window sashes should be separated from frame action except where it can be shown that no glass breakage will result. If the drift is small, sufficient protection of the glass may be achieved by windows glazed in soft putty where the minimum clearance all round between glass and sash is such that

$$C > \Delta/2\{1+(h/b)\}$$

The failure mode of hard putty glazed windows tends to be of the explosive buckling type and should be used only where sashes are fully separated from the structure, for example when glass is in a panel or frame that is mounted on rockers or rollers as described in

### 5.6.2 CHIMNEYS AND TOWERS

Towers and industrial chimneys pose a series of specialist design and construction problems generally related to their height and slenderness. They are vulnerable to earthquakes because they usually have only one line of defense, the failure of any one part of the structure resulting in spectacular failure.

A variety of forms of chimney and tower construction has been used in earthquake areas, including simple cantilevers, guyed structures, chimneys with supporting towers, and structurally combined multiple chimneys. The adoption of the latter two forms has the advantage of increasing the redundancy of the structures and hence decreasing their seismic vulnerability. The structures may be prismatic, or taper or step with height, while the inverted pendulum form is implicit for elevated water tanks. Whereas stack-like structures are basically shells or tubular members, towers or support structures may also involve braced and unbraced frameworks.

**Seismic analysis of chimneys and towers**

For chimneys and towers of moderate size a dynamic earthquake analysis is highly desirable. Equivalent static loadings of codes of practice are not well suited to modeling higher mode effects, which can be significant in slender structures. The controlling design.

Chimneys should be subjected to a thorough seismic structural design lightweight double wall sheet-metal flues should be used where possible and prefabricated stacks should be avoided or used with great care.

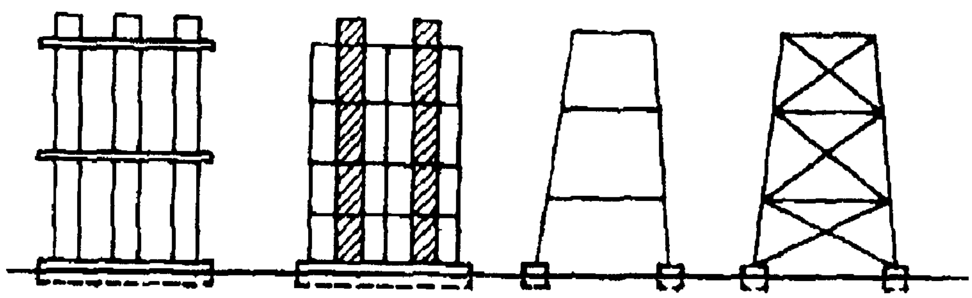


Figure XXXIV BRACING OF CHIMNEY

criterion may be deformation rather than stress in the case of chimney linings, and wind loading may govern the design in shear or moment or both in some structures. Unlike in building structures, it is seldom feasible to use the concept of ductility to make chimneys and towers more economical, as one plastic hinge will usually be sufficient to induce partial or total collapse. The need for elastic rather than inelastic behavior is reflected in the relatively high loadings required by most codes for this type of structure. Only in multi4redundant supporting frames chimney groups is ductility likely to be safely usable.

**Reinforced concrete chimneys**

The ACI recommends that the design of chimneys be based on a modal response analysis, and that they should withstand at least the equivalent static forces described below. In order to make some allowance for the effect of higher modes, the ACI suggests that I~ percent of the total horizontal shear be applied at the top of the chimney. The remainder of the shear is distributed vertical so that the force Fx at any height hx above the base is given by

Fx =(V-Vh) UX hx/(? UX hx)

Where V is the total seismic base shear,

VH is that fraction of application top, and

UX is the weight of the segment of the chimney at height hx.

For deriving the base shear V,

V = ZUCW

Z corresponds seismic zones;

C= 0.1/T 1/3;

U = risk-related use factor varying from 1.3 to 2.0;

W = total weight of lining (excluding lining if not supported by the shell.

### 5.6.3 SAFETY OF SERVICES COMPONENTS

Item Part of portion Containers and full contents and their supporting structures; pipelines, and valves:

(a) For toxic liquids and gases, spirits, acids, alkalis, molten metal, or poisonous substances, liquid and gaseous fuels including containers for materials that could form dangerous gases if released:

(i) Single-storey buildings 0.6 0.5

(ii) Multi-storey buildings 1.3 0.9

Fixed firefighting equipment including fire sprinklers, wet and dry riser installations, and hose reels:

(i) Sing]e-storey buildings 0.5 0.3

(ii) Multi-storey buildings I.0 0.6

(c) Other:

(i) Single-storey buildings 0.3 0.2

(ii) Multi-storey buildings 0.7 0.4

Furnaces, steam bailers, and other combustion devices, steam or other pressure vessels, hot liquid containers; transformers and switchgear; shelving for batteries and dangerous goods:

(i) Single-storey buildings 0.6 0.5.

(ii) Multi-storey buildings 1.3 0.9 ;

| Type of Production | Without Overhead Installations * | With Overhead Installations † |
|---|---|---|
| Small-product assembly on benches; offices | 9–14 feet | 10–18 feet |
| Large-product assembly on floor or floor fixtures | Maximum height of product + 75% | Maximum height of product + 125% |
| Small-product forming | Height of machinery + 100% | Height of machinery + 150% |
| Large-product forming | Height of machinery + 125% | Height of machinery + 125% |

Figure XXXV **Ceiling Height**

### 5.6.4 Suspended ceilings including attached equipment, lighting and attached partitions,

Communications, detection or alarm equipment or other emergency: '

(i) Single-storey buildings 0.5 0.3 ,

(ii) Multi-storey buildings 1.0 0.6

4) Pipe work and electrical wiring connections are vulnerable and therefore must be strong. It would also be wise to allow some flexibility in the pipes and wires away from the equipment in case of relative seismic movement between the items on either side of the connections.

5) Doors to control-panels should be hinged to prevent them being dislodged in earthquakes; loose covers can fall against live contacts, shorting out the equipment.

6) Mercury switches should be avoided, as should essential instruments that have heavy movable components likely to break away from their supports.

(7) Boilers with extensive brickwork are undesirable as it is very difficult to reinforce the fire brick.

