CLASSIFICATION AND CHARACTERISTICS OF INDUSTRIAL BUILDINGS

NIZAM AHMED*

ABSTRACT

There are as many types of industries as there are industrial or manufactured products. However, owing to similarities in the infrastructure required, the processes involved, the wastes incurred, etc it is possible to group a number of "similar" industries under large types. The knowledge of the types of industries is basic to understanding the role the architect or engineer has to play in the design, construction, operation and maintenance of any industrial unit. There are several sets of "types of industries" and they depend on as much as the background of their authors as on the approach chosen for each set.

INDUSTRIAL TYPES

All industries are devoted to manufacture by production and assembly but, because of the differing manufacturing processes employed and the varying conditions necessary within and about each premises, industries can be grouped in terms of their purpose, location, structure, end-products, etc. Such classification helps designers to identify the quality of the working environment necessary and demanded by each industrial type. It is essential to find out about the more common classifications because a study based on different types of industries will ensure that a broad spectrum of industries are covered.

Industries have often been classified as heavy, medium and light. Heavy industries are involved with making large-scale end-products and handling bulky and heavy raw materials. Light industry uses small amounts of easily handled raw materials to make its end-products. Medium industries are obviously between the two. These definitions to some extent correspond with another set comprising primary, secondary and tertiary, with primary corresponding with heavy industry. Sometimes a fourth group, quarternary industries, is identified as those "concerned with the provision of information and expertise" (1).

Primary industries are "those processes which require plant, machinery and transportation facilities of such scale that these parts must be built in-situ; e.g. steel work, mines, etc." (2). To a large extent they are concerned with natural resources and are important because they more often than not provide raw materials for other industries. Primary industries can again be sub-divided as "renewable" and "non-renewable". The industries which have to stop once the raw materials have been used up, as in oil drilling, quarrying, mining, etc, are called "non-

* *Associate Professor, Dept. of Architecture, BUET, Dhaka*

renewable". In industries such as fishing, farming, forestry, etc, the raw materials can be used and replaced and these are called "renewable" (3). Such industries have to be located at the source of the raw material.

Secondary industries are those "processes requiring special or fixed facilities of building, plant, services or environmental conditions, arranged in a given production sequence or sequences (4). Industries in this group "turns raw materials into other useful end-products" (5) or "recognisable products" (6). Such industries can be located almost anywhere. Some are thus located with close proximity of their raw materials, others near the market of their products and some between the two (7).

Tertiary (processes) industries are those "processes which require only general facilities not necessarily permanently fixed" (8).

In another set, primary industries provide raw materials, secondary manufacture the end products and the tertiary (services) industries "are concerned with providing a service and tend to be located where services are required" (9).

On the basis of the processes involved in different industries, most can be categorized into one of the following (10):

1. Light Production and Assembly
   (a) High Technology
   (b) Low Technology
2. Batch Production and Assembly
3. Mass Production and Assembly
4. Process-Based Production
   (a) Centralised facility: primary and secondary processing on one site
   (b) Dispersed facility: primary and secondary processing on different sites
5. Heavy Engineering

The term Light Production refers "variously to the amount of manual work involved, the amount of energy required in the process, or the size and specialisation of the plant or machinery employed" (11). The products are comparatively simple and the production processes "demand little of the building other than enclosure" (12).

In Batch Production the manufacturing processes of a number of products or components are broken up into distinct batches "to maximise the efficiency of machinery and personnel" (13).

Mass Production involves the production of a large volume of products by continuous and repetitive action by man and machine on a particular manufacturing process or assembly.

Process-based industries, as the name suggests, carry out production by means of chemical processes involving mainly liquid and powder materials. Centralised facilities are those industries where the primary bulk and the secondary products are directly related and both processes are carried out on the same site. On the other hand, dispersed facilities include those process-based industries where the primary bulk and the secondary products are processed on different sites.

Examples of the various categories are as follows:

Primary	-	mining, fishing, oil drilling, forestry
Secondary	-	textiles, food, drinks, tobacco manufacturing
Tertiary (Processes)	-	packaging
Tertiary (Services)	-	gas, electricity, water, transport, banking
Quarternary	-	universities, research establishments
Light Production and Assembly (a) High Technology	-	Electronics, Surgical tools
Light Production and Assembly (b) Low Technology	-	Light Engineering, packaging
Batch Production and Assembly	-	Food packaging, clothing
Mass Production and Assembly	-	Automobiles, clothing
Process-based Production (a) Centralised facility	-	Pharmaceuticals, tobacco
(b) Dispersed facility	-	Paper, plastics, paints

The British government recognizes 27 main groups of industries in its Standard Industrial Classification and they are listed under 27 Main Order Headings, based on type of industry. Each main group consists of several Minimum List Headings. The 27 Main Order Headings according to the Standard Industrial Classification 1968 are:

