EFFECT OF INDUSTRIAL PROCESSES ON ARCHITECTURAL DESIGN WITH SPECIAL REFERENCE TO CHOSEN INDUSTRIAL PLANT

A DISSERTATION

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

By

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ROORKEE (INDIA)
July, 1977

CERTIFICATE

Certified that the dissertation entitled, "EFFECT OF INDUSTRIAL PROCESSES ON ARCHITECTURAL DESIGN WITH SPECIAL REFERENCE TO CHOSEN INDUSTRIAL PLANT" which is being submitted by SHRI SUDHAKAR VASUDEO SAHASRABUDHE in partial fulfilment for the award of degree of MASTER OF ARCHITECTURE of the University of Roorkee, is a record of his own work carried out by him under my supervision and guidance. The matter embodied in this dissertation has not been submitted for award of any degree or diploma.

This is to further certify that he has worked for a period of seven months i.e. Jan. 1st, 1977 to July 31st, 1977 for preparing this dissertation at this University.

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Finally thanks are due to all those who have directly or indirectly given author moral support for this humble endavor.

S.V. Sahasrabudhe

Dated August 1, 1977.

PREFACE

An architect is trained to design a building based on human functions, family relations and his socio-cultural requirements. The design solutions are focused on 'Man' activities.

The industry, even if it has wider range of problems of technical discipline and complex relationship between its constituants, is also one of the 'Man' activity, hence why the industrial problems may not be solved by an architect?

Here is an attempt in this direction, to study and solve problems of industries, with special reference to engineering industries generated due to their processes.

The dissertation is basically divided into two parts, the first deal with the problems and the second deal with the architectural solutions.

C O N T E N T S

CHAPTER I

INTRODUCTION

1.1.1 Industries are 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 the regional and even at the local level of working.

1.1.2 The policies at national level are aimed to achieve uniform planned industrialisation for over all benefit. During the process of implementation of such policies , the urbanisation takes place. The industrialisation and urbanisation takes place. The industrialisation and urbanisation, together , leads to encroachment on surrounding areas by way of expansion. If it is unplanned and reckless will be an invitation to disaster for tommoru. It also collectively spoil the environment, and transforms into 'amorphous twilight areas'[1].

1.1.3 The very fact of expansion of city areas and industries, along with parallel growth of population, is leading towards disaster, spoiling the environment and altering natural ecosystems.

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[1] Grube, O.W., 'Industrial Building and Factories', pp.6.

1.1.4 This leads to the importance of planning and policy making for general progress of mankind. The policies must be based on to achieve economic progress, without neglecting humanitarian aspects. The policy makers, as a team, should consider industrial and technological problems to high esteem, but neglecting the humanitarian aspects of it is invitation for disaster. They are to be looked after as 'twins', for the anticipated progress.

1.2.0 DEFINITIONS OF INDUSTRY AND ARCHITECTURE

1.2.1 The industry, which is a simple or complex relationship of input, process and output, where labour, machine, material and energy are combined together to produce an economic product.[2] It is a technical and specialized field of Mechanical Engineering, mainly, but coordination with the economist, the bussiness manager , the planners and the architect is always beneficial and necessary.

1.2.2 In the same way architecture is aimed at creating special environment for mankind. It is an art or science of building, structure, or distinctive style of building, exerts an ideological and emotional influence byspecific forms of its structure and character of spatial organisation, that is by means of architectural images.[3]

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2. Muther, R., 'Practical Plant Layout', McGraw Hill Book Co., Inc. New York, 1965, Chapter One.

3. Rimsha, A., Town Planning in Hot Climates', Mir Publisher, Moscow, 1975, pp.275.

1.2.3 These definitions accept the relationship between industrial function and human convenience as their concerned common goal for its design on the site. Therefore, the team of experts as policy maker, for any industrial design should include the planner and also the architect. They will ensure the physical planning and space utilisation, without causing immediate, or future, danger to human environment.

1.3 OBJECTIVE, SCOPE

1.3.1 In general any industry involves a complex process and interaction between man, material, machine, money 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 take place. They create artificial environment and alter physical working conditions, according to the process involved in it. The cumulative effect has to be taken care while planning industries by an architect and planner.

1.3.2 The architect is not concerned with the technical details of industrial processes but he has to study the facts resulting out of them and see that necessary measures 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[4]. Therefore, the scope of

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[4] Grubb, C.B., 'Industrial Building and Factory', Architectural Press, London, 1971, pp.6.

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

1.3.3 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. He as a mediator, has to plead for such effective control methods to achieve human conveniences, has to deal with within the building codes, factory laws and acts, and other physical characterization, in overall design. In other words the role of an architect in industry is not only a romantic slogan but a vital necessity.[5]

1.3.4 From the above discussion, the objective of this dissertation is to understand the problem generated due to industrial processes (taking illustrative example of engineering industry) and capacity of an architect to provide solutions to such problems with human considerations. Keeping the scope of an architect in mind, the author intends, to study the problems created in engineering industry by

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[5] Grubb, O.B., 'The Industrial Building and Factory', Architectural Press London, 1971, pp.6.

which physical planning,infrastructure, and working conditions are altered and life of the people working is affected.

1.3.5 While attempting this author is fully aware of his limitations and has suggested experts consultancy wherever required or necessary. It is an attempt to give insite of the problems of industries and guidelines to the architect to provide solutions.

PART ONE

THE PROBLEM

This part of the dissertation deals with the problems of industries which arises due to its process. An attempt has been made to study and analyse of the problems of engineering industries.

CHAPTER-2

THE PROBLEMS ARISING OUT OF INDUSTRIAL PROCESSES

The industry involve a complex process and the nature of the problems it generates are also complex. Therefore, it is necessary to understand what the industrial process is, what are classification of industries etc. Accordingly an architect has to study the problems created due to industrial process and how it affect architectural design.

2.1. INDUSTRIAL PROCESSES

2.1.1 The industrial process has a very deep rooted history but the correct record is available only after the industrial revolution. Throughout the historical development, man has used beneficially his capacity to harness the mechanical power, such as levers, pivoted pottery wheel, turn-table wagon, pulleys and compound pulley assemblies, transmission of power by rope and screw press of Gutenberg etc. to his betterment. These early attempts have laid the foundations for modern industrial technology. The figure No.2.1 shows man's attempt in inventing labour saving devices from pre-historic period to this century. It gives the rapid survey

FIGURE NO 1

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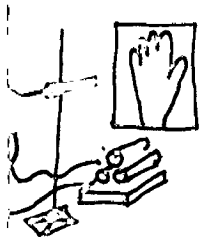

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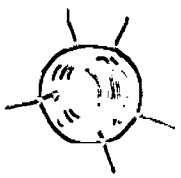
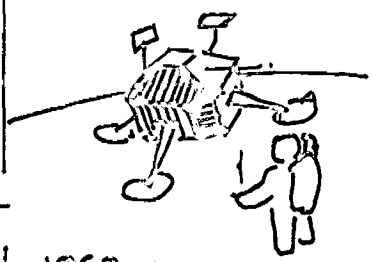


1958 LAUNCHING
OF ARTIFICAL
SATELLITES.



1969 MOON LANDING
N. ARMSTRONG & E.
ALDRIN.

*SOURC

of various industrial process used by man to make his life happy and enjoyable.

The sudden development which took place only after the invention of steam engine, internal combustion engines as well as diesel engine, has given a tremendous source of power to us, for industrial development. In the subsequent years these old methods have been improved by new one and encouraged industrial development and production, to put man his foot on the moon as his highest achievement so far.

2.1.2 Basic Industrial Processes

In order to summarise 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 (6)

a) Attrition,

b) Vaporisation,

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.

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6. Jones, H.L., Shainberg, L.W., and Byer, C.O., 'Environmental Health', Harper Row Publisher, San Francisco, 1974, Chapter 1.

2.1.2 (a) 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.3.1)

2.1.2 (b) Vaporization

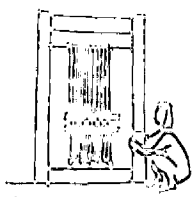
It is a process in which liquids are changed into gases at ordinary temperature or even at higher or lower temperatures. It, may be or may not be, associated with different pressure conditions for acceleration of the process.

It is one of the processes in which removal of moisture is done for drying or as an requirement of

MAN'S ATTEMPT IN INVENTING LABOUR SAVING DEVICES :

FIGURE NO

EARLIST PRE-HISTORIC MAN HAD THE FORESIGHT TO TAKE FROM THE SKELETON A BARING OF ANIMAL, INTO USE TOOLS, SUCH AS TOOLS, KNIVES, SCRAPERS, ETC., AND TO USE WHEEL AS HUNTING IMPLEMENTS.

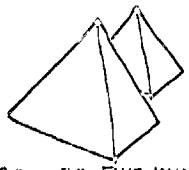


ABOUT 8000 YEARS AGEO LINEN WEAVING ON WOODEN LOOMS.

4000 B.C. CART OF SUMERIA.

3500 B.C. IRRIGATION AND USE OF LEVER.

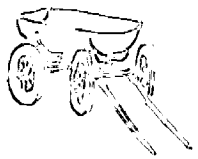
SUN DIALING 3000 B.C. TABLE.



2600 B.C. THE KNOWLEDGE OF MATHEMATICS & MATERIAL.

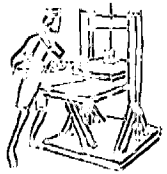
2500 B.C. PIVOTED POTTERS WHEEL.

100 A.D. USE OF COMPOUND PULLEY.



800 A.D. FAN WHEEL

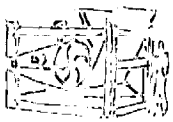
1200 AD. POWER TRANSMISSION BY ROPE BELT.



1441 AD. GUTENBERG SCREW PRESS.

1775 WATT'S STEAM ENGINE.

1785 POWER LOOM "CARTWRITE" ENGLAND



1791 WHITNEY COTTON GIN.

1809 APPERT "CANNING"

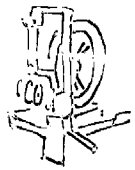
1829 STEAM LOCOMOTIVE.

1831 DYNAMO, "MICHAEL FARADAY" ENGLAND.

1831 McCORMICK REAPER.

1842 BICYCLE MACMILLAN.

1844 MECHANICAL REFRIGERATION.



1845 HOWE SEWING MACHINE.

1845 CEMENT "ASPDIN" ENGLISH.

1855 RUBBER "GOODYEAR" U.S.A.

1859 DRAKE OIL WELL.

1860 R.C.C.

1860 INCANDESCENT BULB, "EDISON" U.S.A.

1862 SUEZ CANAL FERDINAND de LESSEPS.

1876 BELL TELEPHONE

1885 DIESEL ENGINE R. DIESEL, GERMAN.

1886 BENZ AUTOMOBILE

1895 ROENTGEN X-RAY

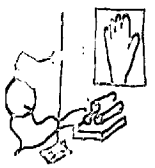
1896 RADIO MARCONI ITALY

1884 MERGENTHALER LINOTYPE.

1888 CINEMATOGRAPHY, GEORGE EASTMAN. U.S.A.

1891 SUBMARINE "HOLLAND" U.S.A.

1892 DURYEN AUTOMOBILE.



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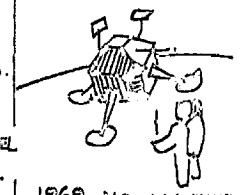

1969 MOON LANDING N. ARMSTRONG & E. ALDRIN.

* SOURCE : P 75, "MARC" VOL. XXXX NO 4, SEPT. 1972.

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Table No.3.1

'Manufacturing processes applied to metals'

Process	Scope	Typical use
1. Brake forming	Long or short folds	Open sectional forms.
2. Broaching	Shaving and shaping of cross sectional forms.	Splines, key ways, holes.
3. Casting		
(a) Sand	Large and small bulk of complex shape.	Machine frame, casting, covers,
(b) Investment	Small to medium bulk of complex shape.	Turbine blades, manifold
(c) Die	Small parts of non-ferrous metals, high finish and accurate dimensions.	Impellor, link parts, housing
4. Contour cutting	Surfacing	level beds.
5. Deep drawing	Large, small in thin walled.	Cups, containers, tubes.
6. Die heading	High speed production of small parts.	Bolts, nuts, rivets, studs.
7. Drilling	circular holes.	Holes, joining and bushing.
8. Extruding	Sectional forms in length	tubes and various sections.
9. Grinding	Precision finishing	Rods, bore, cone, surfaces.
10. Hobbing	Generation of shapes	Gear teeth.

.... / continued

Process	Scope	Typical use
11. Honing	Precision finishing	High grade finish.
12. Jig boring	Placement and cutting of precision holes.	Figures and fixtures, gear housing.
13. Milling	Standard machine for flat surfacing	Flat surfaces.
14. Pressing boring	Pressing thin sheet to 3D	Cap, covers, vessels
15. Plaining/ Shaping.	Production of flat surfaces.	Machine tool, bed 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. Turning all forms.	Machine production	Shafts, drums, tapered.
20. Welding	Joining of metals by fusion.	General.

Source: Casson, P., 'Theory of Design', B.T.Batsford, London, 1974 Table No.6.5 , pp.159.

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 which may omit fumes and thus create problems for the interior and exterior working conditions and also for an industrial building.

2.1.2 (c) Combustion

Combustion is the process of buring 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 is never perfect buring, leaves out unburnt by-products like bits of carbon, carbon monoxide gas and products from impurities

of the fuel. This unburnt byproducts are the major harmful contaminants, and causes atmospheric pollutions. 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 contribute 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.

2.1.2 (d) 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 given out large quantity of industrial waste

and causes water and soil pollution. The problem of selecting building material, resistants to the chemicals used, is special problem arising due to this industrial process mainly.

2.1.2(a) 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 creates 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 industry. It is extensively used in electroplating works, galvanising and ionisation of metals.

It gives out fumes, irritants, poisonous liquids and industrial wastes. The protection against liklihood 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 neutralisation plant, ion exchanger or detoxication plant. In order

to inspect the product, for its quality, it need tidy and bright workroom so that flaws in plating process could be recognised easily. The flexibility of electrical services and shockproofness is the important factor of process which affects architectural design. The corrosive acid vapours, mainly given out during the process, rejects 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.

2.2.1 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 of the basic industrial product. It may be as: (a) Basic industry, (b) Service industry, (c) 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 Gate based industries, (d) Forest based industries, etc. The other method of classification of industry is on the basis of employment potentials such as (a) labour intensive, (b) machine intensive. The basis for classification of industries may be as capital intensive or labour 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: (a) It is based on production capacity, (b) load handling capacity, (c) nature of process involved in it like, (i) continuous or (ii) interruptable[6], (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,

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6. Grant I.N. and Grant, E.L., 'Hand Book of Industrial Engineering and Management', Prentice Hall of India (P) Ltd., New Delhi, 1969, Chapter 1.

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

2.2.2 Reasons for Industrial Problems

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], specially 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 intermixture of life and pursuit was well knitted in the earlier design and utilisation 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 being 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 structures and labour for industry. This very concept has given the temporary look to the industrial structures due to bad economic conditions.

7. 'The Encyclopedia Britanica', Vol.12, pp.286.

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

2.3.1 Problems of Engineering Industries

The reasons for generating the problems in industries are many and varies according to the type of industrial process. According to scope, set for the dissertation, attempt has been made to study the problems of the engineering industries. They come under the manufacturing industries. Their range, is from small scale to heavy industry. Theyare 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

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

of material the product is a tailor made. In case of 'Mill' single envelope 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 other physical requirements of engineering industries depends upon the production capacity, work centres, delay locations, and flow of production assemblies. As the people started realising 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,

---

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

(c) Climatic factors,

(d) Statutory factors.

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

2.3.1 (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 provisions, 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.

2.3.1 (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) 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 facilities for efficient dispatch and circulation of goods produced, (iv) the availability and provision of housing and related social, cultural and habitational infrastructures.

2.3.1 (c) The Climatic Factors

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

2.3.1 (d) The statutary factors

The statutary 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 statutary power provides direction to an architect to provide solutions to industrial problems. They cover environmental control, pollution control, health and hygienic requirements and safety of structure.

The statistical information[11] is also, collected under statutary 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 acidents.

2.3.2 The above information is vital for understanding and analysing the problems of industries for planning purposes. They stand good for all types of industries including engineering industries.

2 .3.3 Hence the problems of industries could be classified, based on above findings, as,

(i) The problems resulting out of functional and physical requirement,

(ii) Occupational interior and exterior environment, and (iii) Ecological balance or disturbance.

The author has tried to interprete them in next chapter.

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11. Labour Bureau, 'Statistics of Industries 1959', Ministry of Labour and Employment , Government of India, Simla.

CHAPTER -III

ARCHITECTURAL INTERPRETATION OF PROBLEM THROUGH ANALYSIS

3.0.0 From the discussion in the preceding chapter regarding the generation of industrial problems it [illegible] becomes necessary to understand them, identify them and analyse them, so as to evolve a logical solution. Such solution, an architect, has to express, in his industrial design.

3.0.1 While interpreting the problems one has to put them in the suitable format to understand, analyse and evaluate as given below:

1. Problems resulting out of function and physical requirements.

2. Problems resulting out of occupational, interior and exterior, environment.

3. Problems resulting ecological onbalance.

3.1.1 (A) Problem due to function

The problems of functional requirements are clearly expressed in the basic principle of manufacturing process. It gives the correct concept of interaction between

constituents of industries such as man, material and machine mainly. The sequence of operations, positioning of labour and material at machines for processes, waiting of material for further processes, handling capacity and location of such facilities gives the functional problems.

3.1.1 (B) Problems due to physical requirement

The physical requirements could be understood from various machines used, quantity of labour and material required at various stages, areas required for housing them at various stages, in general. In other words it help to understand building requirements, loading factor and facilities to achieve the smooth function of industry. It is found that various industrial processes give out dust and particles. The size of it may be small , and visible or in the invisible range, injurious or non-injurious to health and produced continuously or intermittently but it creates problem of collection, dispersion of dust within the working area, envelope and in the surrounding area. The omittance of fumes and gases, which may be poisonous or irritants, do have capacity to create problems in selection of building material, ventilation systems to be used in design.

The involvement of different industrial process created problems for supply of fresh air for occupants and for various industrial operations. The problem of general

ventilation, local ventilation and mechanical ventilation are most common in the industrial processes.

Most of the industries, specially engineering industries, creates problem of noise. The noise in industries is unavoidable. It is never in a pure tone, but a mixed noises. The noise may be of high and low frequency and may be continuous or intermittent. It has a capacity to cause harmful effects due to annoyance, lowering efficiency of workers, interference with speech of communication and permanent hearing loss. These are some of the problems due to noise for interior and exterior environment. Ref.Appendix No.8.2.

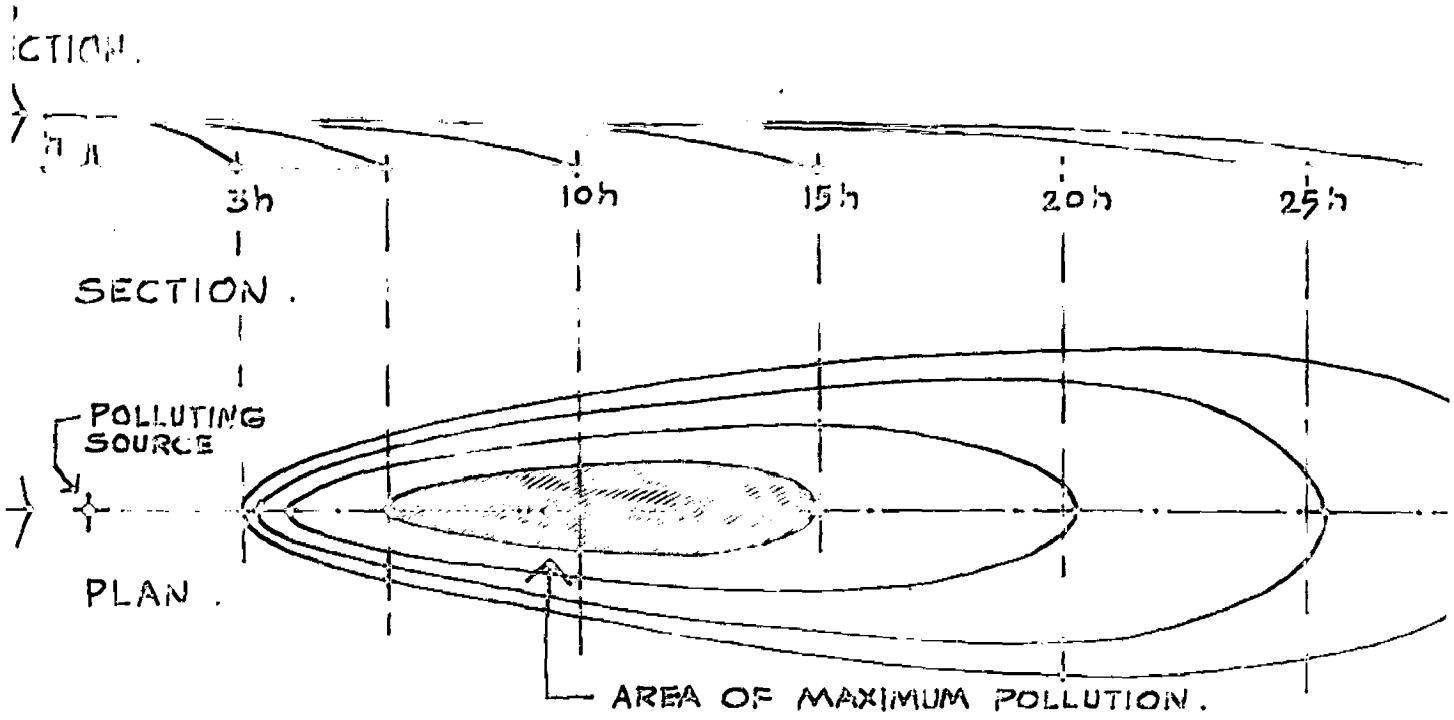
3.1.3 Problem due to ecological imbalance.