The natural periods of vibration were found to be the range 0.2-0.4 s, corresponding to the peak of the response spectra

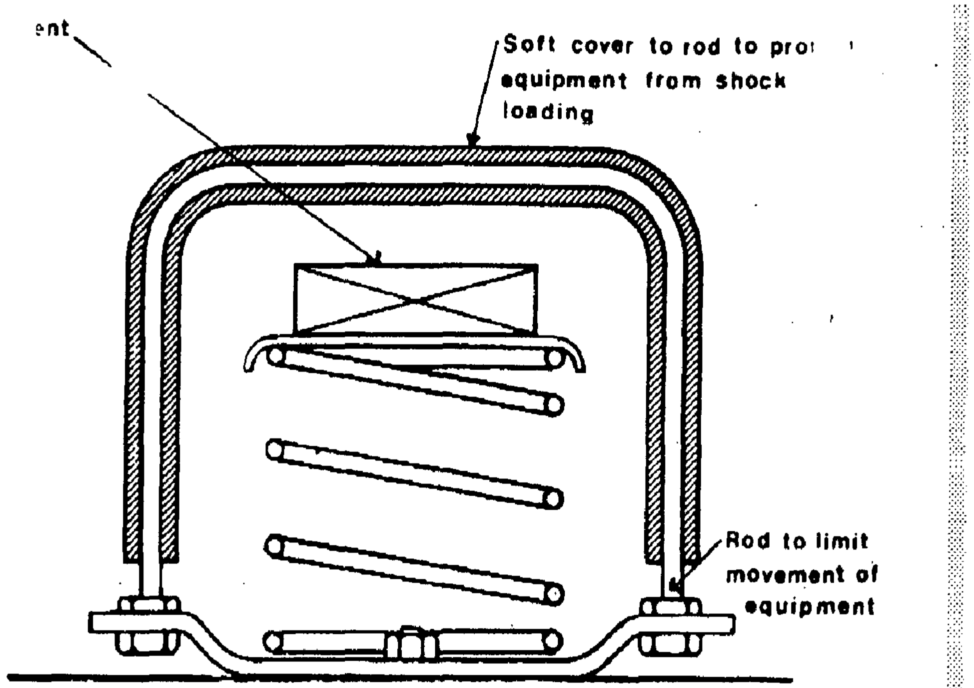



Figure XXXVI EQUIPMENT MOUNTING ON RESILIENT MOUNT

. As the damping ranged. from 0.018-0.006 of critical, the expected response varied from about l.5g greater than 2.0g. Most of the items of equipment involved had strengths appreciably less than those required to withstand such accelerations. In order to deal with this situation it is suggested three alternative procedures as follows:

(1) Provide the required strength with factors of safety of the order of 2-3 to cover uncertainties in the assessment of the strength of brittle materials.

(2) Provide ductile components that yield early enough to prevent the brittle components reaching breaking load."

(3) Provide additional damping. This solution is quite practicable when dealing with small masses of electrical equipment. Equipment used in an electrical installation must in general be suitably rigid to avoid variations in clearance between live parts, and to limit the amount of flexibility to be provided in electrical connections. In fact any acceptable structure of equipment is unlikely to have a period longer than about 0.4 s. From It can be seen that for periods less than about 0.4 s acceleration is taken as constant for any given damping.

The following design rules for this type of brittle equipment may be adopted.

(1) If the amount of damping in the equipment is not accurately known the equivalent-static acceleration for equipment that fails in brittle components under horizontal loading should be I. This should be used as a factor of safety of 2.0 on the guaranteed breaking strength of the brittle portions, and with ordinary working stresses in the ductile parts of the structure.
(2) Alternatively, if satisfactory evidence is available of the amount of damping inherent in the equipment, the seismic coefficient may be that read from for that amount of damping. These rules would be suitable for the design of standard items of equipment installed in any part of a seismic country, because any type of foundation, from externally rigid to highly flexible, could be used without invalidating the underlying assumptions.
4) Pipe work and electrical wiring connections are vulnerable and therefore must be strong. It would also be wise to allow some flexibility in the pipes and wires away from the equipment in case of relative seismic movement between the items on either side of the connections.
5) Doors to control-panels should be hinged to prevent them being dislodged in earthquakes; loose covers can fall against live contacts, shorting out the equipment.

6) Mercury switches should be avoided, as should essential instruments that have heavy movable components likely to break away from their supports.

(7) Boilers with extensive brickwork are undesirable as it is very difficult to reinforce the firebrick.

### 5.6.5 Window sashes

Window sashes should be separated from frame action except where it can be shown that no glass breakage will result. If the drift is small, sufficient protection of the glass may be achieved by windows glazed in soft putty where the minimum clearance all round between glass and sash is such that

$$C > \Delta/2\{1+(h/b)\}$$

The failure mode of hard putty glazed windows tends to be of the explosive buckling type and should be used only where sashes are fully separated from the structure.

### 5.6.6 Tanks

As well as considerations of sliding and overturn, the following points are peculiar to tanks:

(I) Corrugations of copper tanks are liable to collapse with subsequent failure of the bottom joints. Making a stronger joint and possibly reducing the number of corrugations can remedy this. Alternatively, welded stainless steel tanks can be used to increase the tank strength while retaining corrosion resistance.

II) Where there will be a possibility of a tank sliding, severance of the connections can be avoided by flexibility in the pipes (ten diameters on each side of a bend should be adequate) and by provision of strong connections between the pipes and the tank. The bottom connection can be strengthened by passing it right through the tank and welding it at each end. The top connection could be similarly treated unless a large arm ball valve were required, when extra strengthening at the connection would be satisfactory.

(3) Suspended tanks should be strapped to their larger systems, and provided with lateral bracing.

(4) Because of the build-up of surface waves in liquid during earthquakes, same protection against liquid spillage may be desirable. This may be either in the form of a lid, or a spill tray with a drain under the tank. The effects of pressures on the tank due as the liquid oscillation may have to be taken into account in the design of larger tanks.

### 5.6.7 Ductwork

Ductwork is usually quite strong in itself, and despite relatively flexible hangers, it is usually susceptible to earthquake damage only where it crosses seismic movement gaps in buildings. ~t these points flexible joints should be provided which are long enough to take up the seismic movements. Canvas joints may be suitable, asbestos if there is a fire risk, or lead-impregnated plastic if noise is a problem. Wherever possible, seismic movement gaps in buildings should not be crossed. It may be possible to locate fire walls at seismic movement gaps and to design pipe and duct systems to be separate on each side of the gap, thus avoiding crossing the gap as well as keeping the number of systems down to a minimum. The other most vulnerable position in ductwork is at its connection to machines (e.g. fans). At these positions flexible duct connections should be installed in a semi folded condition with enough material to allow for the expected differential deflection between the machines and the ductwork. Duct openings and pipe sleeves through walls or floors should be large enough to allow for the anticipated movement of the pipes and ducts.

### 5.6.8 Pipe worl.

**Flexibility requirements**

Equipment mounted on isolating or energy-absorbing de Flexible mountings as falling into groups relating to the predominant motions of short-period earthquakes, as follows:

**Group 1.**

Mountings with a natural period less than the predominant earthquake period (i.e. below about 0.07 s)-felt, cork, and most rubber mountings would usually come into this category. Provided the mountings will not permit sliding to occur (e.g. by gluing) and the connections to the equipment are reasonably flexible, no further mounting precautions should be necessary.

**Group 2.**

Mountings with a natural period corresponding to the predominant earthquake periods (i.e. above about 0.07 s). Spring mountings fall into this category, such as those used for low-speed fans, engines, compressors, and possibly electric motors. As resonance is likely, some method must be provided which limits the movement and transfers the forces directly to the floor instead

of through the mounts. Steel rods or angles would be suitable and should be designed to yield at the design acceleration.