1. Agriculture, Forestry, Fishing;
2. Mining and Quarrying;
3. Food, Drink and Tobacco;
4. Coal and Petroleum Products;
5. Chemicals and Allied Industries;
6. Metal Manufacture;
7. Mechanical Engineering;
8. Instrument Engineering;
9. Electrical Engineering;
10. Shipbuilding and Marine Engineering;
11. Vehicles;
12. Metal Goods not elsewhere specified;
13. Textiles;
14. Leather, Leathar Goods, Leather Fur;
15. Clothing and Footgear;
16. Bricks, Pottery, Glass, Cement, etc;
17. Timber, Furniture, etc;
18. Paper, Printing and Publishing;
19. Other Manufacturing Industries;
20. Construction;
21. Gas, Electricity and Water;
22. Transport and communication;
23. Distributive Trades;
24. Insurance, Banking, Finance and Business Service;
25. Professional and Scientific Services;
26. Miscellaneous Services;
27. Public Administration and Defence;

Classification of industries is also possible in terms of landscape impact and problems. Tandy (14) classified industries on the basis of the above viewpoint as follows (the examples are samples and not exhaustive of the type):

Class I — Primary Industries (land based)
- (i) Rural: agriculture and horticulture, fishing, forestry
- (ii) Extractive: mining, quarrying, drilling (for rocks, minerals, coal, oil) cement works, brick works

Class II (a) — Secondary Industries (making materials)
- (i) Heavy : smelting and forging, rolling and tin-plate works, coke making, brick making
- (ii) Medium: oil refining, grain milling, chemical works, paper making, spinning, weaving, tanning

Class II (b) — Secondary industries (manufacturing products)
- (i) Heavy: boiler making, ship building, engine making, metal fabrication
- (ii) Medium: wire and cable making, tool making, motor vehicle making, mechanical equipment making
- (iii) Light: clothing, footwear, furniture manufacture,plastics, scientific equipment
- (iv) Light assembly: domestic equipment, electrical and telephone equipment

Class III (a) — Other : Construction
Civil Engineering, building, road making

Class III (b) — Other: Distribution
Wholesale and retail trade, warehousing

Class IV — Utilities (mainly public)
Electric power generation, gas works, water supply sewage and refuse disposal

Class V — Transport
Road, rail, sea-ports, inland water, airports

Industrial buildings may also be differentiated on the basis of the approach to their construction. Bates (15) mentions three fundamentally different approaches. These are:

Purpose-made units
Advance units
Standard units

Purpose-made units are industrial buildings which are specially designed to suit the process, services, handling facilities, etc. of particular industries.
Advance units are those which are constructed, particularly in new industrial estates, in advance of any knowledge of the processes which will ultimately be carried out in them.
Standard units are manufactured by several fabricators as standard buildings or standard components of buildings. Such buildings can be "very economical to construct" because of mass manufacture of standardized components.

The Government of Bangladesh recognises 29 industrial groups (1980), again based on the type of industry. They are (16):

Industry Code

BSIC 1980 (New)	PSIC 1956 (Old)	Title of Category
311-312	20	Food manufacturing
313	21	Beverage industries
314	22	Tobacco manufacturing
320-321	23	Manufacturing textiles
322	24	Wearing apparel except footwear
323	29	Leather, Leather products
324	24	Leather footwear
325	39	Ginning and processing of fibres
331	25 & 27	Wood and cork products
332	26	Wooden furniture and fixtures except metal
341	27	Paper and paper products
342	28	Printing and publishing
350	31	Drugs and Pharmaceuticals
351	31	Industrial chemicals
352	31	Other chemical products
353	32	Petroleum refining
354	32	Misc. products of petroleum and coal
355	24 & 30	Rubber products
356	39	Plastic products
361	33	Pottery and China-ware
362	33	Glass and glass products
369	33	Non-Metallic mineral products
371	34	Iron and steel basic industries
380-381	35	Fabricated metal products
382	36	Machinery except electrical
383	37	Electrical machinery
384	38	Transport equipment
386	39	Photographic and optical goods
393-394	39	Other manufacturing industries

According to Dutt, Dasgupta and Chatterjee (17) large industries, employing 20 or more workers and run by mechanical power, can be classified under four major groups:

1. Agro-industries:
   - (a) Textiles - cotton-ginning, baling, weaving, spinning and hosiery, jute milling and baling
   - (b) Food-processing - rice-milling, flour-milling, sugar, tea and vegetable oils
   - (c) Raw material producing and processing - hides skins and leather works, wool and silk

2. Forest-based industries:
   - (a) Timber - saw-milling, railway sleepers, boats and furniture

(b) Soft-wood - matches, plywood and newsprint
(c) Bamboo - Paper, rayon and nylon