The problems resulting due to ecological imbalances are generally those which are covered under all types pollutions. The dust, as contaminant, emitted out, due to industrial, from its chimney stacks is carried away from wind and is dispersed on the leeward side of the stack over a larger area. The area influenced by such contaminant is governed by the wind direction, force of the wind, topography, presence of obstacles and height of polluting source. Ref.Fig.No.2 and 3. The creation of 'plume' [1] near the smoke source under different wind

[1] Something resembling a feather instructure or lightness.

FIGURE NO 1

" DISPERSION TREND "



AVERAGE RADIUS OF DISPERSION MAY BE DETERMINED APPROXIMATELY BY

1) UNDER UNSTABLE CONDITIONS = 10 h.
2) UNDER AVERAGE CONDITIONS = 15 ~ 20 h
3) UNDER STABLE CONDITIONS = UP TO 2[illegible] OR [illegible]

* SHAPE OF AREA OF DISPERSION IS ELONGATED ELLIPOSED SHAPE CHANGES ON WIND DIRECTION, FORCE OF THE WIN TOPOGRAPHY & PRESENCE OF OBSTACLES.

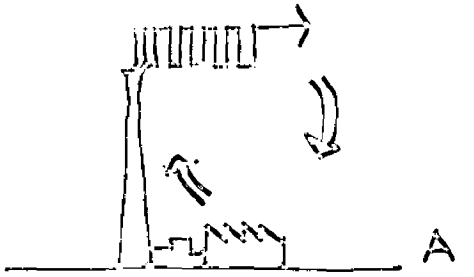
---

* SOURCE : PP 46, RIMSHA, A., "TOWN PLANNING IN HOT CLIMATES" MIR PUBLISHERS, MOSCOW, 1976.

FIGURE Nº

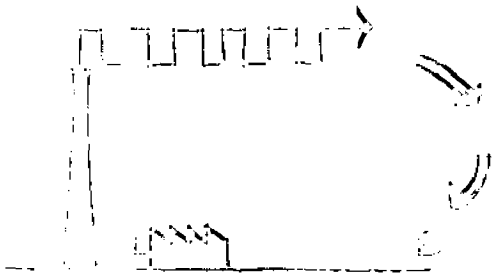
WIND SPEED EFFECT.

(< 3·3 m/s.)
SLIGHT BREEZE



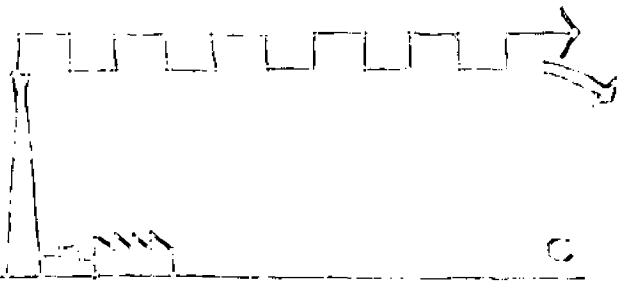
- PLUME CREATE CIRCULATION CLOSE TO SOURCE.
- NO DILUTION.

(3·4 ~ 12·4 m/s.)
MODERATE WIND

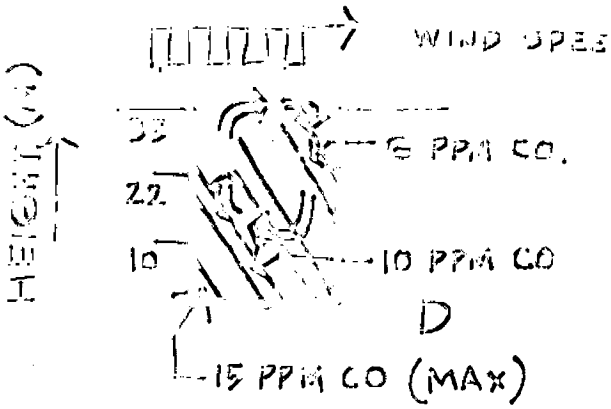


- CIRCULATION AT MODERATE DISTANCE.
- MODERATE DILUTION.

(> 12·5 m/s)
VERY STRONG WIND



- CIRCULATION AT GREATE DISTANCE.
- GREATER DILUTION.



- CROSS SECTION SHOWING SHOWING CIRCULATION OF AIR (⇒) AND ISOPLETHS OF CONCENTRATION OF 'CO' (CARBON MONOXIDE)
- MAX. UP WIND SIDE AT LOWER LEVEL.

---

* SOURCE: A = PP 75, D = PP , C = PP , D = PP 73;
MCCORMAC, B.N., "INTRODUCTION TO THE SCIENTIFIC STUDY OF ATMOSPHERIC POLLUTION" D, REIDEL PUBLISHING CO. HOLLAND.

speed is a major problem by which finally, Ref.Fig.No.4, urban effect is created. This urban effect is not a major problem when only few industries are working in isolation. But on the other hand the large industrial complex has a capacity to create urban effect more prominantly and formation of urban plume over city area in the form of inversion, smog and photochemical smog. They are the most alarming factors of problems in atmospheric pollution, Ref.Figure No.5, resulting out of industrial processes.

3.2.0 The above discussion identifies the problems one has to face due to industrial processes. The problems are of such nature which does not show any immediate bad effect but has a widespread cumulative disastrous effect, which can must plan them today for better future. In order to understand, and for identification factors of condition stimulants due to industrial process, a format is provided in figure No.6 to conduct survey work.

FIGURE NO 4

"URBAN EFFECT".

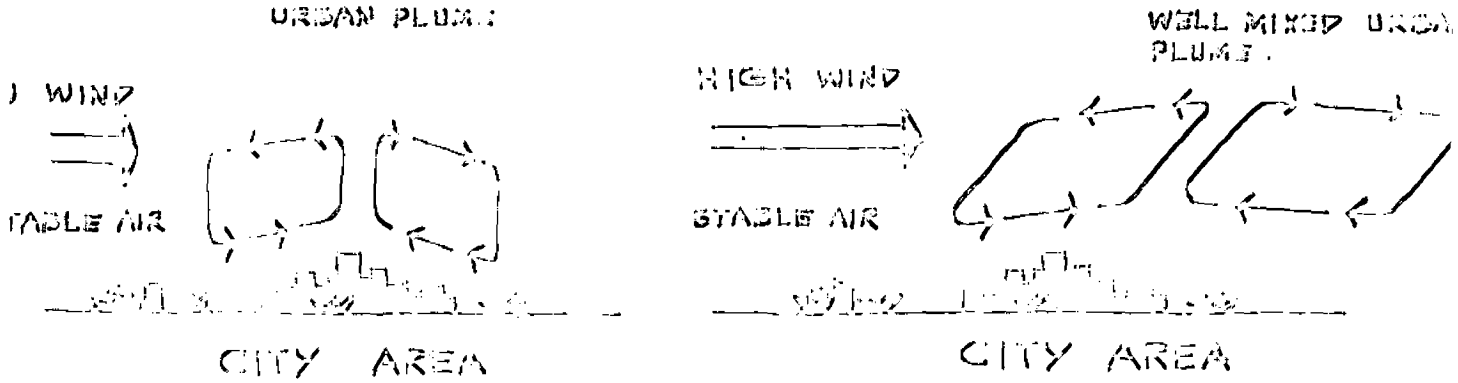
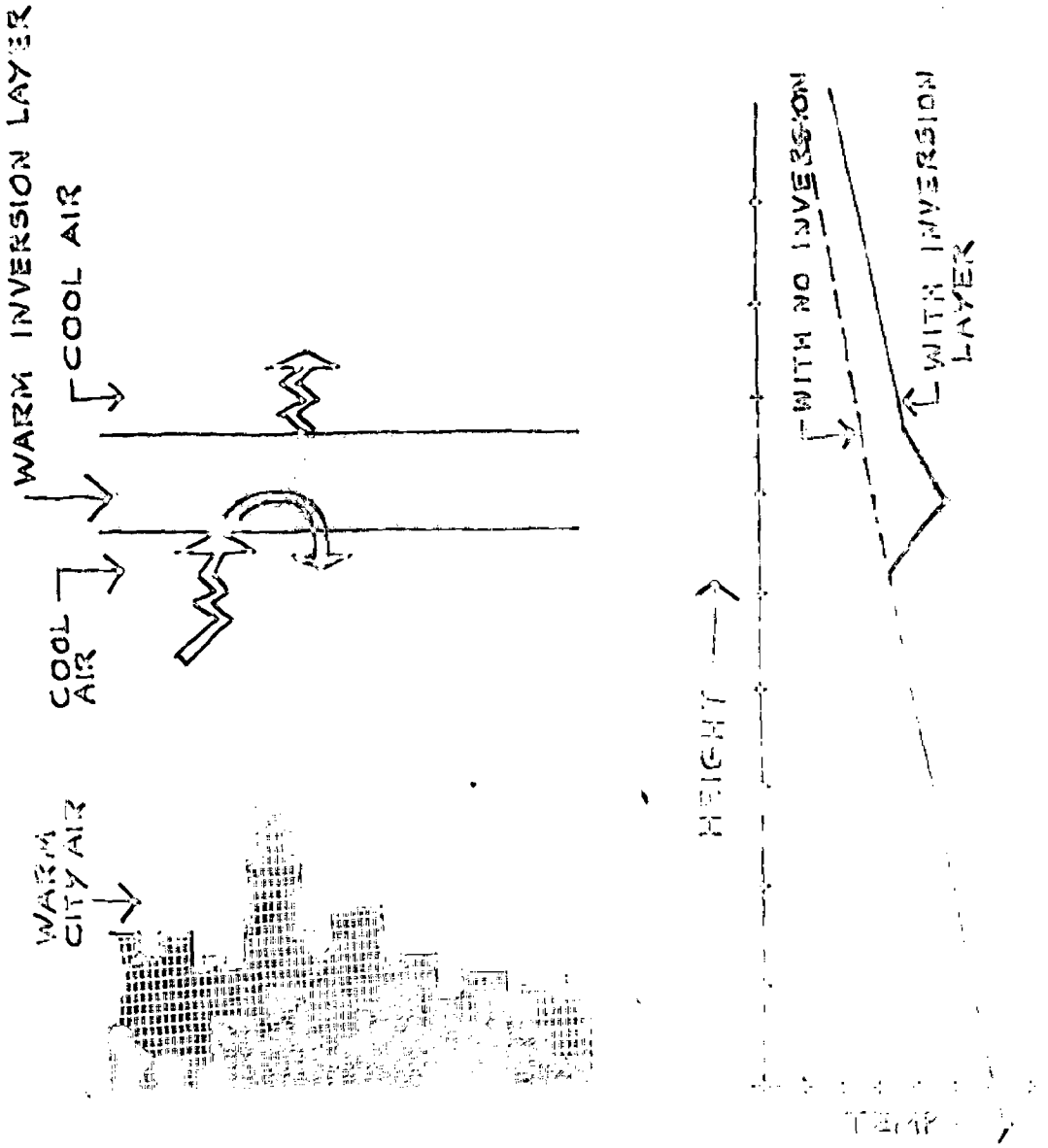


FIGURE NO

" LAYER OF INVERSION "



INVERSION IS A LAYER OF WARM AIR ACTING AS AIR TRAP OVER CITY AREAS. IT PREVENTS AIR POLLUTANTS FROM MIXING INTO UPPER LAYERS OF AIR AND ACCUMILATES WITHIN SEVERAL METERS OF THE GROUND. SUCH LAYER MAY PRESE-NT IN THE AIR FOR MOST OF THE DAYS OF THE YEAR, DEPENDING UPON THE SOURCE OF POLLUTION.

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* SOURCE : CHAPTER 1, JONES, K. L., CHAMBERS L.W., & DYER C. O., "ENVIRONMENTAL HEALTH" HARPER & ROW PUBLISHERS, [illegible], 1974.

"FACTORS OF CONDITION STIMULANT DUE TO INDUSTRIAL PROCESSES."

Condition group	Condition	ATTRITION	VAPORIZATION	COMBUSTION	CHEMICAL	ELECTROLYSIS
PHYSICAL DEMAND CONDITIONS	SITTING	✓	✓	o	✓	o
	STANDING/WALKING	✓	✓	✓	✓	✓
	STAIR CLIMBING	✓	o	✓	✓	✓
	LADDERING	✓	✓	✓	✓	✓
	LIFTING/CARRYING	✓	✓	✓	o	✓
	DEXTERITY	✓	o	o	✓	✓
	STRENGTH	✓	✓	✓	✓	✓
	COLOUR PERCEPTION	o	✓	o	✓	✓
	DEPTH PERCEPTION	✓	✓	✓	✓	✓
	SOUND PERCEPTION	✓	✓	✓	o	o
SELECTED JOB CONDITIONS	INSIDE	✓	✓	✓	✓	✓
	OUTSIDE	✓	✓	✓	✓	o
	TOO HOT	o	✓	✓	✓	✓
	TOO COLD	o	✓	o	✓	o
	DAMP-HUMID-WET	o	✓	✓	✓	✓
	ALONE-REMOTE	✓	✓	✓	✓	✓
	GROUP WORK	✓	o	o	✓	✓
	VENTILATION	✓	✓	✓	✓	✓
	LIGHTING/VISIBILITY	✓	✓	✓	✓	✓
	NOISE	✓	✓	✓	✓	o
HEALTH HAZARD CONDITIONS	DUST	✓	o	✓	o	✓
	HAZARDOUS DUST	✓	✓	o	o	✓
	RESPIRATORY	✓	✓	✓	✓	✓
	SHIFT WORKING	✓	✓	✓	✓	✓
	POISONS/IRRITANTS	o	✓	✓	✓	✓
	ULTRAVIOLET	✓	✓	o	✓	✓
	INFRARED	✓	o	✓	✓	✓
	RADIUM	o	✓	o	o	✓
	NORMAL PRESSUR	✓	✓	✓	o	✓
	HIGH PRESSUR	✓	✓	o	✓	o
ACCIDENT HAZARD CONDITIONS	WORKING AT HEIGHT	✓	✓	✓	✓	o
	SLIPPING/TRIPPING	✓	✓	✓	✓	✓
	FALLING OBJECT	✓	✓	✓	✓	o
	EYE INJURIES	✓	✓	✓	✓	✓
	MECHANICAL HAZARD	✓	✓	✓	✓	✓
	FIRE	✓	✓	✓	✓	✓
	EXPLOSION	o	✓	✓	✓	✓
	GASSING	o	✓	✓	✓	✓
	ELECTRICITY	✓	✓	o	✓	✓
	MOVING OBJECTS	✓	✓	✓	✓	o

KEY

YES	✓
NO	o

CHAPTER IV

EVALUATION OF PROBLEMS THROUGH CASE STUDIES

4.0.0 In order to understand the problems, generated due to industrial processes, and to substantiate them a case study is essential. The cases selected are from available i) literature and , (ii) personal visit to factories. In case of personal interview a questionnaire is prepared and survey work is carried out at the 'ancillary industrial estate' of B.H.E.L., Hardwar and at Govindpur, Bhopal.

4. 1.1 Personal Survey of Factory

In order to understand the problems due to industrial processes a questionnaire is prepared based on the objectives given below:

i) to study the problems faced by industries while performing industrial processes.

ii) how they are generated and how they affect physical working conditions and building envelope.

iii) to collect information regarding the factors which influences space utilization, sequential

arrangement and service factors.

The proforma[1] used during the survey is attached as an appendix No.6.3 of this dissertation.

The methodology adopted for conducting survey is based on personal interview with the manager of the selected random sample. During the interview the questionnaire is used, to keep the track of the discussion, and, get the desired information from the party than getting questionnaire filled in by them.

4.1.2 Survey Conclusions

1. At Hardwar BHEL Ancillary Industrial Estate most of the factories are very new and activity of ancillary industries is in the primary stage.

At Bhopal, Govindpura Ancillary Industrial Estate most of the industries are about 10 to 12 years old and has enough 'weathering' experience.

2. The type of products produced at both the places are similar to each other in general. They are i) Steel rolling and fabrication shops, ii) machine and tool room shop, iii) forging and malleable castings, iv) casting

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[1] Based on Muther, R., 'Practical Plant Layout', McGraw Hill Book Co.Inc. New York, 1955, pp. (adapted)

e-nd moulding of insulating material, and v) Packing cases.

The work force needed is maximum of 20 workers or less in total working in two shifts. The workers are trained in their respective trades or having long experience in the same.

3. Some of the industries need special storage conditions for their raw material, but in general storage is not a serious problem. The space is sufficient for the present and future growth.

The scrap and waste is a problem for store and disposal but has not yet reached to any serious magnitude.

The problem of storage space requirement is also not serious at Bhopal as the process is well organised and coordinated with the needs of the mother industry.

4. The area is sufficient according to the present conditions are contended for the next 10 years development.

In most of the cases the envelope given has failed to give or fulfill the requirements of industrial processes. The major areas, where changes have been made, are in the flooring, security measures and water storage. Most of them have even expressed about poor natural light, orientation of building, roofing, and poor ventilation, even if it is

designed as per 'Factory Act and Regulation' standards. They have installed artificial lighting, exhaust fans, dust collection system etc. at their own expenses to suit their industrial processes.

5. No special handling equipment is needed except a hoist beam and a small gantry[1] crane.([1] only in some Bhopal units).

6. The ash/dust/fumes are common in 'Insulating' industries. In other engineering industries transmission of vibration is a common problem.

7. The height provided was less for engineering industries and was more for insulating industries. Due to inadequate natural lighting local lighting is required in machine and tool room shop.

The flooring in 'light' industry is regarded as satisfactory but in 'medium' machine shop it is unsatisfactory.

Roofing design is defective as gable roof is used at Hardwar and is satisfactory at Bhopal where north light trusses are used.

8. The auxiliary services are satisfactory except frequent interruption of water main.

9. The industrial waste discharged is not treated but drained in open drains, which finally flows through nearby nallah.

10. There was problem of maintenance and cleaning at Hardwar, but at Bhopal general maintenance was good.

4.1.3 Additional Voluntary Information

Following are the opinions expressed by the informant in addition to the questions asked during the progress of discussion.

1. Need for foundation is different as per equipment load and handling load of each machine and material.

2. The development of industrial estate has failed to provide security and time or gate office. It has even not provided fencing all around.

3. The absence of storage tank hinders industrial process and even to maintain reasonable hygienic condition difficult.

4. The workmanship, detailing and specification are of very low quality. This results into leakage and damp problems.

5. The vibrations and impacts are transferred from one production area to another, because of semidetached buildings.

General Observations

The response from party was good. They were glad to participate in the discussion.

4.2.0 EXAMPLES FROM LITERATURE

Apart from the case study of BHEL Ancillary industries, attempt has been made to collect examples from available literature. Some of the examples are given below:

4.2.1 Electroplating Plant of Prakarsan, Zurich, Switzerland[12]

AK: OTTO KOLB,
BRUTISELLEN
ZURICH

The logical grouping of various areas as per their functions, is expressed in the design. The production, office, and social purpose areas are separated so as to form interesting massing without losing function. Ref. Fig. No. 7.

Flexible use of space is necessary and so minimum number of columns are provided inside and all free standing external columns for clear wall surface inside for

12. Grubo, O.W., 'The Industrial Building and Factory', Architectural Press, London, 1971, pp.116,117.

..or and aesthetic improvement from outside.

The industrial process generates acidic fumes, gases and fine dust particles. Therefore, use of steel structure is ruled out and concrete is selected. In order to have easy escape to fumes and fine dust particles, a sky light is designed for improving lighting and also as an effective ventilation system.

The factory is designed with 5 m.high wall of full height with fully glazed curtain walls in special 'Filtra Sol' glass with corrosion-protected steel frames. This gives tidy and bright appearance and assist the inspection of plated articles.

Electrical shock-proofness and working material being liquid, which are unavoidable in this process. The flooring is made of timber with grating over a large trough to suit the industrial process.

4.2.2 In another engineering industry example, large production area is needed (137x183m) with 12.19 m. height, hence provision of workers facilities within statutory control limits was a problem. Under this condition lavatories are provided in between roof and floor in production areas by which lot of production time is saved.

Engine testing is a major operation by which quality

control is achieved. Hence sound-proof test cells are provided with proper air circulation and acoustical systems. Service duct is a special feature in this example.[13]

The scale of the plant is very big and some thing is necessary to reduce its greatness as desired by managing authorities. Architect has carefully located cooling towers, creation of internal court by which double storey height is used efficiently.

Flexibility in expansion in any direction is common requirement, hence selection of structural system having varigated possibilities for extending the directional system, with further possibilities of variations in height and insertion of mezzanine floor for office areas.

Number of services are required for industrial processes at convenient locations, which occupies considerable space and volume. In this example services are grouped as an integral part of structural systems. 'T' shaped R.C. columns are used which are common for structure and service duct.[14] (refer figure No.8).