F1exibility is required in pipe work to allow for building and equipment movement. 5eismic flexibility requirements are different from those or

**Figure XXXVII Mechanical/Electrical Force Level Factor**

**Mechanical/Electrical force level factors**

| Components | Cp | P-factors for Seismic hazard exposure group. I | II | III |
|---|---|---|---|---|
| Boilers, furnaces, water heaters and other equipment using combus tible or high temperature energy sources | 1.5 | 2.0 | 1.0 | 0.5 |
| Chimneys, flues and vents | 1.5 | 2.0 | 1.0 | 0.5 |
| Communications system | 1.5 | 2.0 | 1.0 | 0.5 |
| Conveyor systems (non-personnel) | 0.75 | 2.0 | 0.0 | 0.0 |
| Duct distribution systems | 0.75 | 2.0 | 1.0 | 0.0 |
| Electrical bus ducts and primary cable systems | 1.5 | 2.0 | 1.0 | 0.5 |
| Electrical motor control centres, motor control devices, switchgear, transformers and substations | 1.5 | 2.0 | 1.0 | 0.0 |
| Electrical panelboards and dimmers | 0.75 | 2.0 | 1.0 | 0.0 |
| Emergency electrical systems | 1.5 | 2.0 | 2.0 | 2.0 |
| Fire and smoke detection systems | 1.5 | 2.0 | 2.0 | 2.0 |
| Fire suppresssion systems | 1.5 | 2.0 | 2.0 | 2.0 |
| Life safety system components | 1.5 | 2.0 | 2.0 | 2.0 |
| Machinery | 0.75 | 2.0 | 1.0 | 0.5 |
| Piping distribution system upto 2" | 0.75 | 2.0 | 0.0 | 0.0 |
| ------Do------ 3" and more | 1.5 | 2.0 | 1.0 | 0.5 |
| Reciprocating/rotating equipment | 1.5 | 2.0 | 1.0 | 0.5 |
| Tanks and pressure vessels | 1.5 | 2.0 | 1.0 | 0.5 |
| Utility and service interfaces | 1.5 | 2.0 | 1.0 | 0.5 |

Accommodating thermal expansion, as seismic movements take place in three dimensions. Sliding joints or bellows cannot be used as they do not have the required flexibility and introduce a weakness, which could cause early failure without making use of weakness, which could cause early failure without making use of the ductility of the pipe work as a whole. Accordingly, these expansion joints that are installed to accommodate thermal expansion must be fully protected from earthquake movements. The movements should be taken up by bends, offsets or loops which have no local stress concentrations and which are so arranged that if yielding occurs there will not be any local failure. Note that short-radius bends can cause stress concentrations. Anchors adjacent to loops must also be strong, and connections to equipment must be able to resist the pipe forces caused by earthquake movements. Connections using screwed nipples and some types of compression fittings should be avoided, unless they can be arranged so as to be

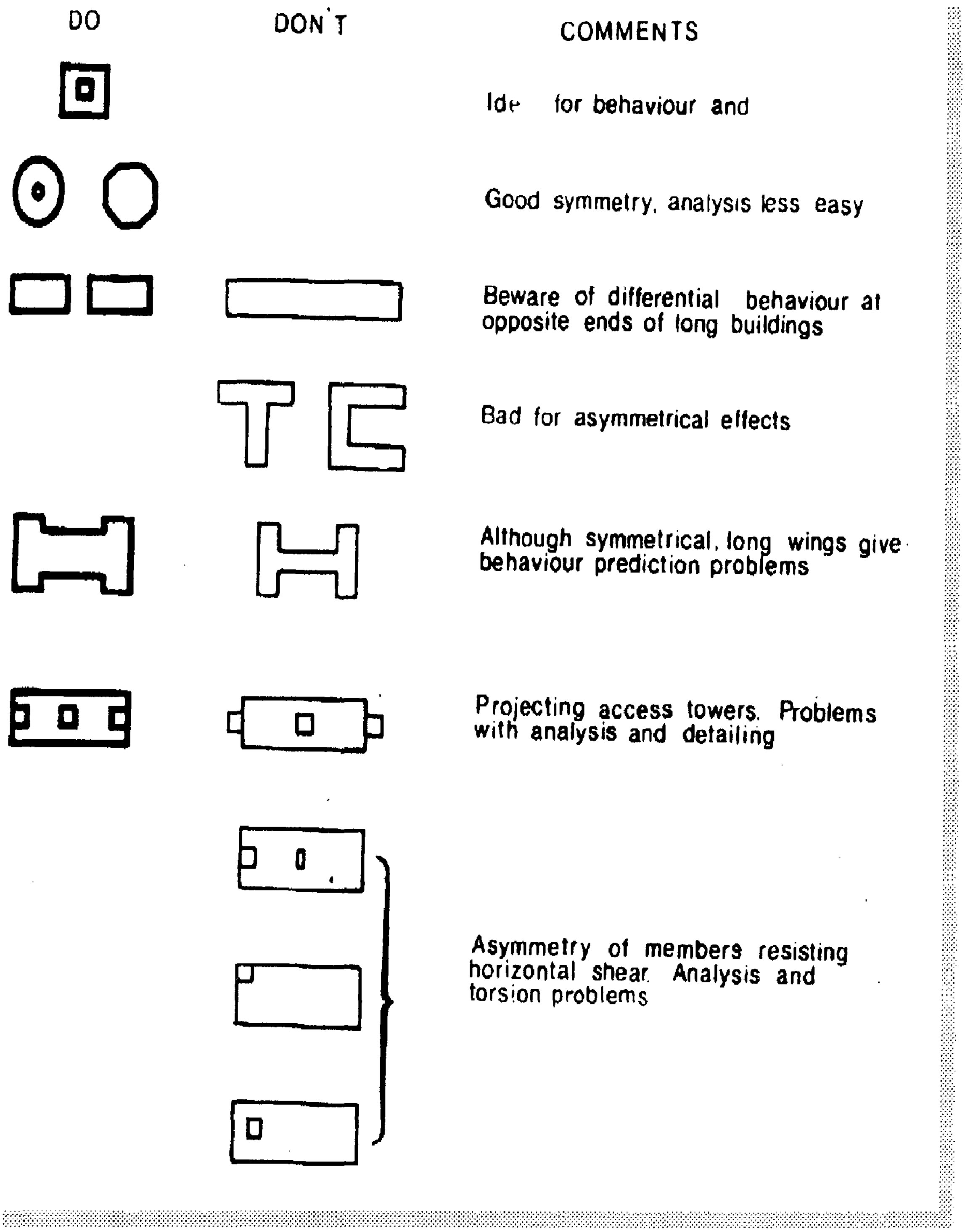



**Figure XXXVIII**

unaffected by seismic movements.