3. Mineral and Metal using industries:
   (a) Cement, glass, chemicals and fertilizers
   (b) Aluminium and other metals
   (c) Steel
   (d) Oil refining
4. Engineering Industries:

   (a) General engineering, railway workshops and ship repairs

In Bangladesh in 1984-85 there were 3955 factories within the 29 major industrial groups (18). However, there are large numbers of smaller industries, which because of the size of the establishments, number of employees per establishment and the meagre amount of capital involved, do not merit the term "industry" as far as the official definition is concerned. Scattered all over the country, particularly within the perimeters of big cities and towns, there are numerous small manufacturing units which employ less than ten persons each but because of the processes involved are industries in every sense of the word. They do not come within the jurisdiction of industrial laws. and many of them function under apalling conditions, such as poor buildings, lack of sanitary and sewerage facilities, high risk of fire and a degrading level of working environment. These urban units are a major contributor to pollution of the air and water. Child labour is very high in these factories. According to an estimate by The Economist, London, (19), there are approximately 300,000 workshops, manufacturing engineering components and counterfeit goods. These workshops mostly work in rented places and therefore have no collateral.

The factories within the 29 major industrial groups in Bangladesh can be categorized as primary, secondary and tertiary; heavy, medium and light; or as Light, Batch, Mass, etc according to the systems followed in the West. Thus, a dockyard at Khulna is a heavy industry, a cosmetics industry is medium and a garments factory light.

It is useful for an architect to choose a set with more types than others and one in which the manufacturing process has been given precedence over other distinguishing factors. A large number of architectural factors such as layout, lighting, ventilation, facilities, finishes, fire protection, etc. will depend to a great extent on the process of production and assembly. Among the sets discussed in this paper, the one containing categories of Light, Batch, Mass, Process-based and Heavy production and assembly procedures seem most apt for architects and the characteristics of each type has been presented in Table1.1. However an architect will do well to keep in mind that other sets for various other reasons exist concurrently.

Table 1-1

Character	Type-IA High-tech Light Production	Type 1B low-tech Light Production	Type 2 Batch Production	Type 3 Mass Production	Type 4A Process-based Secondary Process	Type 4B Process-based Secondary Process	Type 5 Heavy Industries
General Description	Clean processes, some effluents toxic, requires controlled environment.	From simple to the more sophisticated processes.	Closely-spaced ranks of machinery served by overhead cranes; congested floors, cramped working conditions.	Dense layouts for machines, service and handling. Repetitive work, Components are also mass-produced	Primary & secondary processes on one site as transport and handling between processes is dangerous, and can affect sterility.	Easily transportable primary materials, from which secondary products manufaced.	Heavy assemblies broken down to be re-assembled on site. Now up to 1300 tonnes movable as assembled. Work piece moves from process-process.
Production Equipment	Dense planning, lab type benches, sophisticated equipment, eg. micro-welding techniques.	Autonomous; much equipment is old. eg sheet benders, welding plant, small offset printing press.	several machines but each one for one type of operation. Trend is to increase no, of operations on one machine, thus reducing movement and interprocess storage.	Sophisticated equipments and techniques. Automated control, robotics, self-changing tools. Components supplied at each manfg. stage.	Densely laid out. Primary-computer monitored and controlled processes. Secondary packaging bottling. Often sophisticated. Varies in scales depending on end-products.	Primary specialist rpocess plant. Secondary manufacturing finished goods eg. moulding, extrusion, printing, cutting, forming equipment, blending etc.	Specific to type of production. Bldg designed round equipment. Massive equipment so work piece moves. Now equipment moves workplece static.
Materials Handling	Wheeled cages, tote bins, monorail hoists, small forklift trucks.	Forklift trucks, lightweight hoists, eng, fabrication may require larger equipment.	Impt to prevent accumulation of materials between operations. Gantry cranes, hoists, forklifts, stillage trucks, conveyors. Modern equipment.	Integrated much handling system. Overhead cranes, roller, belt, overhead & slat conveyors. Automatic and computerized conveyors as storage.	Between primary & secondary pumped pneumatic & vibrating handling liquids, granules & powder, Belt conveyors, forklifts.	Primary-piped, pneumatic Secondary fork lift trucks, overhead hoists, conveyors.	Heavy overhead cranes, gantry cranes in pairs or more, heavy wheeled equipment, air cushions, oil pressure skids.
Services	Intensive, both for production & environmental control.	Low demand. Some special ventilation for welding, paint spraying.	Varying degree of production services. Flexible relation ships of services to roof structure necessary.	Very intensive. Increased energy costs justifies industrial waste recovery.	Controlled environment. Dense production plant services, Calling roof zones used.	Primary very dense, specialist design, installation. Secondary closely controlled environment.	Meat and funs generated, coolants & lubricants rend. Services for mobile toolk.
Personnel	Small groups of 2-3 specialists, high interaction between groups; or large groups where group interaction is not necessary.	Diverse skills, from female-intensive (clothing packaging) to general labour.	Distinct types for each production function. Some sectors are female dominated.	Little job satisfaction from repetitive work. Trend is to develop teams & remove the distinction between, manfg & organisations & admin staff.	Primary-specialist staff, Secondary female dominated. Hygiens & washing regulation strict.	Primary-plant intensive, specialist staff Secondary-similar to Batch Prod. Washing regulations.	Less manual than before, Labour and technicians. Scale or equip. demands care with working condition.
Growth and Change	Expansion, initially, met by increasing the production density, and re-arranging the facilities. Change must be quick eg. over weekend.	Rapid growth, but little capital. Quick, easy and cheap extension required. Change implies increased pressure on production area.	Expansion by lengthening bldg, duplicating bldg on parallel. Change may involve re-tooling, altering layout, reorganising machines within cells & regrouping inter-related cells.	Expansion met by acclerating machine or adding Shifts. May cause storage problems. Duplicate equip, expand building, improve machinery duplicate factory elsewhere.	For reformulated products, primary process remains unchanged, but secondary may have to be re-organised. Integration of high-tech, handling & storage techniques.	Expansion of secondary manf. similar to Batch production. Growth is contained in bldgs. by increasing density of services, size of storage tanks & employing mech. handling using volume of the bldg.	Growth along predominant axis by repeating bldg, alongside. Change involves replacing prod ,equip. Fixed machinery needs considerable work to floor slab & roof while mobile machinery is easier to adapt to changes.
Planning Implications	Buildings similar to offices and labs. Multi-storey possible.	Law investment in buildings., strong linear emphasis.	Cell concept of development. Cell may add on linearly or laterally. Expansion may cause materials handling and servicing problems.	Linear plan: Bldg. volume may be used. Wide open covered spaces for potential flexibility of operation.	Planning dominated by primary process requirements, intermediate storage. Secondary may be linear or flexibly arranged.	Primary processes have major env. implications, Secondary process-tend to be linear involving volume of building.	Larger scale developments, Generates noise. Heavy cranage demands bldgs. along predminant axis.
Location	Located in industrial areas, to meet the demand as a sub-contractor for high tech industries. Also in rural areas.	Speculative developments Development finance is short.	Located in industrial areas, localities with skilled labour Often housed in speculative developments.	Located in industrial areas, where good communication exists, labour is available. Not suitable for speculative development.	Purpose-built, high investments. Access for raw materials, power and distribution dictate location trends. Risk of contamination so location restricted in urban areas, towns.	Primary located near resources. Secondary located close to primary & markets. Simple processes housed in mobile units, exploiting market condition and land prices and rentals. More complex processes restricted by building needs.	Location governed by acceptibility of large built masses. Industrial areas, coastal sites. Rail access, and where labour is available.