---

13. Grube, O.W., 'The Industrial Building and Factory', Architectural Press, London, 1973, pp. 80-83.

14. Grube, O.W., 'The Industrial Building and Factory', Architectural Press, London, 1971, pp.192.

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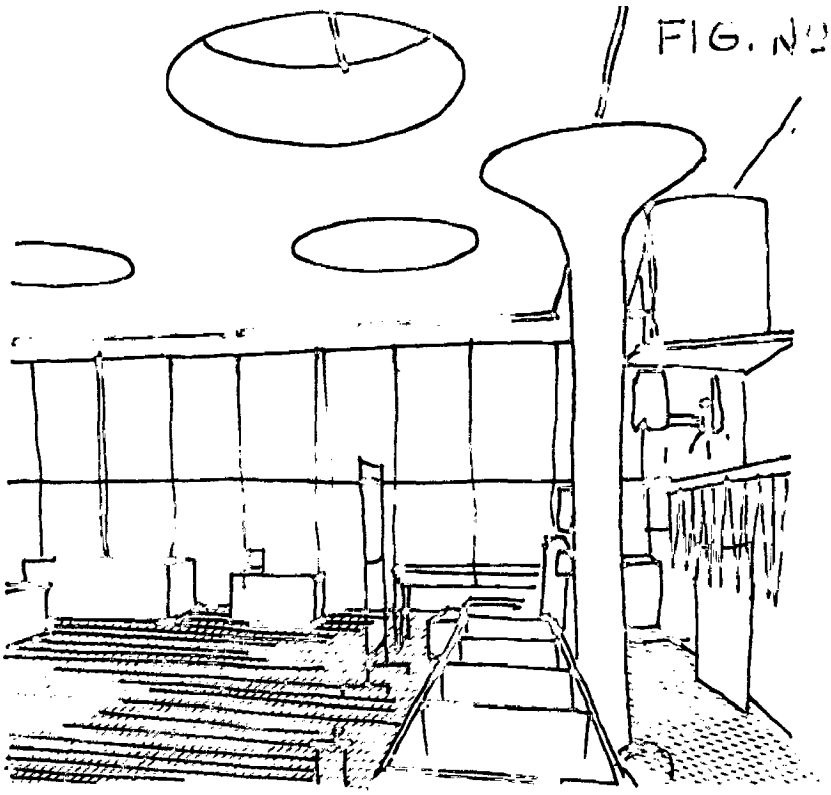
12. Grubo, O.U., 'The Industrial Building and Factory', Architectural Press, London, 1971, pp. 116, 117.

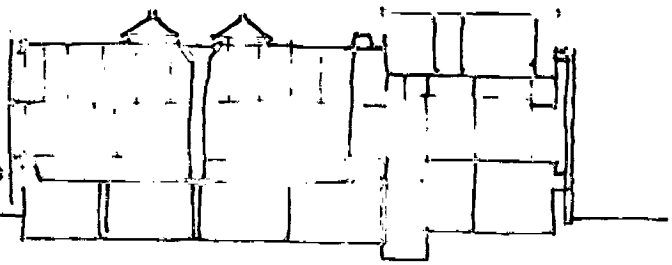
FIG. NO.

ELECTROPLATING PLANT AT FÄLLANDEN, ZURICH, SWITZERLAND.

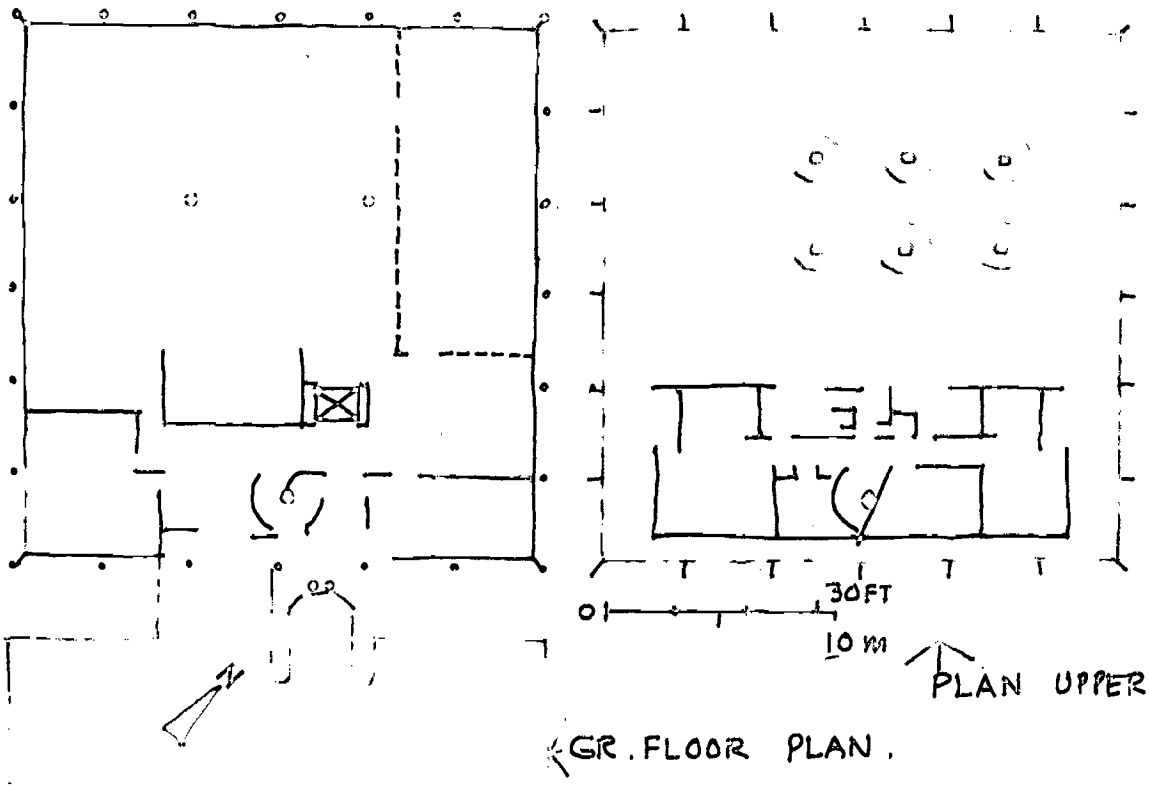
AR: OTTO KOLB, BRÜTISELLEN ZURICH.



FLOOR OF WOODEN GRATING



LOWERED FLOOR FOR ELECTROPLATING SHOP FORMS A CORROSION-PROOF TROUGH.



PLAN UPPER LEVEL.

GR. FLOOR PLAN.

---

* SOURCE : PP 116, 117, GRUBE O.W., "THE INDUSTRIAL BUILDING & FACTORY." ARCHITECTURAL PRESS, LONDON, 1971.

..or and aesthetic improvement from outside.

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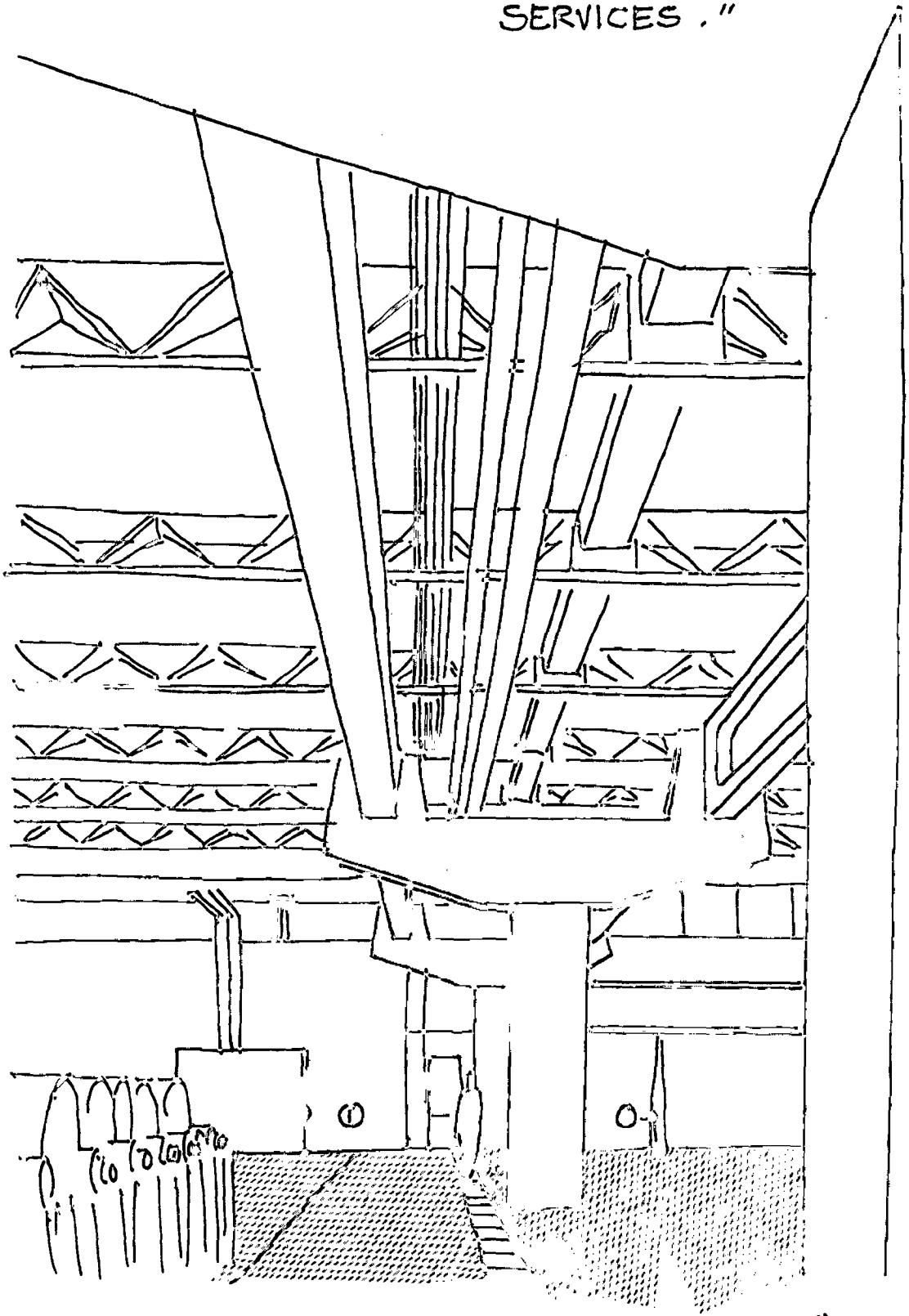
13. Grube, O.W., 'The Industrial Building and Factory', Architectural Press, London, 1971, pp.80-83.

14. Grube, O.W., 'The Industrial Building and Factory', Architectural Press, London, 1971, pp.192.

FIGURE NO

"INTEGRATION OF STRUCTURE AND SERVICES."



PRIMARY SERVICES ARE PLACED ON THE "T" SHAPED COLUMNS BETWEEN R.C. GIRDERS.

* SOURCE : PP 192, GRUBE O.W., "INDUSTRIAL BUILDINGS & FACTORIES" THE ARCHITECTURAL PRESS, LONDON.

4.2.3 Stamping Plant[15], Ford Motors Co.Michigan,
AK. Albert Kahn Association

A good design with careful amenities for a vast auto plant having 2,500,000 sq.ft. (23,0000 sq.m) plant area for 4000 employees. Plant layout is developed from flow chart and so has straight line operations. Material moves from east to west till it reaches 'Push Through', areas for shipping.

Employee goes from parking lot to changing rooms on mezzanine, after going through a check point.

It has maximum workers amenities such as 24 hours open cafeterias to accommodate 700 people. Fully equipped medical facilities , store of safety shoes, meeting rooms, training areas and recreation.

4.2.4 BROCKTON WATER FILTRATION PLANT[16] BROCKTON, MASSACHUSETS
AK: E.Vernor Johnson for Robert H.Hotvert Associate.

Integration of parts in a coherent whole.Two experts have worked out integration for such plant mainly Architect and Sanitary Engineering.

It has flexibility for expansion even without disturbing disturbing natural plantation.All plant parts are grouped around courtyard having sedimentation basin.

15. 'Architectural Record', January 1967,pp.151.
16. 'Architectural Record',February 1971, pp.123.

It is like a core. Other elements like filteration beds, pumps, reservoirs, filters, chemical injection and offices are grouped around sedimentation core.

Facade appears to float over a concrete base, and expression of water is achieved by placing crushed rock bed. Entrance with bridge ramp, supporting floating appearance.

4.2.5 MASCHINENFABRICK, HEBERLEIN AND CO., Zurich, Switzerland.[17]

AK: Prof. Walter M. Custer.

'Why not build factories for people to enjoy? Industrial building should be pleasing and enjoyable, along with operational efficiency and economical to build.'

Factory building has a 'see through' curtain walls (insulated for climatic reasons) and so displays more humanistic and environmental qualities. Production workers are placed in second loor, from where best view is gained. Layout is open so has feeling of close interaction.

Aluminium sun screen having multipurpose use like i) sun breakers, ii) fire escape and iii) maintenance platform.

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17. 'Architectural Record' July 1971, pp.91

In one of the example, according to the visual task level and nature of the industrial production even artificial lighting is sufficient of 500 lux, but the effect of 'Claustrophobia' in worker is present. The architectural solution is to provide slit windows at normal eye level to keep contact with surrounding environment.

P A R T T W O

The solution

This part of the dissertation deals with architectural solutions or provisions to the problems generated due to industrial processes.

CHAPTER V

THE ARCHITECTURAL SOLUTIONS TO INDUSTRIAL PROBLEMS AND AN ILLUSTRATIVE EXAMPLE

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 in to problems first and try to provide solutions.

In most of the case the policy demands flexible or expandable planning for economic or technical reasons. Therefore, the planning should also be adaptive and expandable.

The economic activities are geared up as the industry needs various types of materials, people of various skills and power, needs auxiliary facilities and services. It generates speculative spirit in the region. The type of product i.e. 'ready made' or 'tailor made' (as per customers's specification[18]). Accordingly the requirements of skilled hands changes. It may also need the provision of such special training, educational, and research facilities.

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18. 'Architectural Record' February 1971, pp.123, Example of Monarch Machine Tools Co. Cleveland, New York . AIA: William Deving Associates.

The very existance 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 provides 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.

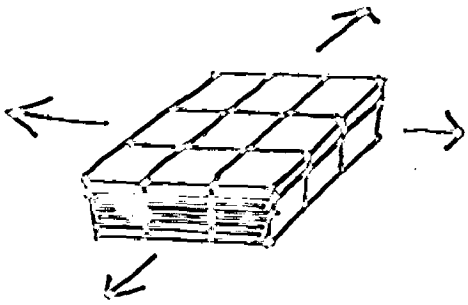
5.2.1 It gives solutions in terms of long term requirements and short term requirements or priority of facilities.

5.2.2 What direction should be of the solution like flexibility, expandibility or/and demountability which will □□ suit the industrial problem. Ref.Fig.No.9

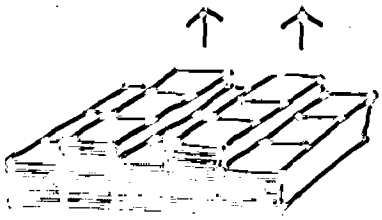
The expected movement of production helps to determine the sequence, flow and assembly line pattern of the industry. It also establishes the link between the receiving stores and finished stores. Ref. Figure No.10 and Figure No.11.

FIGURE NO

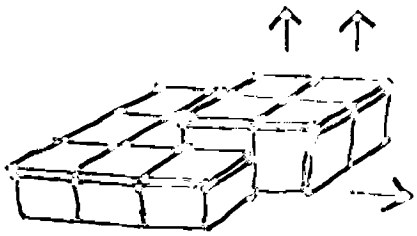
" CONCEPT OF FLEXIBILITY & MULTIPLICITY OF INDUSTRIAL BUILDING :"



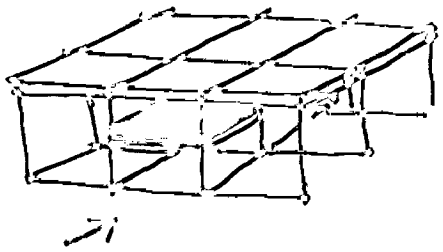
DIRECTIONAL EXTENSION.



VARIATION IN HEIGHT.



DIRECTION & HEIGHT VARITION.



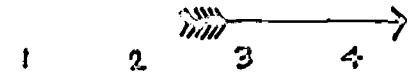
INSERTION OF MEZZANINE.

* SOURCE * PP 70, OSNDE OSWALD N. " INDUSTRIAL BUILDINGS & FACTORIES " THE ARCHITECTURAL PRESS, LONDON. 1971.

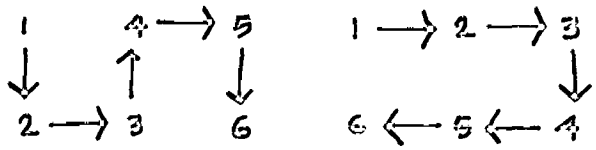
FIGURE NO 10

" TYPES OF GENERAL FLOW WITHIN A PLANT "

FIVE BASIC FLOW PATTERNS :

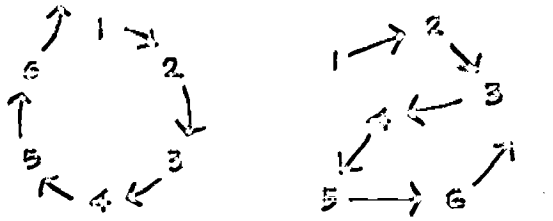


STRAIGHT LINE FLOW.



SERPENTINE FLOW

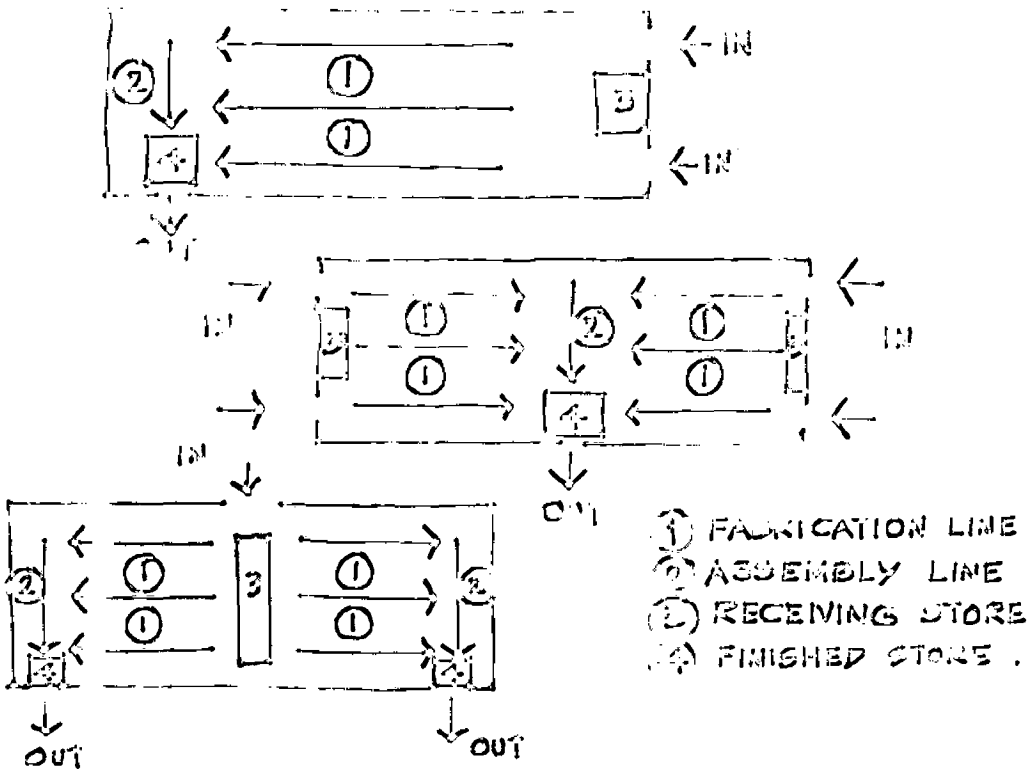
U-SHAPED FLOW



CIRCULAR FLOW

ODD-ANGLE FLOW.