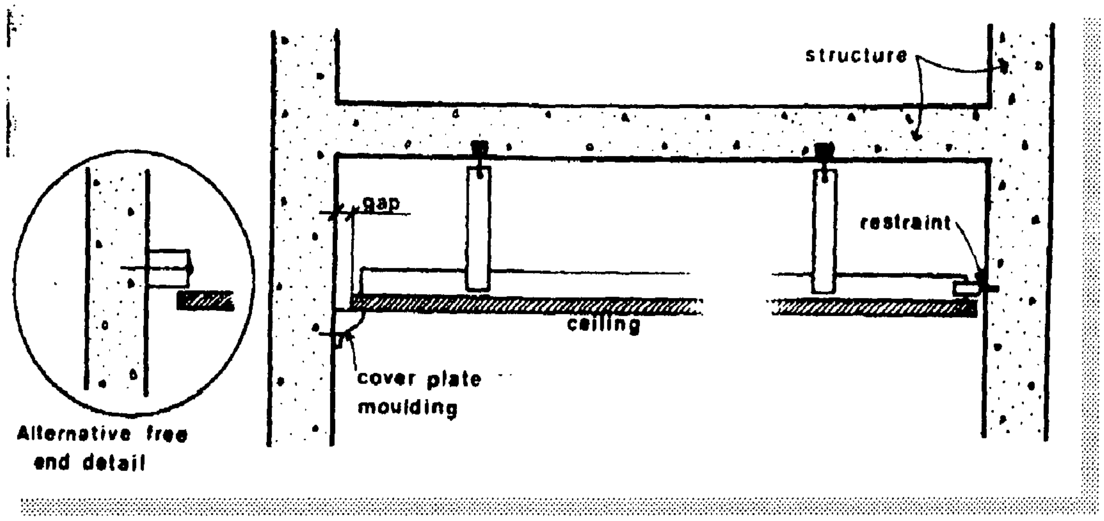
Every consideration should be given to keeping the exit ways clear of obstructer debris in the event of an earthquake. As well as the requirements for wall finishes and doors, the following point should be considered.

Floor covers for seismic joints in corridors should be designed to take the dimensional movements, i.e. lateral, vertical, and longitudinal. Special attention should be given to the lateral movement of the joints. Freestanding showcases or glass lay-in shelves should not be placed in areas, especially near exit doors. Displays in wail-mounted or recessed showcase should be tied down so that they cannot come loose and break the glass during an earthquake. Where this is impracticable tempered or laminated safety glass should be used far greater strength. Pendant-mounted light fixtures should not be used in exit ways or surface-mounted independently supported lights are preferred.

**Standard ceiling construction**

Procedures should be considered. A dimensional allowance should be made at the ceiling perimeter for this motion so as to minimize damage to the ceiling where it abuts the walls: one-way of doing this is to provide a gap and a sliding cover. Some ceiling suspension systems need additional horizontal restraints at columns and other structural elements, such as diagonal braces to the floor above, in order to minimize ceiling motion in relation to the structural frame. This will reduce hammering damage to the ceiling and tiles will be less likely to fall out. The suspension system for the ceiling should also minimize vertical motion in relation to the structure.

Figure XXXIX Detail At Suspended Ceiling




**Lighting fixtures,**

which are dependent upon the ceiling system for support, should be securely tied to the ceiling grid members. If such support is likely to be inadequate in earthquakes; the light fixtures should be supported independently from the building structure above. Diffuser grilles, if required or the air supply system should also be hung independently. In seismic areas, a lay-in T-bar system for ceiling construction should be avoided if at all possible, as its tiles and lighting fixtures drop out in earthquakes.

## 5. 7 Planning of Infrastructure

The physical planning elements are incomplete without assessment of auxiliary infrastructure. According to the process, mechanical and industrial engineer may help in determining such requirements. After that architect has to trat them individually and place them in layout keeping its noisy, or obnoxious character in mind. This will give the correct industrial building concept for an architect to provide solution. There may be various types of stores, and storage spaces for different materials, chemical and oils according to codes. The engineering building, laboratory and administrative building are also the auxiliary infrastructure of the factory.

## 5.8 Welfare Infrastructure

Welfare infrastructure are those which form part of the factory but provides comforts and facilities to workers during rest periods, they are like canteens, tea shops, club, and welfare buildings. The provision of parking arrangement, drinking fountains, lavatories, changing rooms etc. Also provision of housing, medical facilities and other services conducive to life of community may be included in welfare infrastructure.

## 5.9 Transport Infrastructure

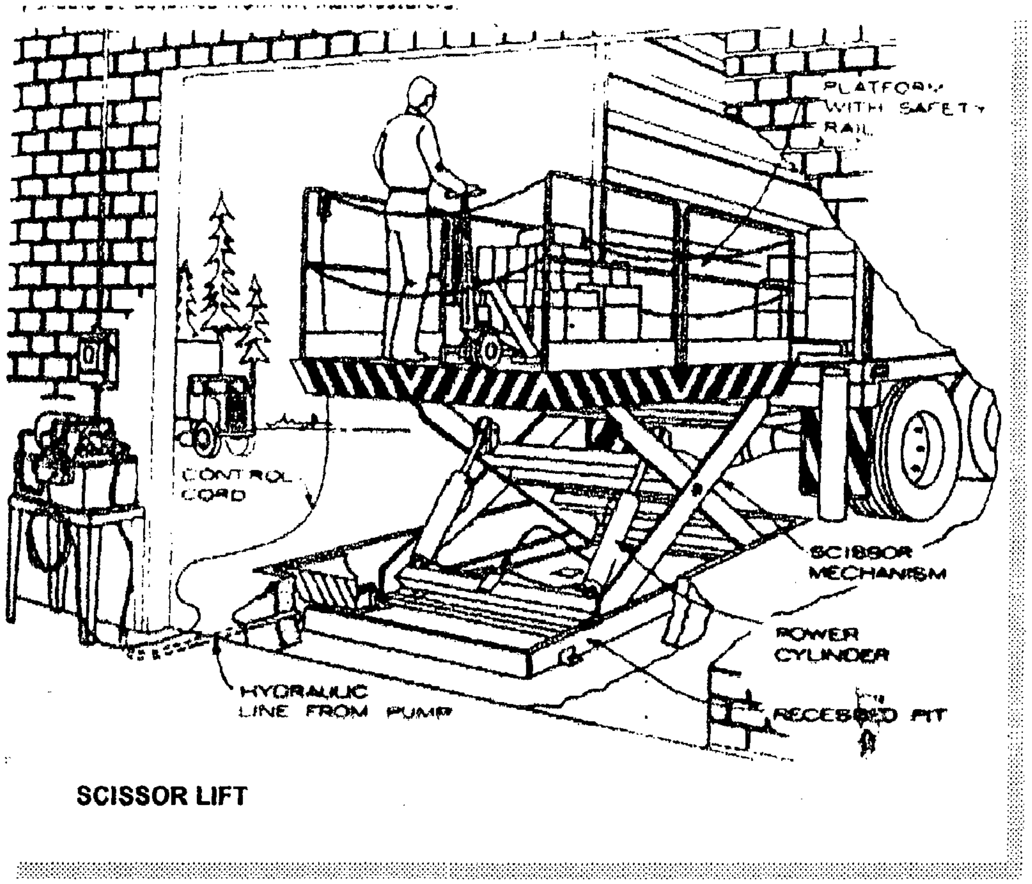



Figure XL SCISSOR LIFT

Transport infrastructure has a vital role in any industry. It may be land, water or air transportation. Out of which road and rail are most common.