(Compiled from pg. 11-22. DRURY, JOLYON., Factories: Planning, Design and Modernisation)

REFERENCES

(1) BALE, J., *The location of Manufacturing Industry,* Oliver and Boyd, Edinburgh,1981, p.12
(2) DARRINGTON, P., *"Factories", Planning: Buildings for Habitation, Commerce and Industry,* E. D. Mills (Ed), Newness Butterworths, London, 1976, pp. 7-1
(3) PRICE, N., BUDGE, C., *Industry,* Edward Arnold, London, 1983, p. 6
(4) DARRINGTON, P., Op Cit., p, 7-1
(5) PRICE, N., BUDGE, C., Op Cit., p.6
(6) DRURY, J., *Factories: Planning, Design and Modernisation,* RIBA, London, 1981, p. 11
(7) BALE, J., Op Cit., p. 12
(8) DARRINGION, P., Op Cit., p. 7-2
(9) BALE, J., Op Cit., p. 9
(10) DRURY, J., Op Cit.,p. 11
(11) DARRINGTON, P., Op Cit., p. 7-1
(12) DRURY, J., Op Cit., p.11
(13) Ibid, p. 11
(14) TANDY, C.R. V., *Landscape of London,* Leonard Hill Books, Industry, 1975, p. 61.
(15) BATES, W., *Introduction to the Design of Industrial Buildings,* Constructional Steel Research and Development Organisation, Croyden, 1978, p.3.
(16) BANGLADESH BUREAU OF STATISTICS, *Statistical Yearbook of Bangladesh,* 1984-85, Govt. of Bangladesh, Dhaka, p. 403
(17) DUTT, K., DASGUPTA, R., CHATTERJEE, A., *Bangladesh Economy: An Analytical Study,* People's Publishing House,New, Delhi, 1973, p.45
(18) BANGLADESH BUREAU OF STATISTICS, Op Cit., p. 403
(19) THE ECONOMIST, London, 18-24 October, 1986, p. 24