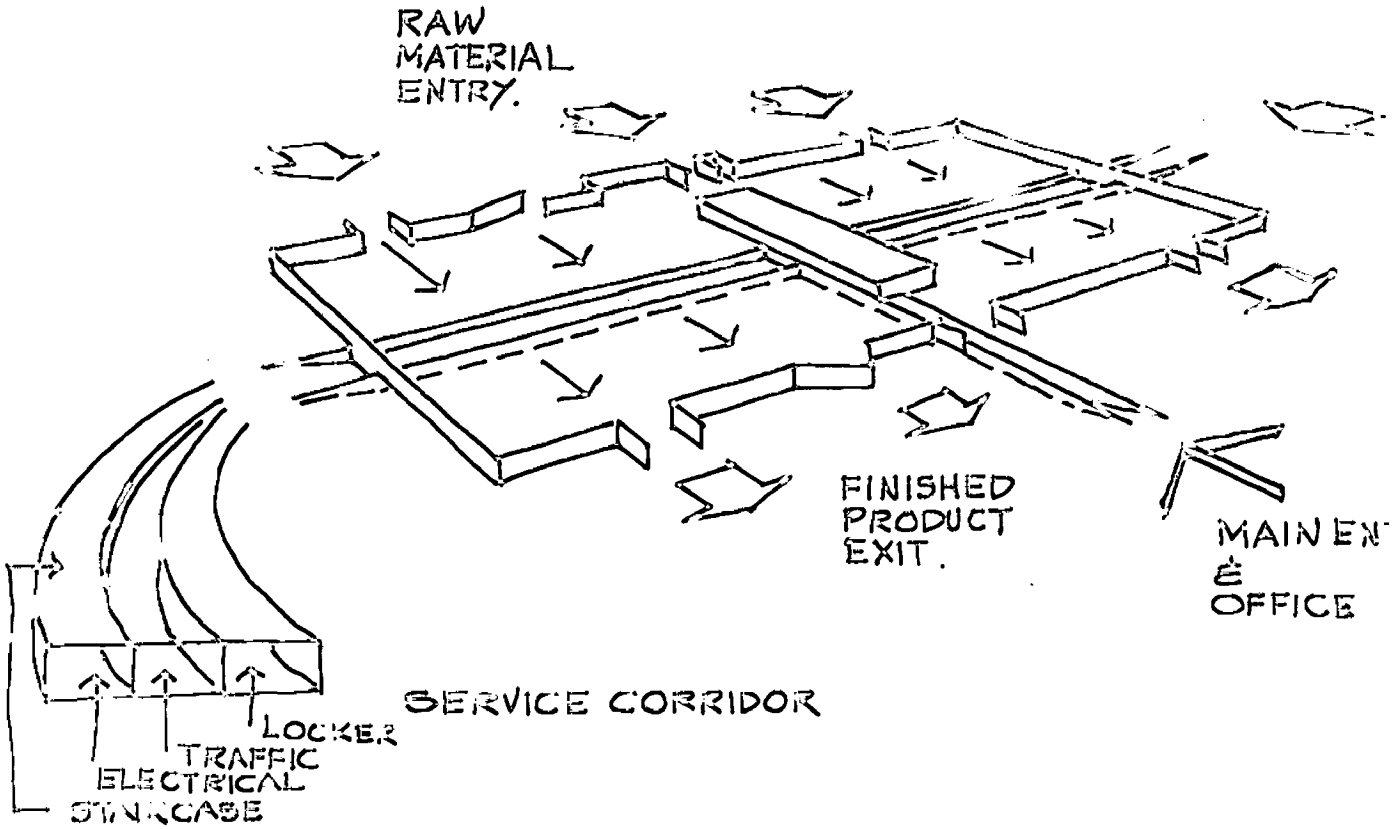
* SOURCE : PP 195, MUTHER R., " PRACTICAL PLANT LAYOUT " McGRAW-HILL BOOK CO INC. NEWYORK, 1955.



* SOURCE : PP 134, FIG. B-21, SHUBIN & MADENUM, " PLANT LAYOUT DEVELOPING & IMPROVING MANUFACTURING PLANT " PRENTICE -HALL OF INDIA (P) LTD. NEW DELHI, 1963.

S.V.S 1977

FIGURE Nº :



" INDUSTRIAL BUILDING CONCEPT "

SERVICE CORRIDOR IS THROUGH THE CENTRE OF THE PLANT ALLOWS TRAFFIC WAY FOR MANY SERVICES. IS UNDER MAIN FLOOR LEVEL. IT THUS CROSS LINES OF MATERIAL FLOW WITHOUT DIFFICULTY. OFFICES SUPPORTING PRODUCTION OPERATIONS ARE LOCATED ABOVE THE PRODU-CTION FLOOR, AND YET ARE CONVENIENT TO BOTH PRODUCTION AREAS AND MAIN ENTRANCE FOR PERSONNEL.

* SOURCE : PP 94, FIG. 3-1.

MUTHER, RICHARD., "PRACTICAL PLANT LAYOUT"; McGRAW HILL BOOK COMPANY, INC. NEW YORK, 1955

5.2.3 The problems of production capacities are better studied by production engineer, hence having frank and free discussion may help in providing solution.

Ref. Figure No. 12

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 industries are large single floor construction with suitable roof and bay arrangements. The most common envelope sections are given in the figure No. 14 and 15 for reference. 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.

. The provision of protective skin to auxiliary process structures is equally important for achieving overall effect of factory.

. The concept of industrial building may be checked, during the planning stage, by expert to ascertain its function and utility.

. The site's 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 function demands other shape. It serves 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. The area is worked on 'Work Centre' theory[20].

Ref. Figure No.13

In the process of overall space assessment consider the physical dimensions, circulation space, operational space, maintenance and executional space. The layout of machine prepared by mechanical engineer may be a useful guide. This further leads to production bay dimensions and finally the column spacings. The height of the structure is governed by the type of product and type of overhead installation. (Ref. Table No.5.2) where the clear height is 100 to 150%

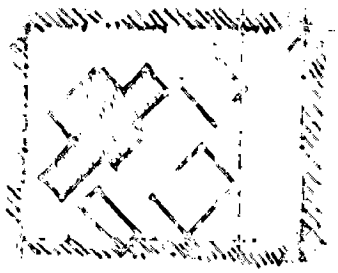
20. Grant, I.W., and Grant, E.L., 'Hand Book of Industrial Engineering and Management', Prentice-Hall of India (P) Ltd., 1969, pp.582,583.

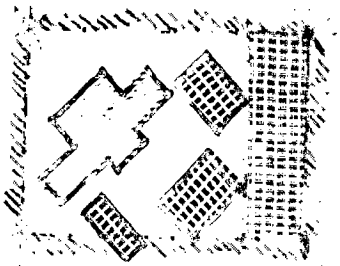
"SYMBOLS OF PROCESS CHART ACTIVITIES"

SYMBOL	DEFINITION OF EVENT	RESULT
OPERATION 	AN OPERATION OCCURS WHEN AN OBJECT IS INTENTIONALLY CHANGED IN ANY OF ITS PHYSICAL OR CHEMICAL CHARACTERISTICS, IS ASSEMBLED OR DISASSEMBLED, OR IS ARRENGED OR PREPARED FOR ANOTHER OPERATION, TRANSPORTATION, INSPECTION, OR STORAGE, OR WHEN INFORMATION IS GIVEN OR RECEIVED OR CALCULATING TAKES PLACE.	PRODUCES OR ACCOMPLISHES
TRANSPORTATION 	TRANSPORTATION OCCURS WHEN AN OBJECT IS MOVED FROM ONE PLACE TO ANOTHER (WHEN MOVEMENT DUE TO OPERATION IS NEGLECTED)	MOVES
INSPECTION 	AN INSPECTION OCCURS WHEN AN OBJECT IS EXAMINED FOR IDENTIFICATION OR IS VERIFIED FOR QUALITY OR QUANTITY IN ANY OF ITS CHARACTERISTICS.	VERIFIES
DELAY 	A DELAY OCCURS TO AN OBJECT WHEN CONDITIONS DO NOT PERMIT OR REQUIRE IMMEDIATE PERFORMANCE OF THE NEXT PLANNED ACTION.	INTERFERES
STORAGE 	A STORAGE OCCURS WHEN AN OBJECT IS KEPT AND PROTECTED AGAINST UNAUTHORIZED REMOVAL.	KEEPS
COMBINED ACTIVITY. 	WHEN ACTIVITIES ARE PERFORMED EITHER CONCURRENTLY OR BY THE SAME OPERATOR AT SAME PLACE (IT INCLUDES OPERATION & INSPECTION.)	

* SOURCE : PP 326, MUTHER R., "PRACTICAL PLANT LAYOUT", McGRAW-HILL BOOK CO. INC. NEW YORK, 1955.

"WORK CENTER CONCEPT:
A GUIDE LINE FOR AISLE WIDTH:"

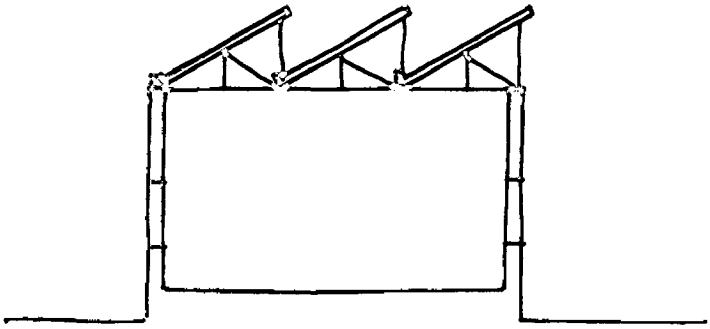




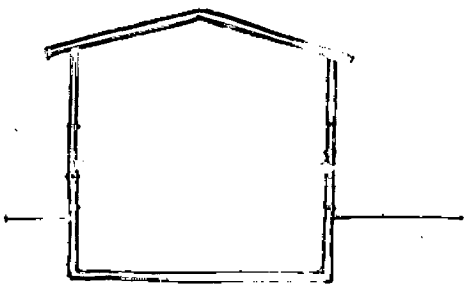
SOURCE: [illegible]

FIGURE NO. 4

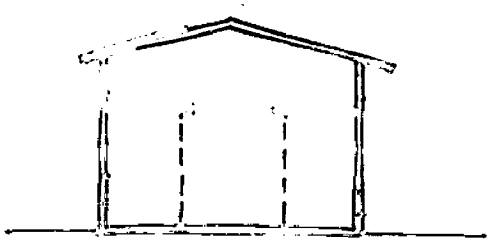
"INDUSTRIAL BUILDING TYPE AS PER FLOORS."



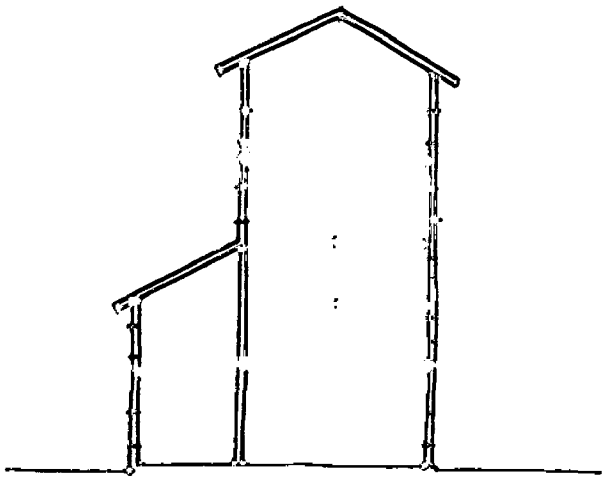
SINGLE STOREY



BASEMENT



BALCONY



MULTI STOREY

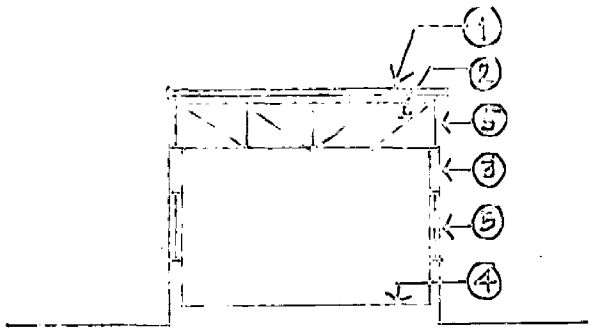
* SOURCE : 1) PP 593, IRESON W.G & GRANT E.L., "HAND BOOK OF INDUSTRIAL ENGINEERING & MANAGEMENT" PRENTICE-HALL OF INDIA (P) LTD. NEW DELHI. 1969

2) PP 112, MUTHER R., "PRACTICAL PLANT LAYOUT" McGROW-HILL BOOK CO. INC. NEWYORK. 1955.

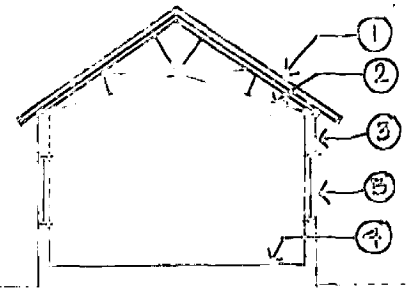
S.V.S. 1977

" STANDARD TYPE OF INDUSTRIAL BUILDINGS : "

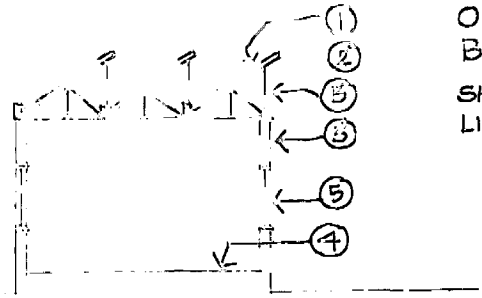
SHOWING POSSIBLE NATURAL LIGHTING ARRANGEMENT.



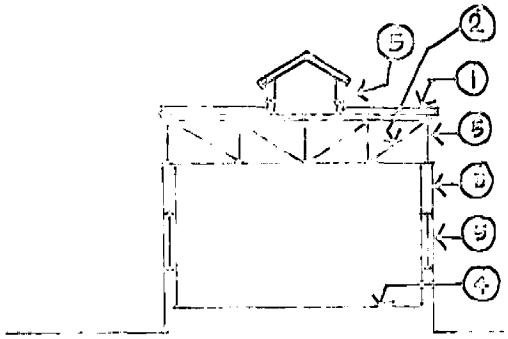
FLAT ROOF



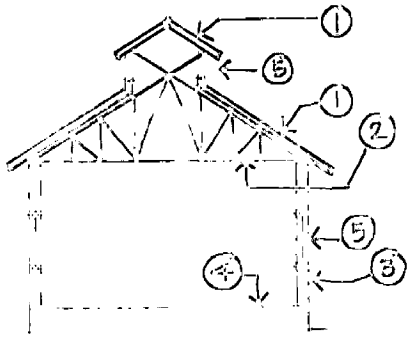
GABLE OR TRUSS ROOF



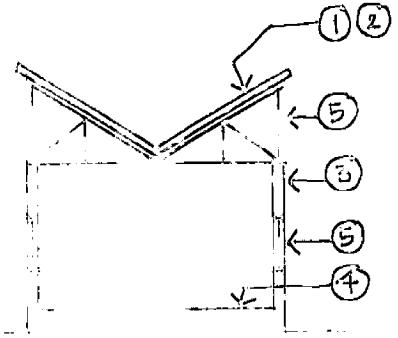
SAW TOOTH ROOF (NORTH LIGHT)



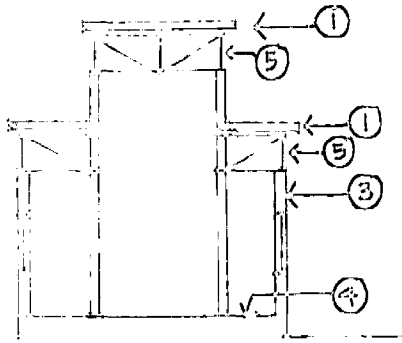
FLAT WITH MONITOR ROOF



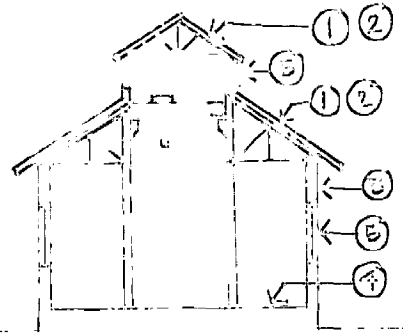
GABLE WITH MONITOR ROOF



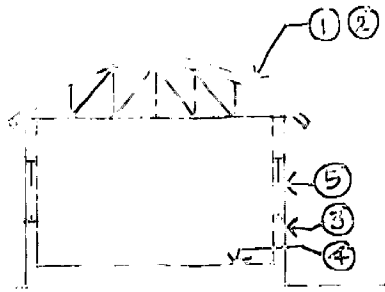
VALLEY ROOF.



HIGH BAY FLAT ROOF



HIGH BAY MILL ROOF



BOWSTRING ROOF

KEY :

(1) ROOFING
(2) TRUSS
(3) WALLING
(4) FLOORING
(5) GLAZING

* SOURCE * (ADAPTED)

PP 565, W.C. HUDSON & E.L. GRANT " HANDBOOK OF INDUSTRIAL ENGINEERING & MANAGEMENT " PRENTICE-HALL OF INDIA (P) LTD., NEW DELHI. 1969.

of the height of product. When the overhead installation are not required then the clear height may be 75% of maximum height of product.

Table No.5.2 Ceiling Height

Type of production	Without overhead installation	With overhead installation
1. Small product assembly on benches, offices	3.0 to 4.2m	3.5 to 6.0 m
2. Large-product assembly on floor or floor fixture	maximum height of product +75%	maximum height of product +125%.
3. Small product forming	height of machine + 100%	Height of machine + 150%
4. Large product forming	Height of machine + 125%	Height of machine + 125%

Source: Mather, R., 'Practical Plant Layout', McGraw Hill Co. Inc. New York, 1955, Table 9.1, pp.115.

. Column Spacing is determined by the space and area requirement and load carrying capacity, flow of product or material, height and services required to assist the production. The most common grid for industrial building is about 15m15m but in cases it may be higher upto 20 or 25 m.

easily. The height of roof column and a combined column carrying roof and gantry may be important aspect of structural design.

. The structural system is the final outcome of industrial process, production lines, resistance temperature differences, resistance to chemicals used in industrial processes, free span bays, services and catwalks. The system so selected be sound in construction, functionally suitable and aesthetically pleasing.

The structural system need not be a hurdle for any vital fitting and finture of equipment used during the process. It may have easy directional extension, variation in height, directional and variation both and incertion possibility.

Ref. Figure No. 9.

. Roofing in industrial building is meant to protect production line, from sun, wind, rain, to keep off dust and dirt, or any such artificial factor. 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 serve 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

loosing its protective quality.

Ref.Fig.No.14 and No.15 for various types of industrial building and roof types.

. Cladding is the outermost 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 with outside. It may be a light industrial cladding of A.C. sheet or G.I. sheets or with partly wall and partly cladding as per the process requirement.

. Flooring of industrial building is important only because of its size and loading factor. It should be levelled, non-skid, uniform and better resistance to wear and tear. Therefore, heavy duty, granolithic floor with hardener is recommended in production areas. The office area may have a mossaic or terrazzo flooring. In case of laboratory the acid resistance flooring may be recommended. The common constructional details are associated with flooring such as railway track in floor, machine foundation, service

pit, ducts, etc.

The design of envelope is the major field of architects contribution in industrial design.

5.3.2 Planning of Infrastructure

The physical planning elements are incomplete without assessment of auxiliary infrastructures. According to the process, mechanical and industrial engineer may help in determining such requirements. After that architect has to treat them individually and place them in layout keeping its noisy, or obnirious , or humid character in mind. This will give the correct industrial building concept for an architect to provide solution.Ref. figure No.11. There may be various types of stores and storage spaces for different material, chemical and oils according to codes. The engineering building, laboratory and administrative building are also the auxilliary infrastructure of the factory.

5.3.3 Welfare Infracture are those which forms part of the factory but provides comforts and facilities to worker during rest period. They are like canteens, tea shop, club, and welfare buildings.

The provision of parking arrangement, drinking fountains, lavatories, changing rooms etc. are also welfare facilities. Provision of housing, medical facilities, and other services conducive to life of community may be listed in welfare infrastructure.

Ref. Appendix 8.4.

5.3.4 Transport infrastructure

Transport infrastructure has a vital role in any industry. It may be land, water or air transportation, o-ut of which road and rail are most common. The technical guidance from transport engineer is necessary.

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

5.3.5 Protection

Protection of property and personnel is equally important from planning aspect. 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, gassing etc. Provision of proper flooring, staircases, ramps and railing are also factors of personnel protection to be provided in planning. Ref.Fig.No.16. Provision of lockers, changing rooms, wash rooms, first aid and medical facilities are equally important. The providing ear pluge, welders' shield, masks, shoes, gloves, etc. are also management provision for personnel safety.

5.3.6 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 so problem of providing better working condition becomes more serious.

Provision of adequate lighting at proper places with suitable luminance ratio is most important. Ref.Fig. No.17 and No.18. Wherever natural lighting is inadequate provision of local light or aritifidal light is necessary.

Ventilation is still a major problem in design of

industrial building due to various processes demanding more fresh air supply. There is little work carried out in this field hence, some headway is achieved through comfortable effective temperature nomograms.

Sound, unwanted noise is a unavoidable in industries. Hence, best way is to keep enough separation between building. Ref. Figure No.19. It could be reduced by i) planning solutions as well as by ii) construction solutions.

Pollution and industrial waste are serious problems and are to be solved in a team work.

General methodology for above factors is given in the next chapter.