The loading and unloading facilities are always associated with it and need careful planning and detailing. The provision of weigh bridge, transportation of essential service like water, oil, steam, gas, electricity are important technical factors in transportation infrastructure.

## 5.10 Security

Protection of property and personnel is equally important from planning aspects. The provision of security measure, alarms, gates, time offices, compound wall and watchman's booths, flood lighting and street lighting are included in it.

The personnel protection is to certain extent covered by the statutory provisions, such as protection from fire, explosion, gases etc. Provision of proper flooring, staircases, ramps and railings providing ear plugs, welders shield, masks, helmet, shoes, gloves etc. are also management provision for personnel safety.

## 5.11 Working Conditions

Providing suitable working conditions for working is the primary duty of an architect. The working conditions are greatly affected due to various industrial processes and no problem of providing better working condition becomes more serious. Not only physical but also psychological environment is to be taken care of during design.

# CHAPTER VI

# "ANALYSIS"

# CHAPTER – 6

# LIGHTING, VENTILATION & ACOUSTIC DESIGN

## 6.0 Abstract

The final aim of the study is to prepare a set of guidelines for the planning and design of industrial buildings in general and engineering industry in particular. These guidelines will be the outcome of the literature review case studies and analysis done on the survey work.

## 6.1 LIGHTING DESIGN MEHTODOLOGY

Lighting affects internal working conditions due to various fenestrations's provided in building envelop. According to the type of industry the method of providing lighting is changed. The industry, which has single shift working, has lighting system different than the industry having 3-shift working.

The lighting design has two basic type of methodology, such as natural lighting and artificial lighting. The selection of any or both system is dependent on the requirement of industrial process. Each type of system has advantages and disadvantages.

Therefore, selection of system is very important. The eye is stimulated by light reflected form objects thus light is prerequisite of seeing. Sun is the only natural source of light and is estimated to give about 1,00,00 lux. The sunlight has wide range of wavelengths, but only a narrow range is perceived as light for our purposes. This wavelength also determines its colour. The light containing all visible wavelength is purposes. This wavelength also determines its colour. The light containing all visible wavelength is perceived as white. The human eye is more sensitive for wavelength of 550 mm which corresponds to yellow colour. The light can be transmitted, reflected or diffused and its intensity reduces as the distance between source and working plane increases. The colour qualities of light are very important when it has importance in the industrial process and may form major design element for artificial lighting.

The intensity of a light source is measured in units of Candela (cd). This is a basic assumed and agreed unit defined as intensity of a 3/60 $cm^2$ uniformly emitting black body radiator at the melting point temperature of platinum. All other units re derived from this. The flux or flow of light is measured in Lumens, which is the flow of light emitted by a unit intensity (1 cd) point source, within a unit solid angle. The illumination is measured as amount of flux falling on unit area i.e. lumen area in meter$^2$, and is expressed as lux. The brightness of the surface is measured by 'Luminance" which is light source per unit area.

The eye responds to a range of illumination levels form 0.1 lux (full moon light) to 1,00,000 lux (bright sunshine). Hence for all practical situations and to perform visual task different illumination values are required. For casual seeing only 100 lux is recommended whereas for exceptionally severe tasks requires 2000 to 3000 lux. The visual efficiency does not only depend on illumination but on the distribution of illumination on central field where tasks is performed, back ground and environment. The ratio varies between 5:2:1 to 10:3:1 if the ration exceed the above ratio it may create glare. Ref. Fig. 17 which is both adequate and suitable for the visual task.

## *Lighting Methods*

There are three basic methods of designed lighting and each has advantages and disadvantages. They are 91) Day light Factor (DF). 2). Permanent supplementary artificial lighting (PSALI). 3) Permanent artificial lighting (PAL).

### 6.1.1 Design with Daylight Factor

The designed lighting in daylight factor is based on natural light available form sun. Due to variable external condition in the sky, atmosphere etc the terms in design of lighting are to based on different principle other than the photometry illumination. In this the ratio of illumination inside and outside is taken as constant and is expressed as percentage. This ratio in percentage is called daylight factor.

$$DF = \frac{\text{Illumination in door at the point}}{\text{Illumination outdoor from unobstructed sky}} \times 100$$

**It could also be expressed as summation of sky component externally reflected component and internally reflected component.**

Thus: DF = S C + E R C + I R C.

According to Indian Standard Institute the illumination out-door form an unobstructed sky hemisphere is taken as 800 lux 21.

There are number of variables involved in the design of illumination and scientists has given easy and simplified methods to achieve designed natural lighting for interior visual tasks.

The most common method of admitting natural light is through 1)-side windows and 2) roof and high-level north light windows.

Admitting light through side windows has most important advantage especially in industries. It provides vision and maintains Contact with the surrounding natural environment. It reduces the effect of claustrophobia, which may be present in their other systems of lighting i.e. PAL system. The other advantage of using natural lighting is its ability for true judgement of colour. There is no equal system in artificial lighting that has this quality of natural light. The only disadvantage of natural lighting is that there is no control over it. The light intensity changes as per the variations of seasons, lengths of the day, sky conditions and other natural disturbances.

It is practically impossible to provide adequate daylight in side lit rooms to a depth factor than three times the window head height (above the working plane). In most of the general purpose buildings the maximum depth of 6m. is required and so could easily be lighted with side-lit windows. For rooms or areas deeper than this the roof-lit or north-lit windows are recommended, when natural lighting is to be provided. The possible cross-sections of industrial building and locations of windows are show in. The method of calculation of illumination through side-lit and roof-lit windows.

### 6.1.2 Designing with Permanent Supplementary Artificial Lighting

This system of designed lighting is recommended when depth or area is more than 3 times of window head height and there is no possibility of providing windows in roof. In this the areas located at greater depth are to be provided with supplementary artificial lighting. In this electric lights are provided to give necessary.

### 6.1.3 Permanent Artificial Lighting

In this the entire lighting is based on artificial lights. It may possibly lead to window less environments. It has been claimed that windows are weakest point of the building envelope for thermal and noise insulation, this system of lighting may be most economical when air conditioning is necessary for industrial process. The counter argument for this reasoning is availability of cheap electrical supply and adverse effects of window less working area that may develop claustrophobia among the occupants, as visual link between the surrounding is lost.