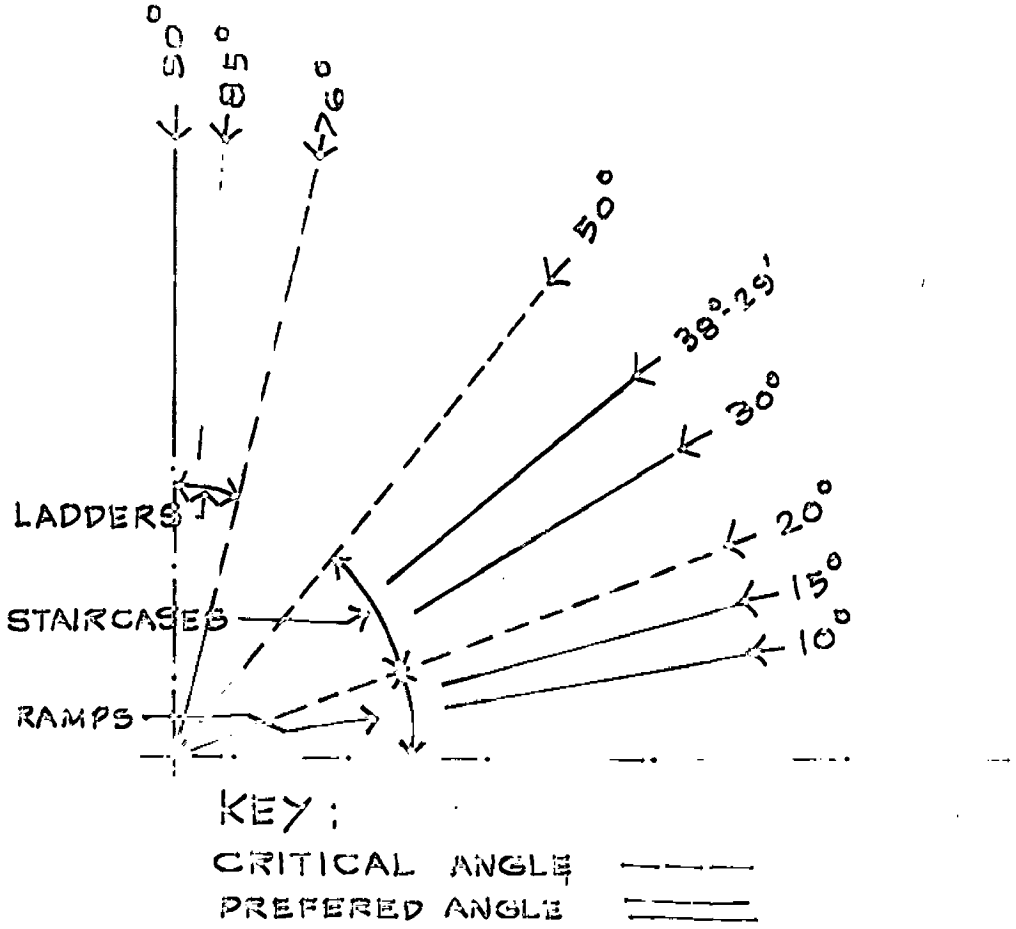
5.4. ILLUSTRATIVE EXAMPLE

In order to illustrate the finding of this dissertation author has selected BHEL's Heavy Electrical Equipment Plant, Hardwar. In general heavy electrical industry is a new concept given to Indian Industrial Development. It is encouraged to achieve to certain extent pollution free industrial growth.

As early as in 1955-56 mother unit of heavy electrical industries has started taking shape at Bhopal as a Govt. of India undertaking in Public Sector. The industry being a

FIGURE NO 1

REFERED SLOPES
OR STAIRCASE,
AMP & LADDER.



NO: STAIRCASE :

SUM OF TREAD & RISER OF STAIRCASE BE EQUAL TO ·45 M.
PREFERED ANGLE IS ACHIEVED BY ·25 TREAD & ·20 RISE.

LADDER :

MINIMUM WIDTH OF FIXED LADDER ·41 M.
SPACING OF RUNG MIN. ·30 M, MAX ·50 M.

HAND RAIL :

HORIZONTAL RAILING HEIGHT 1·00 M. } DIVID' WITH EQ.
STAIRCASE RAILING HEIGHT 0·75 M. } PARTS.

VERTICAL SUPPORT FOR HORIZONTAL RAILING @ 2·40 M. MAX.
VERTICAL SUPPORT FOR STAIRCASE RAILING @ 0·60 TO 1·80 MAX

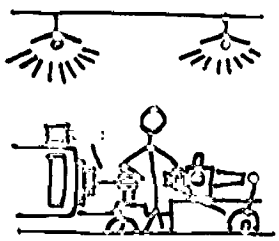
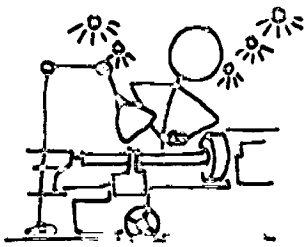
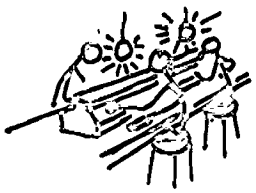
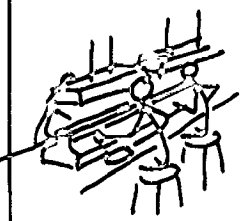
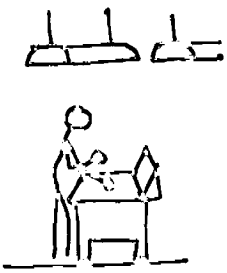
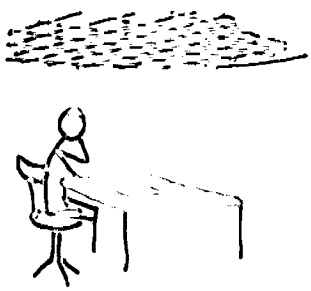
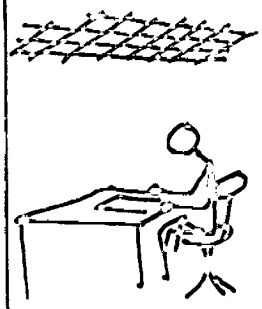
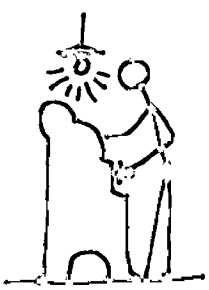
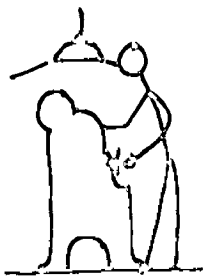
TOE GUARD :

PROVIDE TOE BOARD OR TOE GUARD WHEN HEIGHT OF STAIRCASE OR WALKWAY IS 1·80 M HIGH OR ABOVE.

---

* SOURCE * PP 726-727, IV·10 W.G. EREDON & E.L. GRANT, "HAND BOOK OF INDUSTRIAL ENGINEERING & MANAGEMENT" PRENTICE-HALL OF INDIA (P) LTD. NEW DELHI · 1969.

"QUALITIES OF ARTIFICAL LIGHTING"

PROBLEM		SOLUTION.
	**DIRECTION :** DIRECTION OF LIGHT IS DOWNWARD. PROVIDE SUPPLEMENTRY LIGHT AT LOCAL-IZED AREAS. DIRECT IT AT WORK & ADJUST AS PER FLATNESS OR RELIEF.	
	**DIFFUSION :** DIFFUSION IS NEEDED BECAUSE TOO MUCH LIGHT AT WRONG PLACE AND MAY INTERFERE VISION. IT COMES FROM LARGE WELL-SHADED LIGHT-ING UNITS, INDIRECT LIGHTING, FROSTING OR DIFFUSING GRIDS.	
	**SHADOWS :** IT HIDE DETAILS, CAUSE EYESTRAIN, AND CREATE ERRORS AND HAZARDS. REDUCE SHADOWS BY RELOCATION OF LAMPS, USE MORE LIGHT & AUXILIARY REFLECTING SURFACES OR REMOVAL OF INTERFERING MATERIALS.	
	**STRONG CONTRAST :** TO AVOID EYE FATIGUE REDUCE THE BRIGHT & DARK CONTRAST BY GREATER EVENNESS OF LIGHT. MAKE SURROUNDING AREA LIGHTER. COAT OF PAINT CAN DO WONDERS.	
	**GLARE :** IT IS LIGHT OUT OF PLACE. IT CAN COME DIRECTLY FROM EXPOSED & OVER BRIGHT LIGHT. IT CAN BE REFLECTED FROM POLISHED OR LONG BRIGHT SURFACES. GLARE IS CORRE-CTED BY DIFFUSION, SHADING OR CHANGING.	

* SOURCE : PP, 96 ; FIG. B-2.

MUTHER, RICHARD, "PRACTICAL PLANT LAYOUT", McGRAW HILL BOOK CO. INC.

'tailor made'* type and heavy in nature it is spread all over country. Thus establishing additional plants at Hardwar, Hydorabad and Tiruchirapally. Each unit is a self-contained unit contributing different specialised electrical equipments, required for generation and distribution of electrical energy.

This being a project of national policy, having designed for producing 'tailor made' equipments needs highly specialised skilled hands along with other types of skills normally needed for an ~~M~~ industrial organisation. The factory is planned to work in three shift with additional general shift. In order to provide autonomous character it is invisaged in the policy to have all the essential and auxilliary services of their own. Therefore these are ~~from~~ factory area, training school area, and township basically.

The factory area is to have its own thermal power plant and other auxilliary forging shop which is to use combustion process predominantly. Therefore, the area and trend of dispersion is to be reserved as protection belt or unsuitable area for any habitable area for any habitable development.

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* As per customers's specifications.

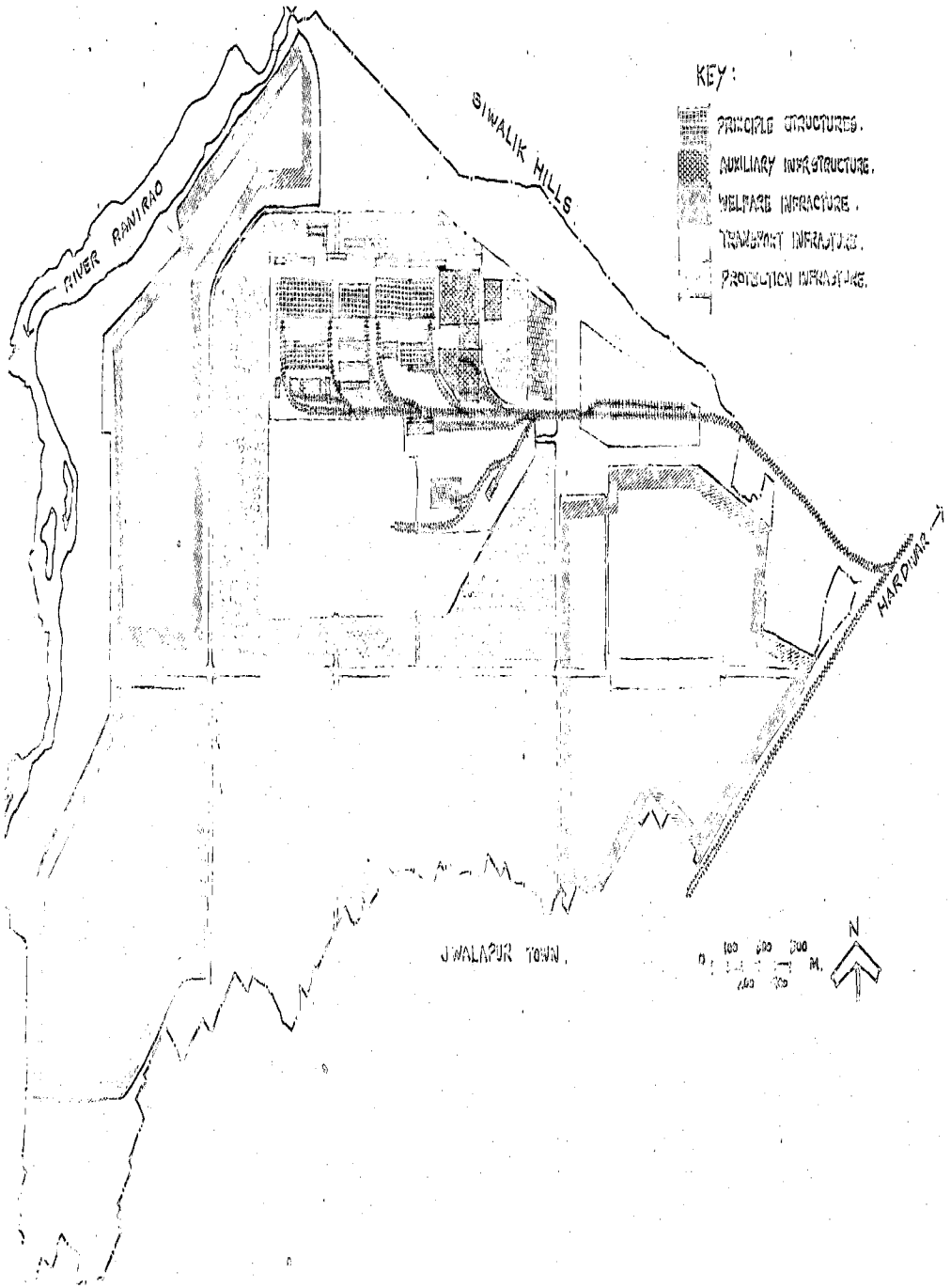
Based on the above policies the planning of the entire factory and township is shown in the figure No.20.

The site is large triangular piece of land in between Shivalik hills on north, Roorkee-Hardwar broad gauge, section of N-Rly on south, Hardwar town on east and river Rani Rao to its west. The site is having gentle slope from North to South of South west, having large flat area in the centre extending east-west.

As per the problem factory needs large level shop area with easy surface movement of heavy material. This central flat area is reserved for factory building only after due conformation of bearing capacity, water table and geological formation. This has the additional advantages of natural lighting, available from the north to most of shops, and railway link starting from Hardwar junction in the east west direction. The topography is not a hinderance to road alignment but to certain extend to railway track.

The production process is classified under three heads, i) Production structures, ii) Auxilliary infrastructures and iii) Welfare structures mainly.

The project is planned at single stage with provision



SPACE STUCTURE OF BHEL FACTORY AT RANIPUR HARDWAR.

ENVELOPE.	PRODUCTION STRUCTURE.	AUXILIARY INFRASTRUCTURE	WELFARE.	TRANSPORT.	PROTECTION.
◦ FUNCTION : DESIGN & MANUFACTURE OF TAILOR MADE PRODUCT. ◦ FLOW : COORDINATION OF PRODUCTION FABRICATION & SUPPORTING ASSEMBLY. ◦ SITE : LEVELED SITE. ◦ SHAPE : RECTANGULAR. ◦ SIZE, AREA : AS PER PHYSICAL DIMENSION. ◦ HEIGHT : KOP MACHINE + 150 %. ◦ COLUMN SPACING : 20 m x 25 m SPAN. ◦ STRUCTURAL SYSTEM : COLUMNS WITH GRID. ◦ ROOFING : STEEL TRUSSES WITH NORTH LIGHTING. ◦ CLADDING : STEEL FRAME WITH A.C. SHEET.	◦ ELECTRICAL MACHINE BLOCK. ◦ STEEL STRUCTURE DEPT. ◦ TURBINE & AUXILIARY DEPT. BLOCK. ◦ APPARATUS WINDING & INSULATION BLOCK. ◦ STEEL FORGE BLOCK. ◦ STAMPING SHOP. ◦ STEEL CASTING YARD.	◦ WOOD WORKING & PATTERNS SHOP & STORE. ◦ CENTRAL PLANT LABORATORY. ◦ TURBINE LABORATORY. ◦ CENTRE SUB-STATION. ◦ REFRIGERATING PLANT. ◦ OXYGEN PLANT. ◦ ACETYLENE PLANT ◦ THERMAL POWER STATION. ◦ CONTROL BOARD & SWITCH-GEAR ROOMS. ◦ COAL HANDLING PLANT. ◦ PRODUCER GAS PLANT. ◦ FABRICATION YARD. ◦ WATER/OIL PUMP HOUSE. ◦ CASTING YARD. ◦ WATER/OIL RESERVOIR. ◦ OIL & CHEMICAL STORE. ◦ CALCIUM CARBID STORE. ◦ COOLING TOWERS. ◦ WATER PURIFICATION PLANT. ◦ ASH PIT. ◦ WELL SINKS.	◦ ADMINISTRATIVE & WELFARE BLOCK. ◦ ENGINEERING BUILDING. ◦ CANTEENS. ◦ CYCLE STANDS. ◦ SCOOTER PARKING. ◦ CAR PARKING. ◦ FIRE STATION. ◦ MAIN GATE. ◦ CRECHE ROOMS. ◦ TOILETS. ◦ [illegible] OIL TANK. ◦ COLONY & INFRASTRUCTURE. ◦ BANK & POSTAL. ◦ POST OFFICE. ◦ BANK. ◦ UNION OFFICE.	◦ GOODS STORE. ◦ DIESEL- LOCO SHED. ◦ GARAGES ◦ TRANSPORT OFFICE. ◦ RAILWAY TRACK. ◦ ROADS. ◦ SERVICES DISTRIBUTION. ◦ CENTRAL PUMP. ◦ WEIGH BRIDGE. ◦ REFUELLING STATION.	◦ MAIN GATE & TIME OFFICE. ◦ CONTROL POST. ◦ WATCH TOWER BOOTH. ◦ COMPOUND WALL. ◦ LEVEL CROSSING. ◦ FIRST AID POST. ◦ MEDICAL FACILITY. ◦ PERSONNEL PROTECTION DEPT

of independent project in the second phase.

The sequence is achieved by identifying blocks or shops for specific function like, Electrical machine block, steel structure department, turbine and auxilliary department block, apparatus winding and insulation block, steel forge block, stamping shop and wood working and pattern shop mainly. All these blocks are performing major functions and sequence in the production process.

The thermal power plant, oxygen and acetylene plant, refrigerating plant, producer gas plant, water purification plant and fabrication yard forms major auxilliary infrastructures of the production layout. In addition to this Plant laboratories, Turbine Laboratory, Sub-station, Pump houses for oil and water, cooling towers, settling tanks, ash pit various type of stores and store yards are also essentially infrastructures.

The administrative and welfare buildings, engineering buildings, canteens, parking areas, toilets and lockers, medical facilities, housing with its infrastructures, commercial services etc are major welfare requirements of the industry.

Handling of heavy materials with railway connections

needs some of its auxilliary structures like marshling yard, loco shed, track and switch points, way bridges and control office etc. under transport facilities.

Under the protection and security compounds wall with main and secondary gates, time office, security facilities, first aid and personnel protection department and fire protection mainly for better f care of property and personnels.

The sequence of production is from the wood working , steel forge and the stamping blocks as per requirements of the component. They are served with effective r-ail and road links. The half made heavy components are moved to steel structure department or electrical machine block or turbine block with the help of central bay of gantry linking and serving the entire production areas.

The column spacing which is between 20 m to 24 m. suitable for the moving gantry equipments. This allows most of the movement of products in parallel assembly lines.

The shape of product are circular but of extra ordinary size and shape hence they are produced as smaller parts and components. This needs large levelled floor area. The approximate size of each block is given below for understanding.

Block 01,	Electrical machine block	= 121.50mx36.00m
Block 02,	Steel structure block	= 109.50x192.0 m
Block 03,	Turbine block	= 121.50mx372.0m
Block 04,	Apparatus winding and insulation block	= 72.0x288.50 m
Block 05,	Steel forge shop	= 48.0x87.0 m
	Insulation block	= 72.0x288.50 m.
Block 05,	Steel forge shop	= 48.0x87.0 m
Block 06,	Stamping shop	= 48.0x132.0 m
Block 07,	Wood working and pattern shop	= 48.0x200.0m

(Ref. table No.6.3 for space utilization)

Maximum flexibility in assembly flow is necessary in the first three blocks, and relatively less in the remaining blocks.

They are served with railway lines along the shorter dimensions and movement along longer direction is through assembly or production line.

Table No.6.3

SPACE UTILIZATION OF BHEL FACTORY

FACILITY	AREA m^2	%
1. Production area	153,038	10.19
2. Auxilliary infra-structure	179,381	11.94
3. Welfare infrastructure	77,600	5.17
4. Transport infrastructure	247,981	16.52
5. Green belt, ashpit and store yard.	843,500	5 6.18
	1501,500	100%
Hot walled factory area is (1+2+3+4)	658,000 m^2	43.82 %

NB: Areas calculated including green belt etc. only because there are important structures located outside walled factory area.

Source: Layout plan of factory area BHEL Hardwar drawing No. TPUP/R003/10 dated 27.1.1966

The shape of the each block is rectangular with bays of supporting columns of steel of various heights from 15m to 20m or more, in a square grid of 20.0 to 25.0m. The roofing is designed for natural north light trusses in saw tooth formation with rising bays for better lighting.

The cladding for lower part is in bricks where auxiliary areas are planned to have windows or otherwise finished with A.C. sheet cladding. The ~~lowered~~ cladding is provided to have better ventilation and movement of air. It also acts as sound absorbent.

Flooring is hard and levelled with track embaded for movement ~~for movement~~ of heavy components along n the production assembly line.

The other auxiliary facilities are located along the periphery so as to have proper coordination.

The welfare structures are placed at easy accessible locations according to the codes and regulations.

The efficient transport link is achieved between each production centre for man, material and services required for production.

The protection against property and life is provided as per requirement.

The separation distance between each production and auxiliary facilities is based on its generation of noise, and dust particles which governs its location.

The lighting in combination of natural and artificial on production areas are to be used in these shifts. Due to often extraordinary scale, of the factory block and site for the entire complex, the block, even being a window less, has created its own atmosphere. The workers do not feel 'Co-zapped' inside though they miss visual contact of outside environment. The effect of claustrophobia may be present in workers to certain extent for lack of natural environment.

So as to conclude the planning of this large engineering industry emerges from certain basic points as i) to site limitations, ii) transportation limitations, iii) wind direction and iv) inter relationship with work place to rest place and service facilities for social and cultural demands of the people.

The layout is purely functional but lack in rational use of topography, transportion and work place relationship. The township has practically divided in two parts and common town centre is yet to be developed.

CHAPTER VI

DESIGN METHODOLOGY

6.0.1. The scope of dissertation for planning elements in engineering industry is restricated only for the building factors and environmental factors. Therefore the detail discussion is given below only for the factors which control physical and occupational environment. Under this lighting, ventilation, sound are the factors responsible for creation of interior environment. The need of various intensities for lighting, ventilation and sound protection are different to perform different industrial processes. In the same way sound, pollution and treatment of industrial waste are the external environmental factors to be discussed in general.

6.0.2 The methodology of designing of these factors is given below. The objective of this section of the chapter is to give link between scientific principle and its practical application by architect to the problems of industries.

6.1.0 LIGHTING DESIGN METHODOLOGY.

6.1.1 Lighting affects internal working conditions due to various fenestrations provided in building envelope. 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.

6.1.2 The lighting design has two basic type of methodology, such as natural lighting and artifical 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 from objects thus light is prerequisite of seeing. Sun is the only natural source of light and is estimated to give about 1,00,000 lux. The sun light has wide range of wave length[1] but only a narrow range is perceived as light for our purposes. This wave length also determines its colour. The light containing all visible wave length is perceived as white. The human eye is more sensitive for wavelength of 550 nm 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.

6.1.3 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 1/60 cm^2 uniformly emitting black

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[1] 380 to 700 nm (nanometer).

body radiator at the melting point temperature of platimum. All other units are 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.[1] 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 where light source per unit area.

6.1.4 The eye responds to a range of illumination levels from 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 depends 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 exceeds the above ratio it may create glare. Ref. Fig. 17.

6.1.5 Hence the design of lighting must ensure light

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[1] As the surface of a sphere subtends at its centre 4π (12.56) units of solid angle, a 1 cd = 12.56 lumen in all directions.

which is both adequate and suitable for the visual task.

6.2.0 Lighting Methods.

6.2 There are three basic methods of designed lighting and each has advantages and disadvantages. They are 1) Day light Factor (DF). 2) Permanent supplementary artificial lighting (PSALI). 3) Permanent artificial lighting (PAL).

Design with Daylight Factor

The designed lighting in daylight factor is based on natural light available from 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 photometric 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 summission 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 from an unobstructed sky hemisphere is taken as

6000 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 specially in industries. It provides vision and maintain contact with the surrounding natural environment. It reduces the effect of claustrophobia[△] which may be present in the 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 which 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, length of the day, sky conditions and other natural disturbances.

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21. Refer. IS 2440, Indian Standard Code of Practice for daylighting of buildings.

△ Claustrophobia = constant fear of confined place.

It is practically impossible to provide adequate daylight in side lit rooms to a depth greater than three times the window head height (above the working plane). In most of the general purpose buildings the maximum depth of 6 m. 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 buildings and locations of windows are shown in the Fig. No. 15. The method of calculation of illumination through side-lit and roof-lit windows are given in section 6.4.0 of this dissertation.

6.2.2 Design with Permanent Supplementary Artificial Lighting:

This system of designed lighting is recommended when depth of areas 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 illumination. The method is discussed in section 6.5.0..

6.2.3. 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 which may develope claustrophobia among the occupants, as visual link between the surrounding is lost.

6.3.0 Fittings and Fixtures for Artificial Lighting

6.3.1 The most common types of electrical light fitting used for industrial lighting are incandescent lamps, flourescent lamps, mercury arc lamps and cold cathode lamps. Out of these the first two are commonly used. They emit alongwith light certain amount of heat also, which is a matter to be considered. If the overall economy is worked out for the above two 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[1] which may be a major cause for accidents in industries. The methodology for design is given in the section 6.6.0 of this dissertation.

The qualities of artificial lighting are expressed in the Fig. 15 in which the various elements such as

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[1] Stroboscopic effect = when any object moving at multipal speed of fluctuation the object

a) Direction, b) diffusion, c) shadows, d) contrast and e) glare are explained and provide practical hints for artificial lighting for industrial tasks.

6.4.0 Use of Lux Grid Chart for Side-lit Windows

6.4.1 There are different methods[22] 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.

6.4.2 The real need of an architect is satisfied by the method given as lux grid chart by C.B.R.I., Roorkee as "Design for Daylighting" special publication March 1972. This method is similar to the method of perspective projection method and provides reasonably accurate prediction of daylighting. It is very handy and does not involve complicated calculations and has a capacity to use as a tool for design and verification of the lighting.

6.4.3 The lux grid chart is a handy tool for design of side lit windows for a building having maximum depth of 6.00 m. and having the selected interior finishes and its reflectance factors. It consists of two charts and each

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22 Koenigsberger, Ingersoll, Mayhew, Szokolay, "Manual of Tropical Housing and Building", Part I, climate Design, Orient Longman Longman, New Delhi, 1973-Chapter 5.2.0, 5.3.0.

serves specific purpose. The lux grid chart I is used when there is no external obstruction. The second chart is used where there are obstruction present within the distance of 3 times the height of obstruction.

6.4.4 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.

6.4.5 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.

6.4.6 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 U P U (working plane) corresponds with the window elevation. The relative position from the reference point need to be adjusted along with the line P_H Y_H.

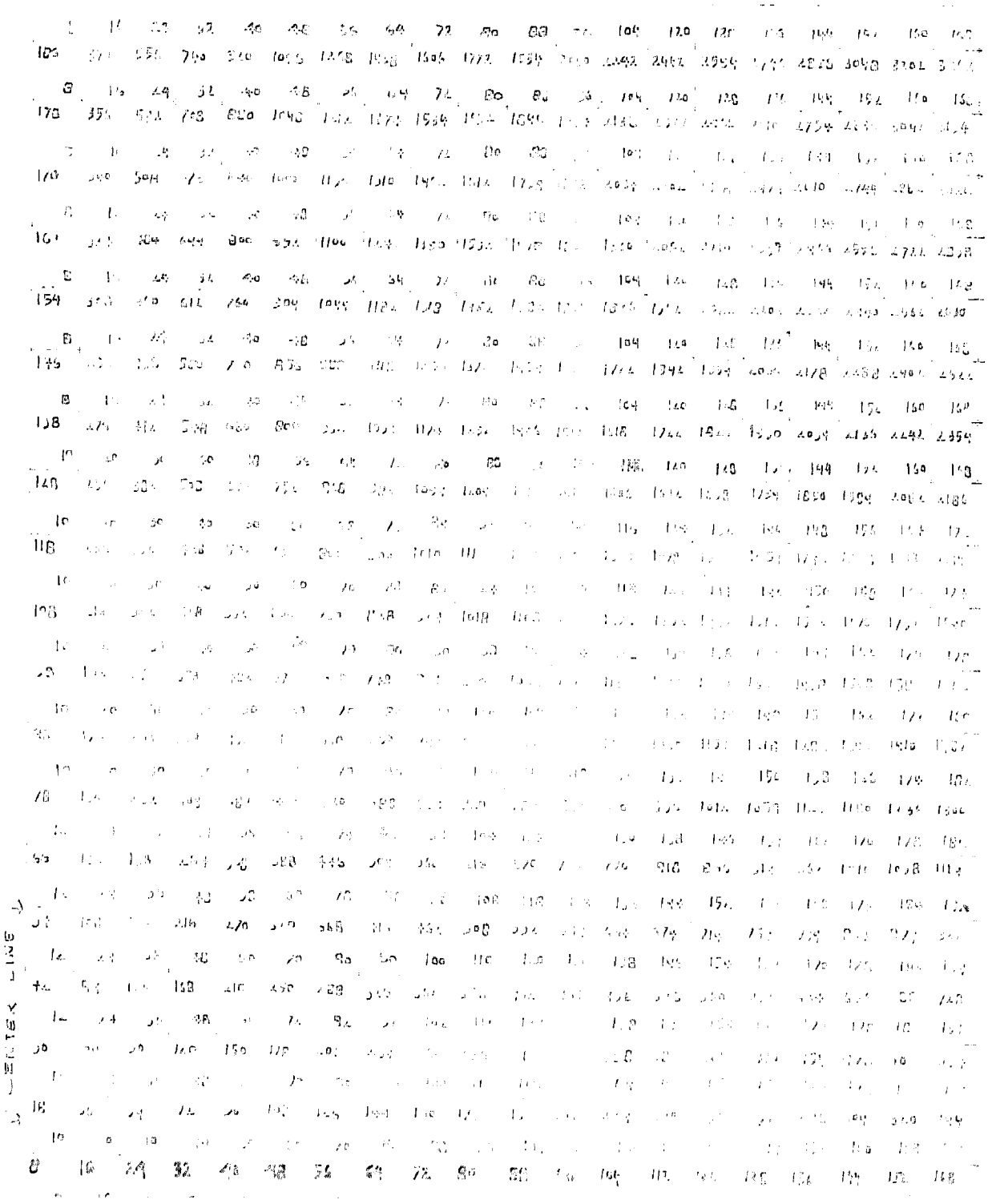
6.4.7 Under this position window elevation will give the maximum area possibily admiting light inside. In order to

got the illumination, 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.

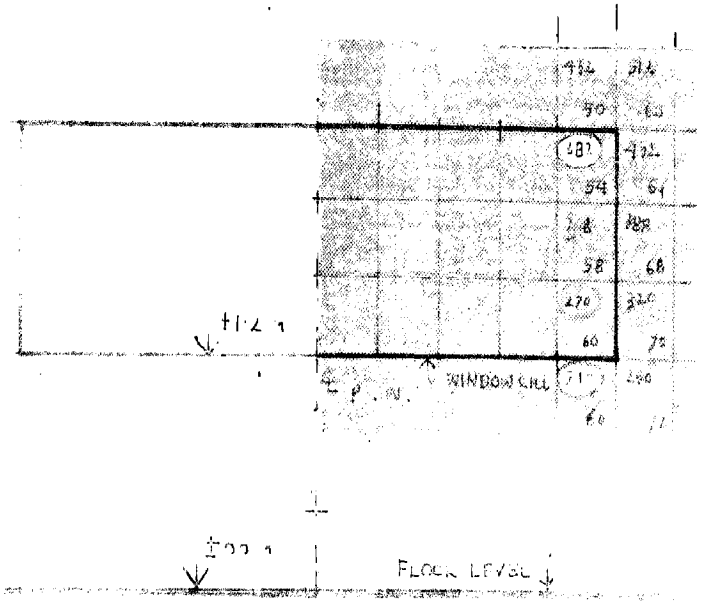
6.4.8 This value will be on higher side and so necessary reduction factors are to be applied to bring down to workable standard.

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

6.4.10 The method is very useful to architects because it is simple and more towards graphical than mathematical. It has only one drawback that counting of dots and stars on wall 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 simetrical from P Y line for 'X' axis and U P 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



HALF "LUX GRID CHART" FOR UNOBSTRUCTED OPENING.



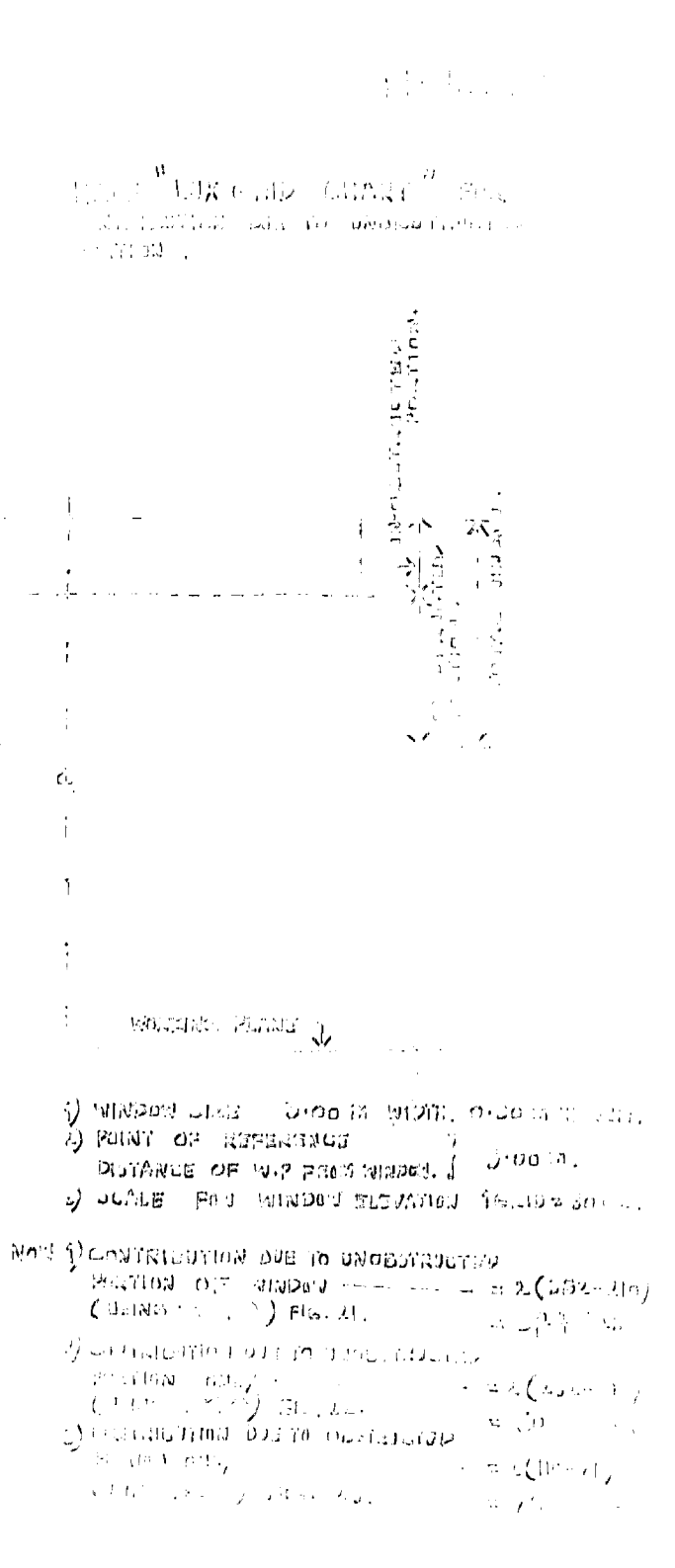
USE OF HALF LUX GRID CHART SHOWN :

LIGHT CONTRIBUTION IN LUX = [illegible]

= [illegible]

THIS CHART IS HALF OF TOTAL [illegible]

= [illegible]



of lux grid chart I on B.H.S.

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

6.5.0 METHOD FOR ROOF LIGHTING

6.5.1 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 7.4[23]

"Daylight factor at the centre 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	5.5	4.0	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) $DF = \frac{IN}{ID} \times 100$ ... (1)

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

23. Lecture Programme, "Functional Aspects of Building Design" C.B.R.I., Roorkee 26th, 28th April 1976., Table 7, pp.22.

6.6.0 Method for Supplementary Lighting

6.6.1 In case of supplementry artificial lighting design. It is assumed that good day lighting is available for 90% of the day time and only 10% a may have poor lighting conditions. The estimation of supplementry artificial lighting may be predicted as per the table given below:-

TABLE 7.5[24]

Number of 40 W. Fluorescent tubes recommended for artificial lighting

Floor area M^2	% Penetration		
	5%	10%	20%
25	3	2	2
50	6	5	4
100	9	8	6
150	13	10	9
200	16	14	11

The supplementry lighting fixtures are provided where in such work areas where day light is expected to be poor.

NB :- The recommended values of illumination to perform visual tasks in various industries are given in the code of lighting by Indian Standard Institute.

24 pp.12-23. Table 8, ibid, Lecture programme, "Functional Aspects of Building Design", C.B.R.I., Roorkee, 26 and 20th April, 1976, Table 8, pp.23.

6.7.0 Ventilation

6.7.1 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 ~~so~~ nothing is so far standarised. 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 provision of natural ventilation may be economical solution if more and more research is carried out in this field.

6.7.2 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 putforth the proposals for ammendments in the respective act. The only information available regarding ventilation in industrial buildings is given below in Table 7.6.

TABLE 7.6[25]

"Recommended minimum rates of fresh air supply to buildings for human habitation"

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

6.8.0 Design of Ventilation

6.8.1 The design for ventilation is dependent on supply of outside air in place of interior air which is vitiated due to used by man 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 carbondioxide 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 odours and maintain satisfactory thermal environment.

6.8.2 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 table

25- Table 2, NBC. Handbook for engineers, pp. XVIII-9.

available are for the mechanical ventilation and no scientific information so far is available for natural ventilation.

6.8.3 Design of Ventilation with Air Change

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

6.8.4 The system of ventilation can beardly be divided into two catogories, a) Foremotive or wind force and b) thermal or temperature force. They are very effective in case of ventilation of industrial buildings. In industrial building artificial generation of thermal force is also a matter of careful study and attention.

6.8.5 The scale and magnitude of ventilation problem in industrial building is different than the normal residential building. In industrial buildings appart from ventilation requirement 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 is 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.

6.8.6 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 of air flow.

6.8.7 The movement of air can be utilised as heat carrying medium and effective comfort conditions could be achieved by dispertion 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"[1] and given in the paychrometric charts.

6.8.8 In order to use this expression for achieving comfort ventilation in industries the two nomogram given in Fig. 24 and Fig. 25 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

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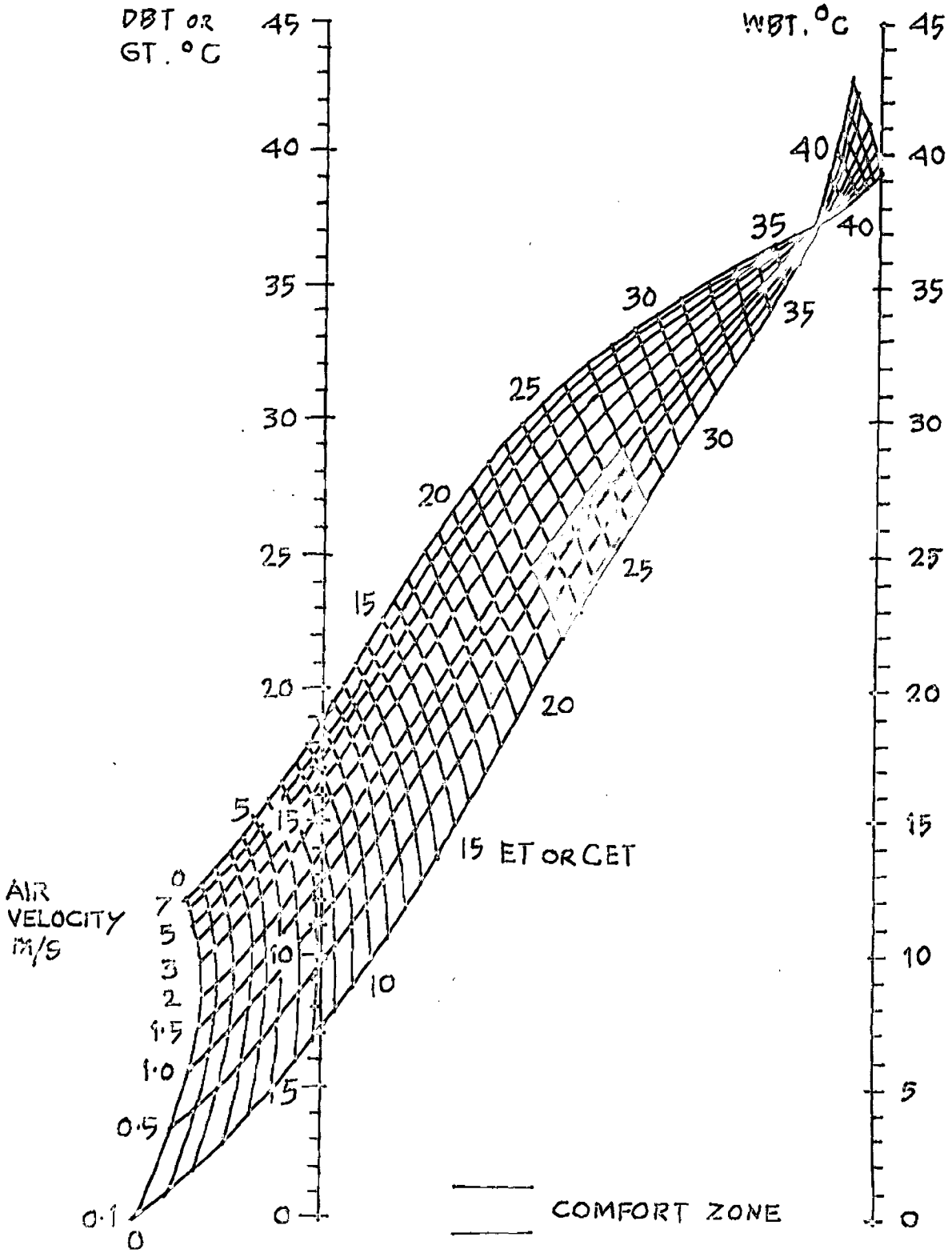
[1] Effective temperature is defined as the temperature of still, saturated atmospher, which would, in absence of rediation, produce the same effect as the atmosphere in question. It integrates three variables, [illegible]

" EFFECTIVE TEMPERATURE NOMOGRAM FOR PERSON WEARING NORMAL BUSSNESS CLOTHING ."



* SOURCE : PP 54, FIG. 30; KOENIGBERGE & ETC., MANUAL OF TROPICAL HOUSING & BUILDING," ORIENT LONGMAN, NEWDELHI. 1975.

range of the comfort zone is shown but is subjected to have variations. The Fig. 24 provides the effective temperature when person is wearing "normal bussiness clothing" and Fig. 25 is when a person is "stripped to the waist". These are the normal working style in various industrial processes.

6.8.9 Under the statutory control vide "Factory Act 1948" section 15 schedule of drybulb and wet bulb relationship is to be maintain. This regulation is taken as a mandatory the nomograms may be used to know air velocity by which effective temperature will be within comfort zone or within adaption range of comfort zone inside the industrial building. Once the required air velocity is established then it can easily be converted into area of opening by using following formula.

$$P_w = 0.612 \times V^2$$

Where, P_w = wind pressure in N/m^2.