### Fitting and fixtures for Artificial Lighting

The most common types of electrical light fitting used for industrial lighting are incandescent lamps, fluorescent lamps, mercury arc lamps and cold cathode lamps. Out of these the first two are commonly used. They emit along with light certain amount of heat also, which is a matter to be considered. If the overall economy is worked out for the above the fixtures most commonly used, then fluorescent lamps are more advantages over the incandescent lamps. It emits heat less than incandescent lamps but has special drawback. This is called a stroboscopic effect which may be a major cause for accidents in industries.

The qualities of artificial lighting are expressed in the Fig. 15 in which the various elements such as a) direction, b) diffusion, c) shadows, d) contrast and e) glare are explained and provide practical hints for artificial lighting for industrial tasks.

**Use of Lux Grid Chart for Side-lit Windows**

There are different methods suggested by different authors for designing and prediction techniques for lighting. They are as given below: a) The lumen methods, b) Daylight protractor method, c) Daylight factor method, and d) Perspective projection mainly. Each method involves tedious calculations and takes into account number of variables.

The lux grid chart is a handy tool for design of side lit windows for a building having maximum depth of 6.00m. And having the selected interior finishes and its reflectance factors. It consists for two charts and each serves specific purpose. The lux grid chart is used when there is no external obstruction. The second chart is used where there are obstruction. The second chart is used where there are obstruction present within the distance of 3 times the height of obstruction.

The use of the respective 'Lux grid" chart could be made for predicting the illumination in lux available through the side lit window at the point on a selected working plane.

In this the elevation of the window is to be drawn on a tracing paper. The selection of its scale is proportional to the distance of the point under reference, for which illumination in lux is to be predicted. The scale is 1/10 of the distance of observation point from window wall in cm. Equivalent to one grid marked on the lux grid chart in cm.

After the elevation of window provided in architectural solution, is drawn, to the required scale (as given above) place the same tracing on the lux grid chart so that line W P W (working plane) corresponds with the window elevation. The relative position form the reference point needs to be adjusted along with the line $P_x$ $Y_x$.

Under this position window elevation will give the maximum area possibly admitting light inside. In order to get the illuminations count the stars and dots within the window elevation. The value of each star and dot is assigned them by simple multiplication of respective of stars and dots value and adding them provides the possible "lux" value from the area of window.

This value will be on higher side and so necessary reduction factors are to be applied to bring down to workable standard.

The process may be repeated in the reverse order when amount of illumination is known and area of window could be worked out.

The method is very useful to architecture because it is simple and more towards graphical than mathematical. It has only one drawback that counting of dots and stars as well as squares are necessary for each solution. Therefore, author has recorded the cumulative values along "X" axis and then along "Y" axis. The values are symmetrical from PY line for "X" axis and WP line for "Y" axis. It has advantage of simple addition or subtraction of figures to get quantity of lux achieved through the opening. The modified lux grid charts are shown in the Fig.21.22 And 23. It gives half charts of lux grid chart I on R.H.S.

NB: Whale using this modified chart valued shall be doubled and placing of window elevation centrally and carefully is necessary.

**6.2 Method for Roof lighting**

In case when building is very big and side lit windows provide inadequate lighting then roof lighting is recommended. It may be in the form of North light or saw tooth type following table is helpful tool for designing roof lighting.

**Table**

**Daylight factor at the center of a two bay North light Factory**

| Bay width in m. | % Fenestration to floor area | 15 | | 20 | | 25 | |
|---|---|---|---|---|---|---|---|
| | Sill height (m) | 5 | 8 | 5 | 8 | 5 | 8 |
| 4 | | 5.0 | 3.0 | 4.0 | 6.5 | 6.5 | 4.5 |
| 7 | | 6.0 | 4.5 | 7.5 | 5.0 | 9.0 | 6.0 |
| 10 | | 6.5 | 5.5 | 8.5 | 7.0 | 10.0 | 8.0 |

**N.B.:-**

1) $DF = \frac{EI}{ED} \times 1000$ ..(1)

2) $\%Fenestration = \frac{\text{Total window area}}{\text{total Floor area}} \times 100$ ...(2)

**Method for Supplementary Lighting**

In case of supplementary artificial lighting design. It is assumed that good day lighting is available for90%

of the daytime and only 10% a may have poor lighting conditions. The estimation of supplementary artificial lighting may be predicted as per the table given below:

**Table**

**Number of 40 W. fluorescent tubes**

**Recommended for artificial lighting**

| Floor area $M^2$ | ***Fenestration*** | | |
|---|---|---|---|
| 25 | 3 | 2 | 2 |
| 50 | 6 | 5 | 4 |
| 100 | 9 | 8 | 6 |
| 150 | 13 | 10 | 9 |
| 200 | 16 | 14 | 11 |

The supplementary lighting fixtures are provided where in such work area where daylight is expected to be poor.

MB: The recommended values of illumination to perform visual tasks in various industries are given in the code of lighting by Indian standard institute.

## 6.3 Ventilation

Ventilation is the major problem in any industry responsible for creating unhealthy working conditions. In order to perform any industrial process ventilation is necessary. There is very little work and research carried on in this subject and nothing is so far standardized. The simple solution generally recommended for the problem of ventilation as "go for air conditioning". Under this circumstances architect has to deal with this problem by his ability of providing constructional details. The provisions of natural ventilation may be economical solution if more and more research is carried out in this field.

There are statutory provisions for ventilation. The section of "overcrowding" and "lighting" provides some indirect clue for the ventilation problem. The statutory provisions are much more below the actual requirement. The absence of scientific and statistical data is unable to put forth the proposals for amendments in the respective act. The only information available regarding ventilation in industrial buildings is given below in Table 7.6.

Table

**"Recommended minimum rates of fresh**

**air supply to buildings for human habitation"**

| Type of buildings | Fresh air supply (min.) |
|---|---|
| Assembly halls and canteens. | 28.5m$^3$ per hour per person. |
| Factories and Workshops. | 22.5m$^3$ per hr. per person. |
| Lavatories | 2 air changes. |

### *6.3.1 Design of Ventilation*

The design for ventilation is dependent on supply of outside air supply in place of interior air, which is vitiated due to used by men or machine. The requirement of fresh air supply is governed by the type of occupancy, number and activities of the occupants and nature of process carried out inside. The replacement of air is necessary to maintain carbon dioxide concentration of air within safe limits on one hand and provide sufficient oxygen content in the air for respiration. It is also necessary to remove odors and maintain satisfactory thermal environmental.

The requirement of fresh air may be stipulated as per code and regulation in terms of 'meter cube of air per hour: as per the persons occupying the area. The tables available are for the mechanical ventilation and no scientific information so far is available for natural ventilation.Design of Ventilation with Air Change.

In satisfactory design of natural ventilation is prediction of airflow pattern based on results of laboratory experiments. They could give useful guideline to the designer. The scaled model technique is the only recommended method for ventilation design. The flow pattern induced due to configuration of solids and voids, relationship of inlet and outlets, height and area of the *opening, shape and subdivision of partition mainly.*

The system of ventilation can boardly be divided into two categories,

a) Aero motive or wind force and

b) Thermal or temperature forces.