V = wind velocity in m/s.

(Where N is the unit of force expressed as "newton" and constant as Ns^2/m^4.)

6.8.10 In general practice the wind speed and other characteristics are expressed in Beaufort scale therefore the table 7.7 given below, is computed for the

airvelocities used in the nomograms in term of wind force and Beaufort Scale and it symbol.

TABLE 7.7

Relationship of air velocity, wind force and Beaufort scale

Vel-ocity m/s	Force N/m^2	Beaufort	
		Number	Symbol
0.10 0.50	0.061 0.306	0	0
1.00 1.50 2.00	0.612 0.918 1.224	1	0
3.00 4.00 5.00	1.836 2.448 3.060	2	0
6.00 7.00	3.672 4.284	3	0

6.8.11 This will help in predicting the area required for admiting fresh air supply to maintain proper ventilation inside the industrial building.

The pre-requisite for this data is the meterological observations for the wind speed, direction and duration. This could be used for determining area for ventilation as per available wind speed.

6.9.0 Sound or Noise Engineering

Sound is the sensation caused by vibrating medium acting on ear, but it is applied to the vibration itself.

In general as the range of natural frequency increases the isolation or displacement reduces, and accordingly the resilient material is selected.

6.9.5 In some of the engineering industry where forcing frequency of machine creates noise the solution is achieved by proper designing of construction details. Under such circumstances "Inertia block" may be recommended with vibration isolations used below the blocks.

In case of large press, drop hammers which creates serious impact vibrations may be mounted rigidly on very massive block of concrete. The mass of the concrete be many times the weight of the supported machine. Such heavy foundations[27] are to be isolated from the building structure by large wooden blocks with thick cork pads in constructional details.

6.9.6 Architect should be careful in providing services, like pipes, shafts, conduits etc. to such machine needing heavy foundations by flexible joints. In absence of such detailing the machine would transmit noise through them and instead of reduction in noise it will contribute to it.

6.9.7 The noise reduction is possible by enclosing the source in the form of acoustic box. The design of such box be such that normal working and access areas are provided for operation. The encloser may be made of steel,

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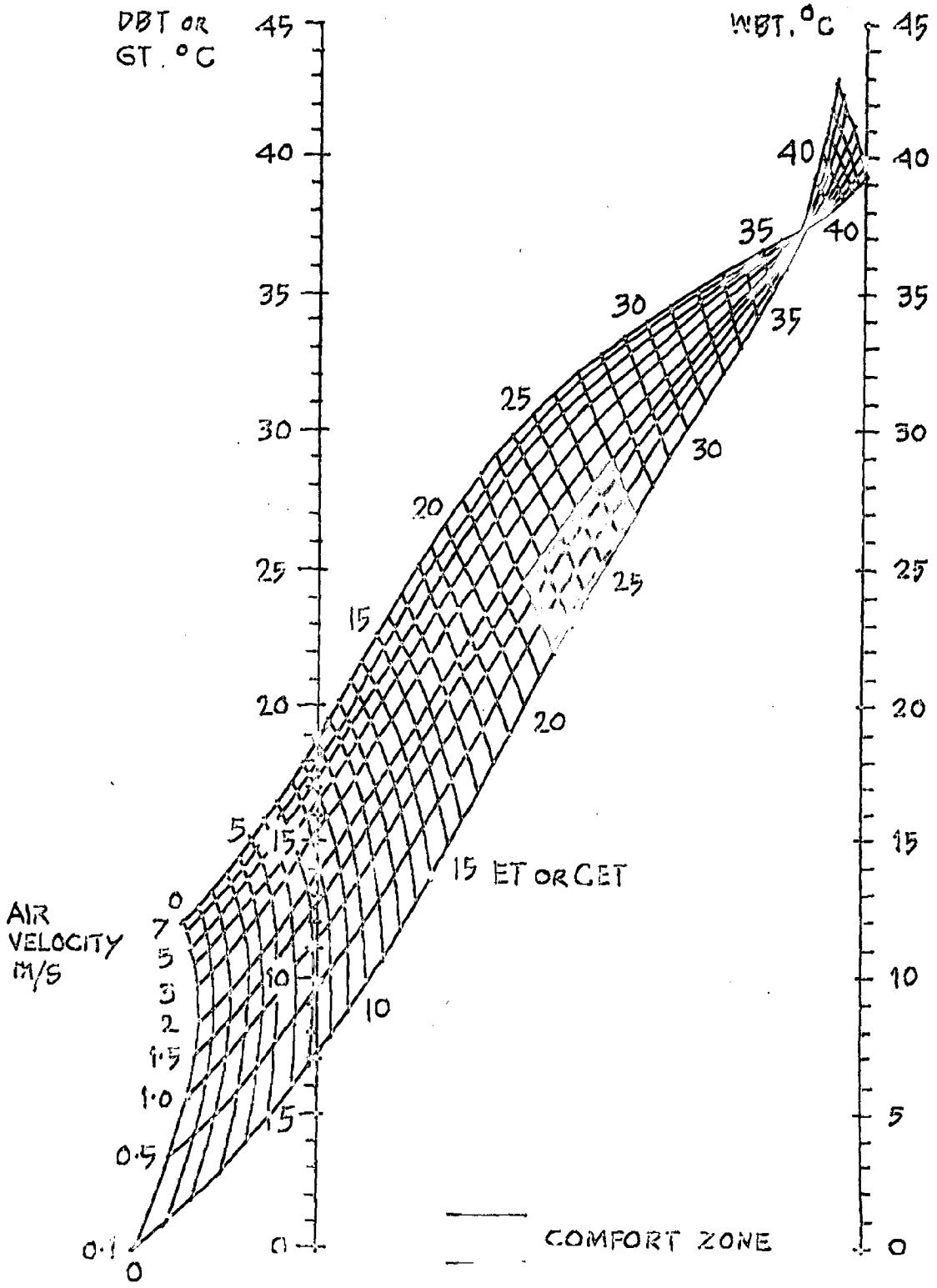
27- Section 9.4.3.5(b) 2, National Building Code 1971 pp VIII-16.

" EFFECTIVE TEMPERATURE NOMOGRAM FOR PERSON WEARING NORMAL BUSSNESS CLOTHING ."



* SOURCE : PP 54, FIG. 30; KOENIGBERGE & ETC., MANUAL OF TROPICAL HOUSING & BUILDING," ORIENT LONGMAN, NEW DELHI. 1975.

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The pre-requisite for this data is the meterological observations for the wind speed, direction and duration. This could be used for determining area for ventilation as per available wind speed.

6.9.0 Sound or Noise Engineering

Sound is the sensation caused by vibrating medium acting on ear, but it is applied to the vibration itself.

The vibration are transmitted through air, liquid and solid. The sound is scientifically expressed in terms of amptitude, velocity, frequency and wavelength. The wavelength and frequency determines the pitch of the sound and strength by amptitude. The intensity at the threshold of audibility gives the sound level scale or decibel (dB) scale.

6.9.1 Internal Sound Reduction

The sound, particularly in industries, is major source of problem and pollution. It is a common element as internal sound created due to the operations within the building and as a external element for neighbour.

6.9.2 The sound has two distinct subdivision one as wanted sound and other as unwanted sound. The unwanted sound, may be called as noise, has all polluting qualities and needs control methods. It is because of this one has to study the character and properties of unwanted sound and provide solution to reduce or eliminate the same.

6.9.3 There is no process in which sound is not generated and so noise is a serious problem specially in industries. It needs such solution which will take care of both internal and external noise.

6.9.4 The control of noise within the industrial envelope could be effectively achieved by reducing the noise at the

source. The machines used for various production processes creates noise and majorolity is transmitted through the foundation and mounting. If these details are worked out properly by using resilient material and vibration isolator the noise problem is reduced at source more efficiently. The selection of isolators and resilient material depends upon the nature of generating sound frequencies.

The following table 7.8 gives guide-line for for constructional details by which noise control could be achieved a the source.

TABLE 7.8[26]

Selection of constructional details to reduce noise at source

Nature of frequency c/s	Displacement in cm.	Nature of isolation	Material for isolation and the thickness.
1.50 to 3.00	2.50 to 14.00	Eliminating direct contact	Steel springs.
3.00 to 7.50	0.50 to 2.50	Isolation	15 cm thick rubber.
7.50 to 8.00	0.40 to 00.50	Resilient met surface	20 mm corks.
8.00 to 9.00	0.30 to 0.40		15 mm corks.
9.00 to11.00	0.20 to 0.30		11 mm corks.
11.00 to19.00	0.05 to 0.20		7 mm corks.
19.00 to30.00	0.03 to 0.05		2.5 mm felt.

26- National Building Code (adapted from fig. 3) PP VIII-15.

In general as the range of natural frequency increases the isolation or displacement reduces, and accordingly the resilient material is selected.

6.9.5 In some of the engineering industry where forcing frequency of machine creates noise the solution is achieved by proper designing of construction details. Under such circumstances "Inertia block" may be recommended with vibration isolations used below the blocks.

In case of large press, drop hammers which creates serious impact vibrations may be mounted rigidly on very massive block of concrete. The mass of the concrete be many times the weight of the supported machine. Such heavy foundations[27] are to be isolated from the building structure by large wooden blocks with thick cork pads in constructional details.

6.9.6 Architect should be careful in providing services, like pipes, shafts, conduits etc. to such machine needing heavy foundations by flexible joints. In absence of such detailing the machine would transmit noise through them and instead of reduction in noise it will contribute to it.

6.9.7 The noise reduction is possible by enclosing the source in the form of acoustic box. The design of such box be such that normal working and access areas are provided for operation. The encloser may be made of steel,

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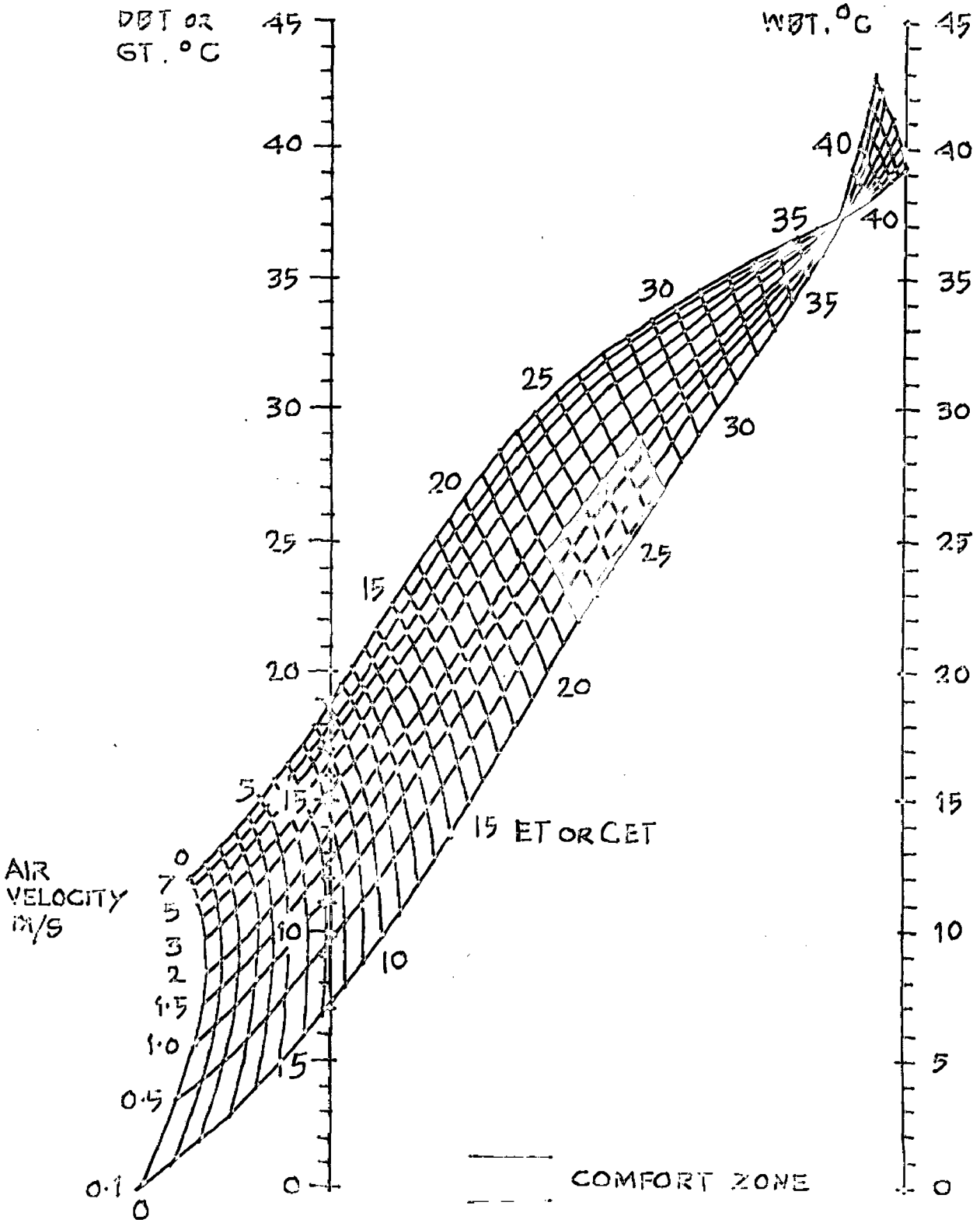
27- Section 9.4.3.5(b) 2, National Building Code 1972 pp VIII-16.

FIGURE NO.

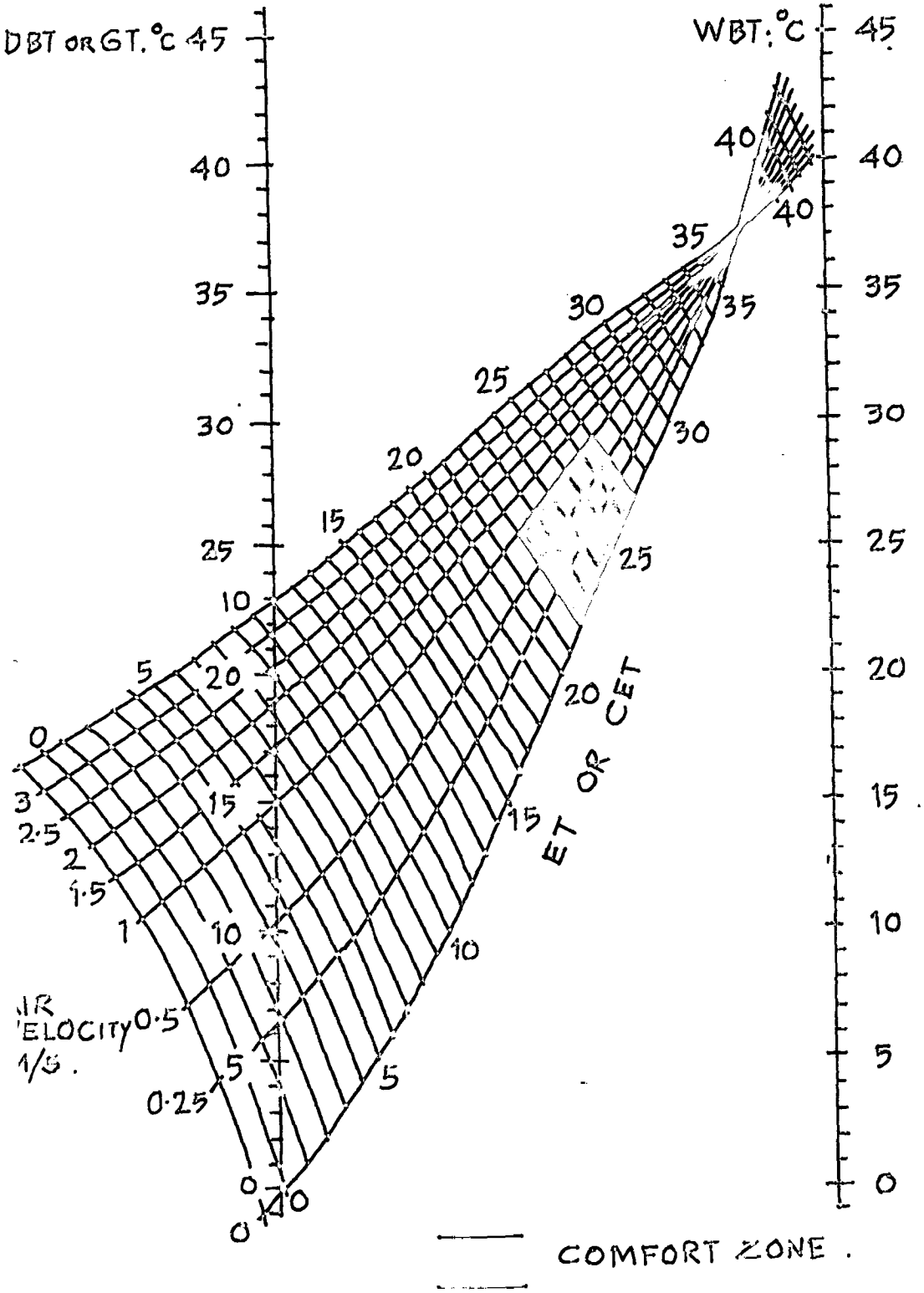
" EFFECTIVE TEMPERATURE NOMOGRAM FOR PERSON WEARING NORMAL BUSSNESS CLOTHING ."



* SOURCE : PP 54, FIG. 30; KOENIGBERGE & ETC., "MANUAL OF TROPICAL HOUSING & BUILDING," ORIENT LONGMAN, NEW DELHI. 1975.

FIGURE NO

"BASIC EFFECTIVE TEMPERATURE NOMOGRAM FOR PERSONS STRIPPED TO THE WAIST."



* SOURCE : PP 55, FIG. 31, KOENIGBERGER & ETC. "MANUAL OF TROPICAL HOUSING & BUILDING" ORIENT LONGMEN, NEW DELHI, 1975.

range of the comfort zone is shown but is subjected to have variations. The Fig. 24 provides the effective temperature when person is wearing "normal bussiness clothing" and Fig. 25 is when a person is "stripped to the waist". These are the normal working style in various industrial processes.

6.8.9 Under the statutory control vide "Factory Act 1948" section 15 schedule of drybulb and wet bulb relationship is to be maintain. This regulation is taken as a mandatory the nomograms may be used to know air velocity by which effective temperature will be within comfort zone or within adaption range of comfort zone inside the industrial building. Once the required air velocity is established then it can easily be converted into area of opening by using following formula.

$$P_v = 0.612 \times V^2$$

Where, P_v = wind pressure in N/m^2.

V = wind velocity in m/s.

(where N is the unit of force expressed as "newton" and constant as Ns^2/m^4.)

6.8.10 In general practice the wind speed and other characteristics are expressed in Beaufort scale therefore the table 7.7 given below, is computed for the

or other material but shouldbe lined with acoustical material inside. If the size of the machine is large for a box then separate room may be provided with inside lined with acoustical material.

6.9.8 In case of partial reduction of noise specially of high frequencies in certain directions may be obtained by providing barriers or partitions. This partial enclosor may be temporary or permanent. It may be of two sides, three sides or with or without top. Such barriers may also be treated with acoustical material.

6.9.9 In some of the industries where noise is a constant unavoidable problem then acoustical treatment becomes necessary. The acoustical treatment related to the properties of materials used and methods of construction adopted. It includes from lining to machine covers to pannelling to the room walls, ceiling and floor treatments. This is necessary to reduce the general reverberant noise level in machine shop. This ~~moisture~~ may reduce the noise level by 3 to 8 dB of medium and high frequency.

6.9.10 The sound reduction is also possible by effective maintenance of machine and driving systems and wheels of trolley etc. If, places where friction produces noise, proper lubrication is provided, it results into reduction in noise level by at least 3 dB. Further reduction is

possible by using resilient material wherever possible (i.e. loading and unloading areas, rubber wheels etc.).

6.9.11 In order to facilitate the selection of material index of some of the building materials taken into account.

6.9.12 External Sound Reduction

The reduction external noise is achieved by providing proper distances, screening barriers etc. The noise reduction is possible by keeping sources at distance and physical separation in industrial building (Fig. No. 26 of this dissertation). The distance between source of noise and one needs protection is alarming during the night time which causes disturbance of sleep. The distance between the two is increased then every doubling of distances reduces 6 dB of noise.

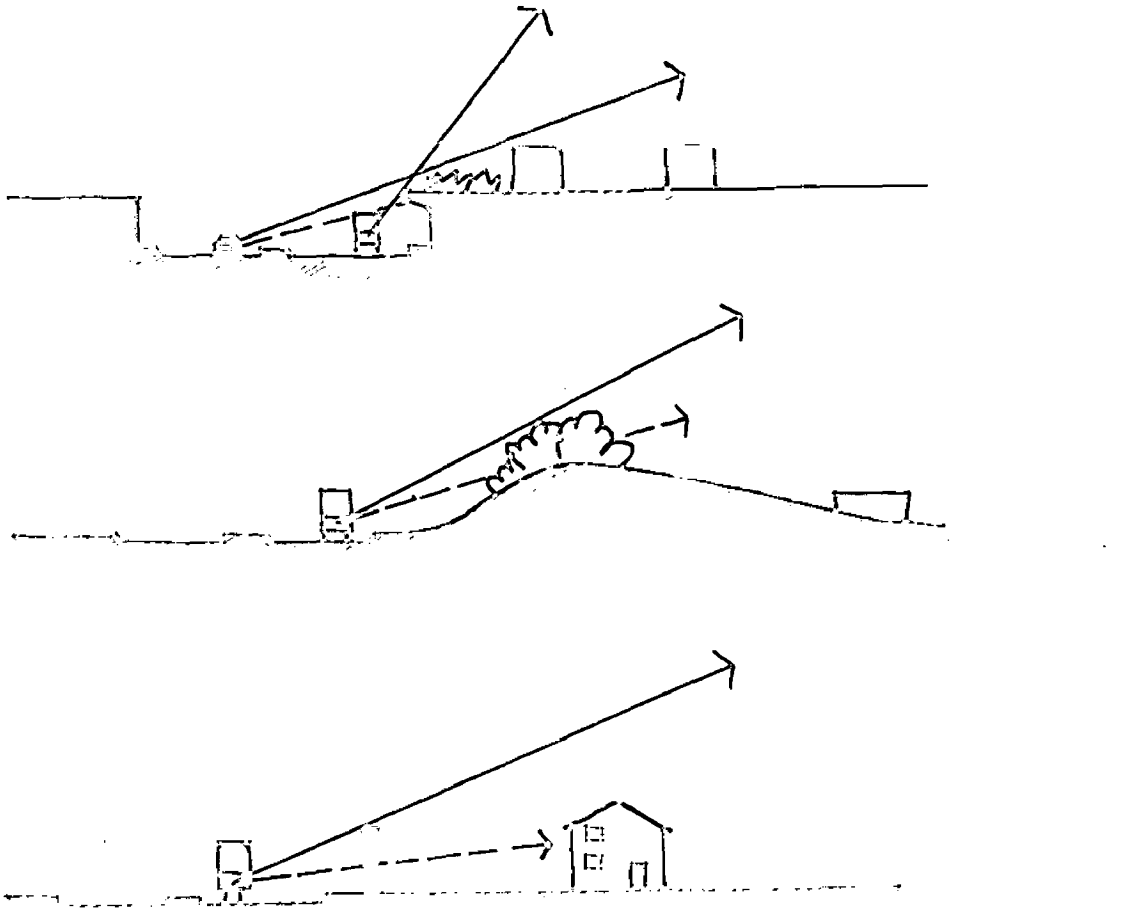
6.9.13 The influences of distance and the treatment required for such sound barriers in the form of green belt or protection belt are given in the Fig. 19. It gives the screening effect, location of barrier and sound diffraction between source and listener.

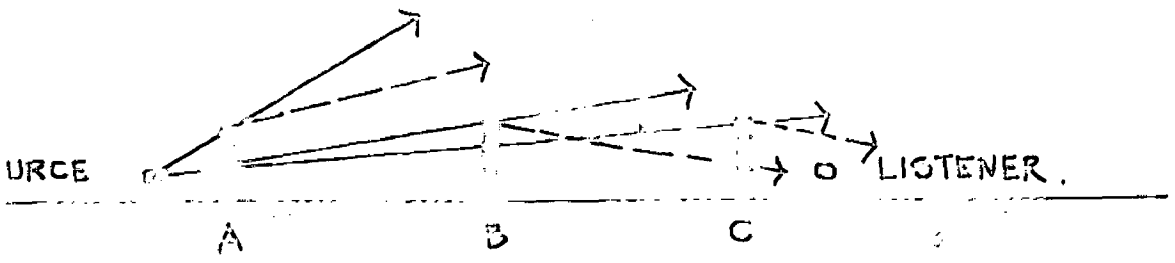
6.9.14 The width of such belt may be between 50 to 70 m. and is to be treated with relief work and plant materials.

6.10.0 Atmosphere and Air Pollution

6.10.1 Pollution is the presence of impurities having harmful contamination beyond natural balance of purification

"SCREENING EFFECT OF BARRIERS." FIG. Nº 2





POSITIONS OF BARRIER. (: A : B : C)

NB: BROKEN LINE INDICATES THE SAME DEGREE OF DIFFRACTION.

BEST POSITION OF BARRIER: NEAREST TO THE SOURCE.

WORST POSITION: HALF-WAY BETWEEN SOURCE & LISTENER.

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* SOURCE : PP 183, FIG 122, KOENIGSBERGER & ETC. "MANUAL OF TROPICAL HOUSING & BUILDING" ORIENT LONGMAN, NEWDELHI. 1975.

capacity in the environment. It may be a contribution due to natural or artificial doings of our civilization. The pollution has unlimited area of influence and is not a matter of individual but collective and comprehensive planning.

"Pollution obviously does not confine itself to the political jurisdiction in which it originates. Polluted air drifts freely from State to State. Polluted rivers may flow through many states. Pollutant dumped into ocean from one state may easily wash-up on the beaches of another. Thus, the control of pollution rightfully becomes an interstate problem and subject of Federal control"[20].

6.10.2 The types of pollution due to any reason are classified as a) Air pollution, b) water pollution, c) Radiation pollution and d) noise pollution. It affects one and all present in this earth's environment and may be to certain extend the outter space. The nature and magnitude affects faster or slower, directly or indirectly the environment. It is estimated that about 90% of the mass of pollutants emitted as gases and only 10% of the mass as particles and liquids.

20- Jones K.L., Shainberg L.W., Byer C.O., "Environmental Health", Harper and Row Publishers, San Francisco PP.12.

6.10.3 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 traping of contaminants under the warm inversion layer. This trapping discourages the natural phenomena of reducting air temperature for every successive increase in height. This urban plume is undisturbed by the daily temperature cycle of the place but on the contorary present over the urban areas for most of the days and months of the year.

6.10.4 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 keeps 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 better understanding.

6.10.5 In the same way both urbanisation and industrilisation creates "SMOG"[1] mostly over the urban areas and in particular which are close to sea coasts. The presence

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[1] A mixture of "smoke" and "fog" together.

of smog and getting it charged due to suns rays results into photo-chemical smog. It produces more harmful pollutants like, ozone, nitrogen dioxide (NO_2), nitric oxide (NO) and atomic oxygen (O).

Most of these chemicals causes lung damage and eye irritation if exposed to them for longer period.

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

6.10.7 Radiation Pollution:

6.10.8 There is some natural radiation present in all form of life. It is a free gift of radio-active substances in the ground, air, and water on this planet and also as a cosmic radiation from outter space. This is much below the alarming radiation level and is considered as harmless.

6.10.9 In the recent years there has been more increase in man made radiation and increase in radiation in the atmosphere. The extensive use of radio-therapy in to-days technology and in industry has noticeable effect. The uncontrolled use of radiation causes killing of

cells, and damaging them, where as controlled use of radiation has a curring effect and boon to present civilization.

6.11.0 Water Pollution and Industrial Wastes:

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

6.11.2 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 alkalies, toxic substances, carbo hydrates, fats, grease and oil etc..

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

6.11.4 The water pollution can have adverse effect on soil, ground water, water life, crops and vegetation and finally directly or indirectly on human life.

6.11.5 The pollution and waste treatment are the specialised branches of Public Health Engineering or Environmental Engineer, hence in any design where there are

chances of pollution the respective export may be consulted.

6.11.6 As an industrial building designer, an architect has to study and collect data from respective specialist regarding the problems of industrial waste. This data as hints for industrial waste infrastructure[29] given in Fig. 27 are helpful to plan the provision in the industrial designing by an architect.

Collect the following information for assessment industrial waste provisions:

1) Study the complete flow diagram of the industry and outlet points of such waste.

2) Chemical and biochemical analysis of each waste and combined waste.

3) Access the volume, quantity duration of flow and nature of waste from each process.

4) Analysis of the body of water likely to receive the said waste.

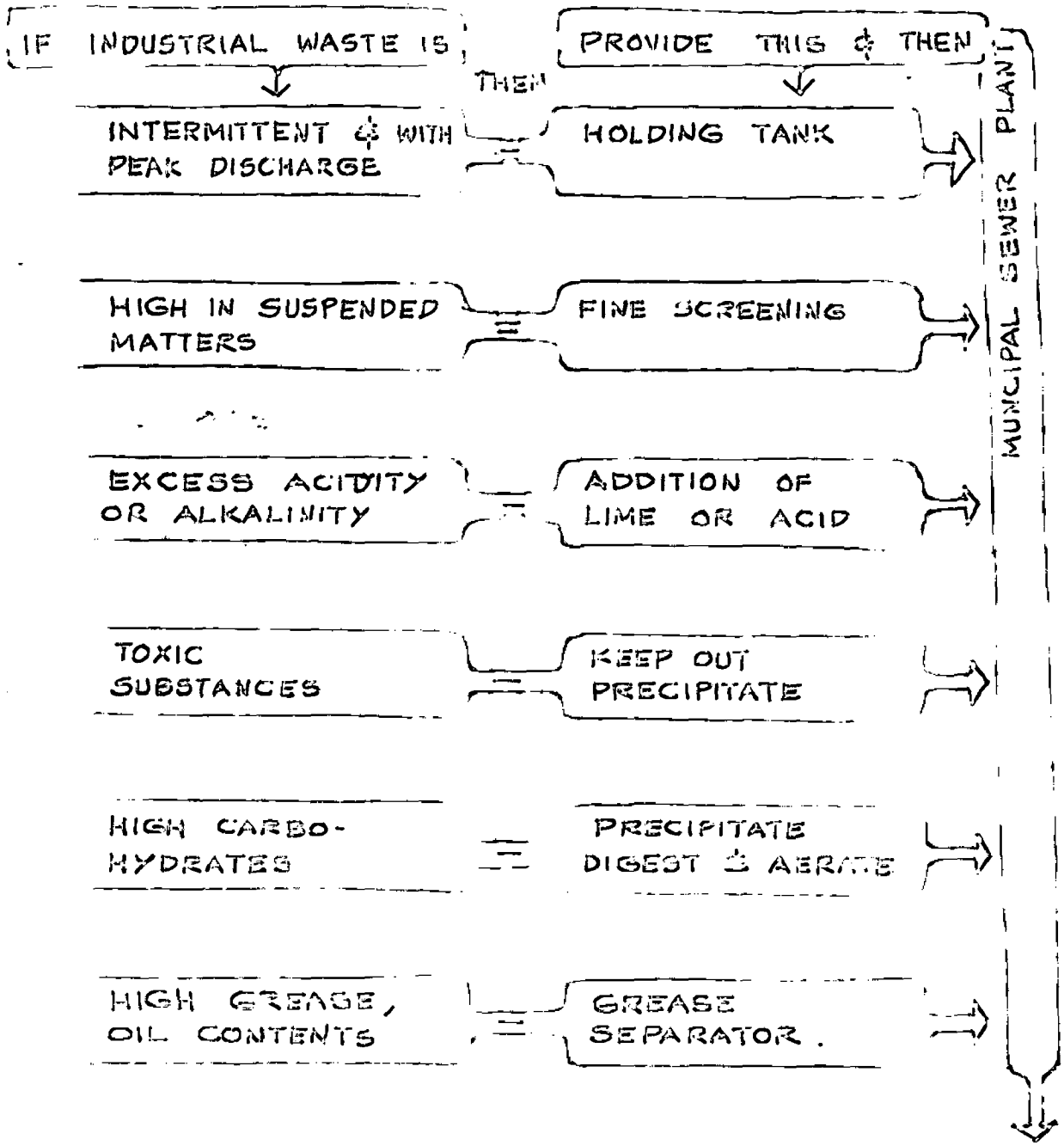
5) Study the use of the water body to be made on downward direction.

This will help in deciding the qualitative and quantitative aspects of industrial waste. The experts advice is necessary.

29- Sooiyo E.E.. Data Book for Civil Engineering, Design Vol. I, John Willey and Sons inc. New York, pp.5.92 to 5.97.

FIGURE NO

HINTS FOR INDUSTRIAL WASTE INFRASTRUCTURE.



DATA REQUIRED TO MAKE AN INDUSTRIAL WASTE STUDY :

- (A) COMPLETE FLOW DIAGRAM OF INDUSTRY.
- (B) VOLUME OF WASTE FROM EACH PROCESS.
- (C) DURATION OF FLOW.
- (D) CHEMICAL & BIOCHEMICAL ANALYSIS.
- (E) ANALYSIS OF WATER BODY RECEIVING IT.
- (F) STUDY OF USE MADE OF WATER BODY.

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* SOURCE : (ADAPTED) PP 5-52 TO 5-57 SEELYE E.E., "DATA BOOK FOR CIVIL ENGINEER,

CHAPTER -VII

CONCLUSIONS

1. In the industrial design, till recently, there was little contribution by an architect even as a-n mediator. An architect has only the role of draftsman in large industries, for factory design, and has to manage the township on his desire. In smaller industries, an architect has not played a role and has produced wonderful results, on his professional merits.

2. The industrial policy at the micro-level is always tuned with the national, state or regional policies.

3. The basic difference, between other industries and the engineering 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.

4. The engineering industries are, mostly, 'tailor made' industry hence space requirements will depend upon the type and size of product, and expected capacity.

5. 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.

6. 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 areas.

7. Study various factors of condition stimulant according to the industrial processes.

8. Study the factors due to which occupational environment and ecological imbalance may occur.

9. The correction and justification of planned layout, flow, sequence, lighting, ventilation, sound and separation of building or closeness are to be verified by respective experts.

10. Industrial building should be such which will enhance the landscape without aesthetic pollution.

RECOMMENDATIONS

(A) POLICY PLANNING

1. The policy for any industrial design should be based on micro-level circumstances, adhering to national

or state or regional policy frame work. For this this study of following factors is necessary:
(a) Economic factors, (b) service factors, c) climatic factors, d) Statutory factors.

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

(B) 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 pattern straight, serpentine, u-shaped, circular or odd-angle.?

(b) What type of relationship is expected between i) 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, (iv) Delay, (v) Storage and vi) 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, electricity, engineering building, welfare building, and specialised, ancilliary and protection services.

(c) 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, expandibility 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 roof, gable roof with monitor, high bay 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 centre'[1]

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[1] Ref. Grant, I.W., and Grant, E.L. pp.382, 383.

principles for the industry to be designed. Mechanical Engineer, or Production Engineering Consultancy 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 some anthropometric data* and its effectiveness in pulling and pushing. (d) determine type of floor and its nature to perform all the process operations. (e) Determine enclosure requirements after considering the opening like large industrial doors, windows and structural bracings etc. in mind.

The enclosure is also governed by climatic considerations, vision, dust collection and noise elements. This will give the 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 eye level.

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

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

* Ref. appendix 8.5.

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 after due consultation with material handling expert and production engineer.

10. Determine the protection system required according to the industrial 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 wash rooms, lockers, overalls, safety equipments and shields according to the stimulants.

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

(e) Provide measures to protect property by providing (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 2 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.

(a) Adopt methodology given in this dissertation for awareness about harmfulness of pollution and industrial waste disposal. It is also recommended that respective experts may be consulted during the planning stage as a precaution and as corrective majors after planning.

(12) By using the survey format, for assessment of problem of industries due to industrial processes, for providing architectural solutions under (a) planning or (b) construction heads.This survey format will help to study existing and proposed design problems to be provided with architectural solutions. Ref.Figure No.28.

This is an 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 recommended is expected to prove useful in planning new factories or providing corrective remendies to the existing one with special reference to engineering industries.

APPENDIX

8.1 Recommended illumination and limiting glare index.

Visual task	Illumination in lux.	Glare index.
1) Casual seeing	100	28
2) Rough task with large detail	200	25-28
3) Ordinary task, medium details	400	25
4) Fairly severe task, small details. (eg. drawing office sewing)	600	19-22
5) Severe, prolonged task, small details (e.g. fine assembly.).	900	16-22
6) Very severe, prolonged task, very small details (e.g. gem cutting, ganging very small parts)	1300-2000	13-16
7) Exceptionally severe task, with minute details, (e.g. watch and instrument making).	2000-3000	10

Source :- Koenigsberger O.H., Ingersoll T.G., Mayhew A., and Szokolay S.V., "Manual of tropical housing and building", Orient longman, New Delhi 1975, pp.304.

8.9 INDUSTRIES SURVEY QUESTIONNAIRE PROFORMA

1. Name of industry and year of establishment.
2. Name of product produced, workforce needed and their educational standard.
3. Need for special storage of raw material, scrap, waste as well as finished products.
4. Is the present area sufficient for your 10 year's programme? Does it serve your purpose without any alteration, modification etc? If yes state what changes you have made?
5. Do you need special handling equipment?
6. Does the process produce ash/dust/fumes or any other pollutant?
7. Are the physical dimensions serving you best or not? (with special reference to height, lighting ventilation, flooring and roofing etc.).
8. Are the auxiliary services adequate or properly used?
9. What is the policy of treating the industrial waste?
10. What is your maintenance schedule of work place, shed and surrounding?

8.4 A) Planning personnel facilities in factory.

1. Employment interviewing, testing, examination, practical assignment, training etc.

2. In plant medical service, dispensaries, first aid.

3. Comfort working conditions relative to heat, light, noise, humidity, dirt, dust and fumes.

4. Lockers and toilets including wash rooms.

5. Food services.

6. Social and Recreational facilities and crench.

7. Special services - Post, Bank, Union activities, insurance programmes, tax and legal bureau.

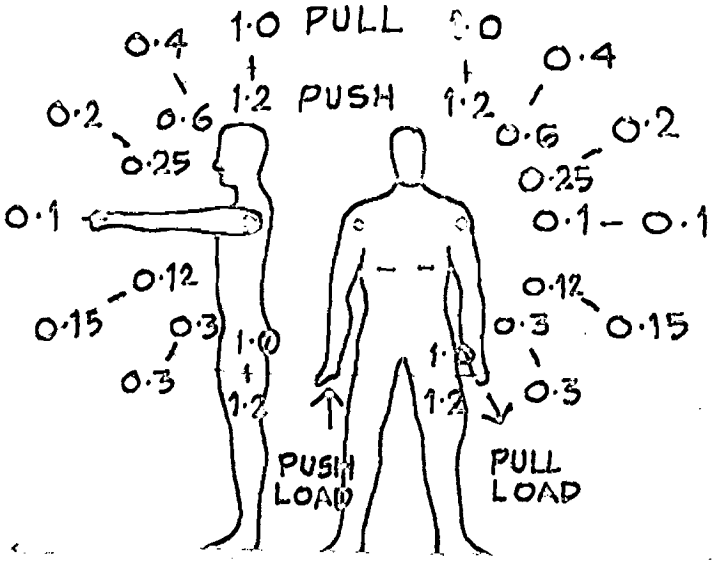
NB:- Space will be determined according to number of employees in total and in each division or section.

B) Medical Service.

No./shift	Medical service provision
25 or less	One first-aid station, two trained persons and contract with one local doctor.
26 to 100	Two to three first-aid centres with 6 to 10 trained persons and contract with local doctor.
100 to 200	One full-time nurse with examination room with complete first aid, regular doctors visit, with 3 or 4 emergency centres.

No./shift	Medical service provision
201 to 400	A full-time nurse and part-time doctor, with office and examination room.
401 to 600	Full-time nurse and full-time doctor and othe arrangements.
601 to 1000	Full-time nurse and full-time doctor and othe arrangements with treatment two rooms.
1000 and above	Full-time nurse and full-time doctor and other arrangements with treatment two rooms, one doctor and two nurses.

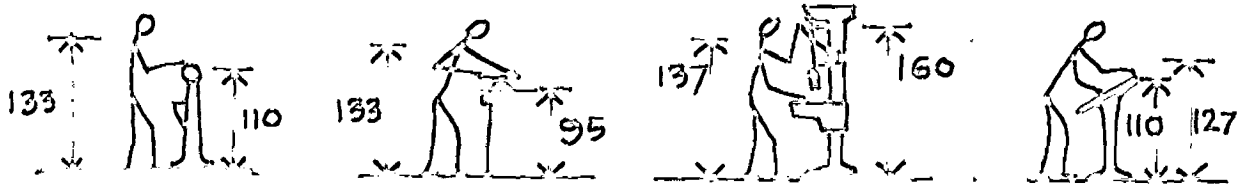
Source:- Grant I.N., and Grant E.L., "Handbook of Industrial Engineering and Management" Prentice Hall of India (P) Ltd., New Delhi 1969, pp. 591 to 595.

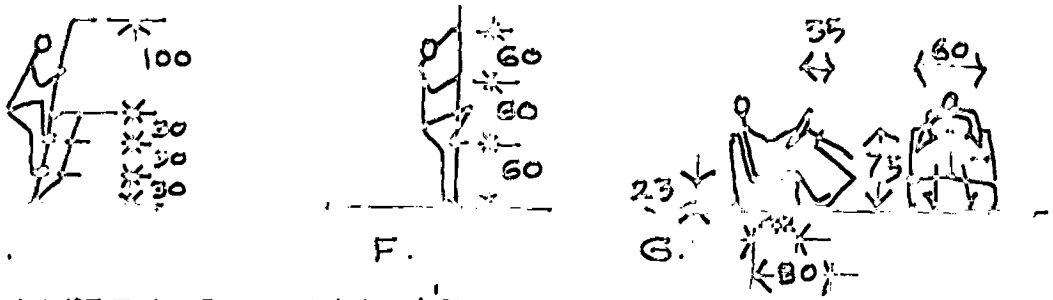


MAXIUM FORCE IS FUNCTION OF WEIGHT.
WEIGHT IN KG = 0·4 HEIGHT(CM.)

"MAN'S EFFECTIVENESS IN PULLING & PUSHING"

* SOURCE : PP. 21 FIG. 2·10





"AVERAGE MAN'S BASIC REQUIREMENTS."

* SOURCE : PP 20 , FIG. 2·8

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