They are very effective in case of ventilation of industrial buildings. In industrial buildings artificial generation of thermal force is also a matter of careful study and attention.

The scale and magnitude of ventilation problem in industrial building is different than the normal residential buildings apart from ventilation requirements for human occupation, it creates large difference between externally given and internally created conditions. Under this rate of air exchange and air flow must be regulated particularly in industrial building where energy in consumed for production processes. Therefore, the design of Ventilation be based on air flow due to natural elements and where it fails then mechanical ventilation is to be adopted.

### 6.3.2 Ventilation with Air Flow

In mechanical ventilation the air is moved by motor driving fans, located at suitable places with ducts etc.

to improve the effectiveness the effectiveness of airflow.

The movement of air can be utilized as heat carrying medium and effective comfort conditions could be achieved by dispersion of heat by movement of air. The desired comfort ventilation depends upon the dry bulb temperature and relative humidity. This relationship is properly established in the expression of "Effective temperature" and given in the psychometric charts.

In order to use this expression for achieving comfort ventilation in industries the two monogram given in and could be used. They provide effective temperature achieved by air movements under different dry bulb temperature and humidity. The expression of humidity is in the form of wet bulb temperature. The range of the comfort none is shown but is subjected to have variations. The provides the effective temperature when person is wearing "normal business clothing" and is when a person is "stripped to the waist". These are the normal working style in various industrial processes.

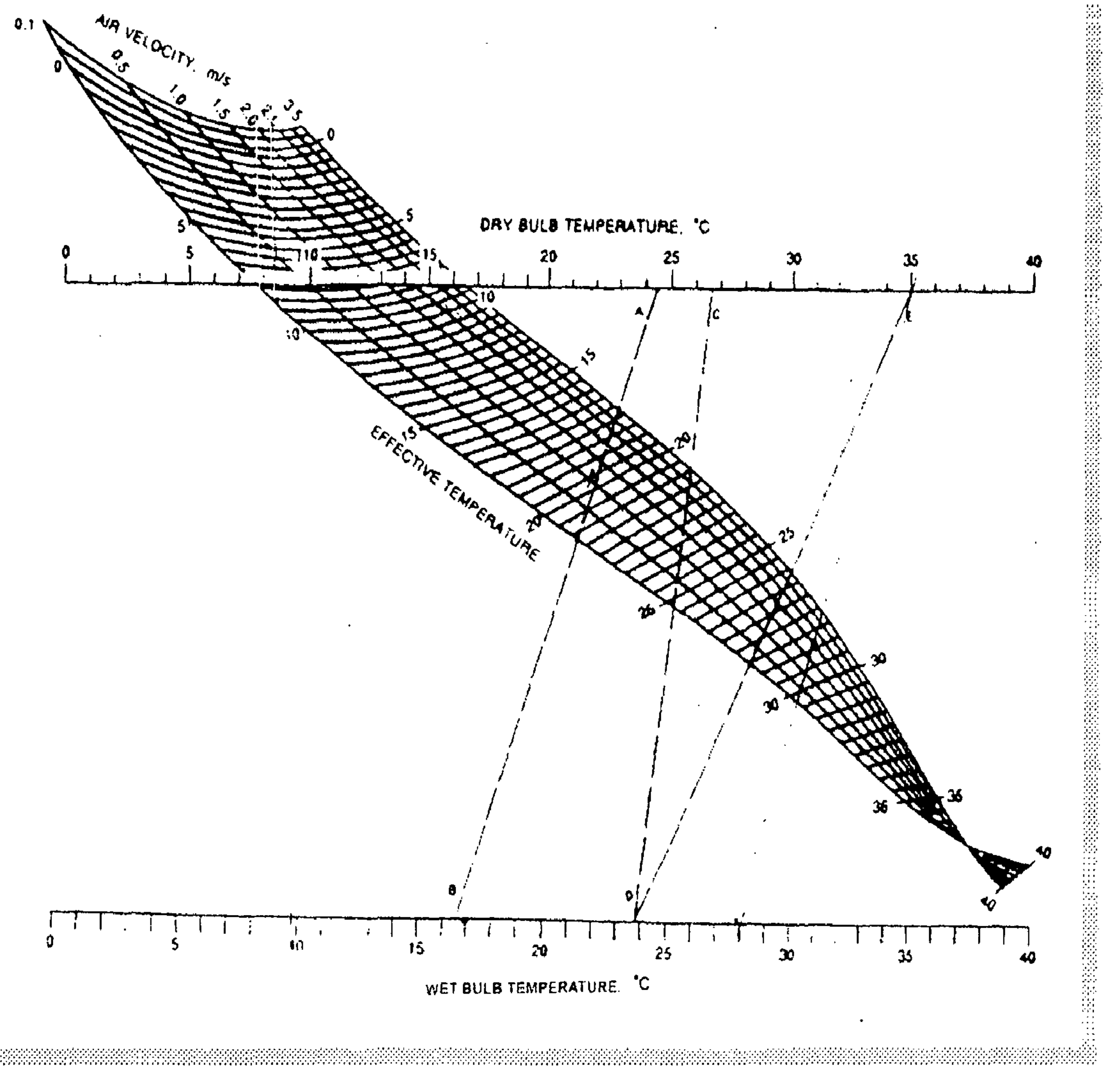



Figure XLI EFFECTIVE TEMPERATURE NOMOGRAM

Under the statutory control vide "Factory Act 1948" section 25 schedule of dry bulb and wet bulb relationship is to be maintain. This regulation is taken as a mandatory the monogram may be used to know air velocity by which effective temperature will be within

# CHAPTER VII

## "CONCLUSIONS"

# CHAPTER -7

# "CONCLUSIONS"

In the industrial design, till recently, there was little contribution by an architect even as a mediator. An architect has only the role of draftsman in large industries, for factory design, and has to manage the township as his domain. In smaller industries, an architect has to play his role and has produced wonderful results, on his professional merits.

Architects who undertake the design of factories are faced with conditions different in many respects from those to which they have been accustomed. These differences are perhaps more in degree than in kind, for same fundamental principles apply to all types of architecture. In the industrial field they are simplified, are more clear-cut and uncompromising, than in most others. Here function is actually the predominant factor, followed closely by economy. No aesthetic consideration can prevail unless it is completely consonant with these other factors.

In a developing country like India rapid industrialization is a necessity so that the country will not only be self sufficient but also will be able to export finished products. It has therefore become essential that a proper planning of such industries is done so that the cost and the time for construction can be kept to the minimum and at the same time able to have a reasonable layout without either over crowding or to much of space in the factory building.

The general conclusions drawn can be summed as

1. The industrial policy at the micro-level is always tuned with the national, state or regional policies.
2. The basic difference, between other industries and the Heavy industry, is it needs greater flexibility in production space and evaluation of physical space requirements. It should be functional and rational in every inch of its space.
3. The Heavy industries, mostly. 'Tailor-made' industry hence spaces requirements will depend upon the type and size of product, and expected capacity.
4. Understanding flow chart and process layout is of more important to assess the physical-planning requirement by careful analysis of process into smaller independent units.
5. According to the size, capacity and services needed, transport facilities are determined, which finally provides clues for bay width, column spacing, structural system and inter-relationship of production and auxiliary area.

6. Study various factors of condition stimulant according to the industrial processes.
7. Study the factors due to which occupational environment and ecological imbalance may occur.
8. The correlation and justification of planned layout, flow, sequence, lighting, ventilation, sound and separation of building or closeness are to be verified by respective experts.
9. Industrial building should be such which will enhance the landscape without aesthetic pollution.

## 7.1 RECOMENDEATIONS

### (A) POLICY PLANNING

1.) The policy for any industrial design should be based on micros-level circumstances, adhering to national or state or regional policy framework. For this study of following factors is necessary.

(a) Economic factors, (b) Services factors, (c) Climatic factors, (d) Statutory factors.

2.) Analysis each of them for the industry under design

### (A) FUNCTIONAL PLANNING

3.) Study the flow and process charts and diagrams prepared by the production or Industrial Engineer, and understand the following:

(a) Is the flow patterning straight, serpentine, u-shaped, circular or odd-angle?

(b) What type of relationship is expected between (1) Receiving store, (ii) Finished store, (iii) Fabrication line and (iv) Assembly line?

(c) Understand various positions in the process chart where (i) operation, (ii) transportation, Inspection, (iii) Delay, (iv) storage and (v) Combined activities take place.

(d) Understand the industrial building concept by studying (i) entry of raw material, (ii) process or processes, (iii) finished product exit and (iv) location of various services like, traffic, ramps and staircases. Lockers, entry, engineering building, welfare building, and specialized, auxiliary and protection services.

(e) Assess according to predominant industrial process or processes what type of pollution and industrial waste likely to be.

**( C) PHYSICAL PLANNING**

4.) According to the flow and sequence determine industrial building concept like (a) Single storey (b) Balcony, (c) Basement or (d) Multistorey.

5.) Determine according to flexibility, expandability and type of component to be produced, the type of industrial structure to be selected like:

(a) Flat roof, flat roof with monitor, high bay flat roof.

(b) Gable or truss roofs, gable roof with monitor, high by mill roof.

(c) Saw tooth roof, valley roof, bow string roof.

6.) Workout the area requirement for man, machine and material based on 'Production" or 'work center' principles for the industry to be designed, Mechanical Engineer, or Production Engineering Constancy is necessary? Then (a) determine the area required for production bay, auxiliary bay, (b) Verify the sizes to suit to the industrial structure bays, and (c) Determine the various vertical dimensions based on mans anthoropometric data and its effectiveness in puling and pushing, (d) determine type of floor and its nature to performs all the process operations. (e) Determine enclosure requirements after considering the opening like large industrial doors, windows and structural bearings etc. in mind.The enclosure is also governed by climatic considerations, vision, and dust emission and noise elements also govern the enclosure. This will give design for cladding. (f) Determine roof system according to the rainfall, type of natural light to be planned and locations of production bays in the entire industrial structure, Provide visual, link, to avoid the effect of 'claustrophobia' at normal planning requirements.

7.) List out the auxiliary infrastructures required and locate them at suitable places after assessing their functional, physical planning requirements.

8.) Determine welfare infrastructures according to human conveniences and factors of condition stimulants specially the health and accident hazards

Take the guideline from the Factory Act 1948 for providing such structure. Provide social and commercial infrastructure like canteen, bank, post offices, parking training school, auditorium, club and housing.

9(a) Determine type of transportation required and provide them as per technical requirements of the same, for external transport system.

(b)Determine internal transport system due consultation with material handling expert and production engineer.

10.) Determine the protection system required according the ndustrial process from mainly condition stimulants given.

(a) Provide fire protection, adequately,

(b) Provide scientific storage spaces for oil, explosives and chemicals according to IS recommendations,

(c) Provide washrooms, lockers, overalls, safety equipment and shields according to the stimulation.

(d) Provide expansion joints, weather seals, lead lining etc, wherever necessary (especially for radiation hazard).

(e) Provide measures to protect property by proving (a) boundary wall, (b) gates with check, (c) time offices, d) street lighting, and flood lighting, (e)Various types of alarms and detectors (f) Green belts.

(11) In achieving better working conditions adopt and check them, minimum recommendations of IS Code for (a) lighting and check by the methodology proposed in this dissertation, (b) for ventilation consult expert as no specific

information is available in IS Code, (c) Adopt noise control methodology given in this dissertation. (d) Adopt methodology given in this dissertation for awareness about harmfulness of pollution and industrial waste disposal. It is also recommended that respective experts many are consulted during the planning stage as a precaution and as corrective majors after planning.

This is a humble attempt made by the author to bring out the problems of industries resulting out of their processes and how to provide solution to the best capacity of an architect.The analysis and suggestions are expected to prove useful in planning new factories in providing corrective remedies to the existing one with special reference to heavy industries.

mass of pollutants emitted as gases and only 10% of the mass as particles and liquids.

The addition of contaminants in the atmosphere due to various industrial processes creates urban effect. The basic cause of it is formation of inversion layer over the urban areas. The air mass above the urban areas forms a feathery "urban plume" due to trapping of contaminants under the warm inversion layer. This trapping discourages the natural phenomena of reducing air temperature for every successive increase in height. This urban plume is undisturbed by the daily temperature cycle of the place but on the contrary present over the urban areas for most of the days and months of the year.

The process is additionally supplemented by large areas of brick, concrete and asphalt, the smoke carbon monoxide, carbon dioxide etc. Emitting from various combustion processes etc. They keep on accumulating pollutants in the urban plume. The wind speed has no diluting effect in this matter. The wind drifts the urban plume on to the leeward side but does not vanish completely. This is explained in the Fig. 4 for betters understanding.

In the same way both urbanization and industrialization creates SMOG mostly over the urban areas and in particular that are close to sea coasts. The presence of smog and getting it charge due to suns rays results into photochemical smog. It produces more harmful pollutants like ozone, nitrogen dioxide ($NO_2$) nitrogen oxide (NO) and atomic oxygen (O).

Most of these chemicals cause lungs damages and eye irritation if exposed to them for longer period.

Keeping the harmful and widespread damaging quality of pollution it is necessary to study the respective example, analysis them and control them for future generation to live in healthy atmosphere. The necessary experts advise is unavoidable.

**Water Pollution and Industrial Waste**

The water pollution and treatment of industrial waste are of similar nature form architects points of view. It generally consists contaminants mixed in water and kills aqua life and alters biochemical composition of water body.

The reasons of water pollution are mainly due to discharge of industrial, agricultural, domestic waste and silt due to erosion into water bodies. They may have suspended matters, acids or alkalis, toxic substances, carbohydrates, fats, grease and oil etc.

The measure of water pollutant is the amount and type of organic waste it contains. The contribution to water pollution is maximum form the industrial wastes.

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