A Guide to Good Factory Planning

Some tips before you start your factory construction project

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1 Introduction

A factory construction project is always a major undertaking, so it is crucial to pay attention to every detail to ensure your project is completed on time and on budget. Your facility also needs to be efficient, productive, accessible and safe.

The key to the success of your facility, and therefore the ongoing success of your business, is to engage the right design/construct team. The greatest opportunities for cost savings happen during the preliminary design stages, so be sure to select an experienced team to optimise your building design and layout.

Bid out your project to several companies with expertise in factory design and construction. Ask for specifics about the project manager assigned to your building and monitor the design and construction schedule closely to avoid delays.

Educate yourself on all aspects of factory design basics and internal planning so you can communicate your individual business requirements effectively with your design and construct team, from construction methods, to layout, door size and location, work flow and product flow to vehicle access and energy-efficiency.

Laying the groundwork with good initial planning pays dividends, while poor planning can lead to cost blow-outs, delays, scheduling issues and, inevitably, costly changes down the track.

Controlling Construction Costs

Be aware of these points regarding construction costs:

- Around 80 per cent of construction costs come from these areas: concrete, steel, earthwork, site utilities, roofing, fire protection and design fees. Focus on controlling costs for these large items.
- The square metre costs of factories follow a parabolic curve – small buildings are expensive; bigger buildings are more economical so don’t necessarily skimp on space.
- If possible, make the footprint of the building square rather than rectangular to reduce walling costs.
- Spend extra money on a good deceleration lane and a wide curve at the building’s entry drive apron for ease of vehicle access.

Modern Factory Basics

When constructing a new factory facility, the following factors need to be considered.

Selecting a Site

It is preferable to construct the building on level ground, ideally slightly raised above the surrounding area, which is well drained. Low locations are to be avoided. If it is difficult to find a level area, then the least undulating or sloping area should be selected, and the site should be oriented along contour lines, in order to minimise the amount of levelling and filling in to be done.

The characteristics of the soil must also be determined: its load-bearing capacity, resistance to compaction, and drainage characteristics. The building and the approaches will need to be protected from running water by an effective drainage system, and the site should be able to accommodate such a system.

The facility should be sited as near as possible to a main road, in order to enable easy access and movement of stocks. It is also important to ensure that the approaches to the factory permit easy movement and manoeuvring of vehicles around it.

Standard Factory Construction

At the most basic level a factory should be easy to clean and maintain and should provide good working conditions.

Foundations and Floor

Unstable clay soils and areas which have been filled in should be avoided wherever possible, due to risk of subsidence. In all cases, it is necessary to dig the foundations down to a point where the soil-bearing pressure is 150 kN/m2 or better.

The floor must be able to bear the weight machinery and other contents and must also be impermeable to ground water. For these reasons, the floor should consist of a slab of reinforced concrete laid upon well compacted hard core, with a moisture barrier sandwiched between the two. This moisture barrier should consist of a layer of bitumen or asphalt, bitumen felt, or a polyethylene film.

The reinforced concrete slab must be made with expansion joints, in order to prevent cracking and should be covered with a cement cap a few centimetres thick, which is rendered smooth and hardened (to prevent powdering).

The floor level must be sufficiently above ground level to ensure that water will not enter the factory. Consideration can be given to erecting the facility on a plinth raised about 1.2 metres above ground level, to facilitate loading and unloading of vehicles, however this alternative can add up to 40% to the cost of construction.

Doors

The number of doors will vary according to the size of the factory. If possible there should be at least two doors, to enable rotations of stocks on a 'first in, first out' basis.

Double sliding steel doors are one option. A more modern alternative are compact sectional folding doors. On opening, these doors fold upwards within the side tracks above the door space, providing more useable space within the building. The rail system for these doors has a smooth and quiet movement, which uses little energy and guarantees a long life cycle.

Walls

Most modern factories are constructed with a framework, usually of reinforced concrete. The supporting pillars are linked together by lower tie-bars, which are secured to the floor slab, and by upper tie-bars, which hold the frame firmly together. It is essential that all joins are secure and accurate, and that the reinforcing rods are well covered with concrete. The walls of the warehouse are built between the supporting pillars.

The walls may be made of breezeblocks, or stabilised earth bricks, and should be rendered smooth on both sides. Alternatively, the walls may be made of a lightweight material such as fibre-cement, galvanised metal sheet, or aluminium sheeting. However, these materials can be easily damaged, have poor insulating properties, and can be prone to erosion.

New developments in prefabricated, modular construction techniques are largely superseding traditional building techniques and allowing speedier, more cost-effective construction.

A vapour-proof barrier should be incorporated into the base of the walls, to prevent damp rising and causing damage to the factory structure and its contents. Also, a concrete strip about one metre wide should be laid around the outside perimeter to prevent rain from eroding the base of the walls below the damp course.

Ventilation

Ventilation openings are necessary to allow the renewal of air and reduce the temperature in the building and also allow some natural light to enter. Ventilators should be placed under the eaves and fitted on the outside with anti-bird grills and on the inside with 1 mm mesh screens (removable for cleaning) to deter insects.

Roof

Roof frames should be designed so that they transfer the weight of the roof to the supporting columns (in framed buildings), or to the walls if the facility is small.

A steel portal frame should be used if the span is to be greater than 15 metres. Factories less than this width may have reinforced concrete roof frames.

Roof cladding may be of galvanised steel or aluminium sheeting, or fibre cement; the latter being more fragile but having better insulating properties. Tiles are not recommended, especially for large warehouses.

The roof should overhang the gables by 0.7 to one metre, and the eaves by at least one metre in order to ensure that rainwater is shed well clear of the walls. The overhang also helps to keep walls cool and protects ventilation openings from rain.

Illumination

Adequate light in a factory is an important factor as far as the safety of workers inside it is concerned.

The building design should provide adequate natural lighting during daylight hours and artificial lighting for facilities that continue to operate during the night. .

Ancillary Spaces

As well as the factory floor and storage areas, the building will need to include adequate space for offices, toilets and washing facilities for workers and other desired spaces such as a covered break-out area.

Factory Layout Principles

Determining the interior layout of a factory involves deciding where to put all the facilities, machines, equipment and staff involved in the manufacturing operation.

Layout determines the way in which materials and other inputs (such as people and information) flow through the operation. Relatively small changes in the position of a machine in a factory can affect the flow of materials considerably. This, in turn can affect the costs and effectiveness of the overall manufacturing operation. Getting it wrong can lead to inefficiency, inflexibility, large volumes of inventory and work in progress, high costs and unhappy customers. Changing a layout at a later date can be expensive and difficult, so it is best to get it right first time.

The type of layout chosen will depend largely on product volume and variety. At one extreme, a factory will produce a wide variety of bespoke products in small volumes, each of which is different (this is called a 'jobbing' operation). At the other extreme a factory will produce a continuous stream of identical products in large volumes (a 'batch' operation). Between the extremes, the factory might produce various sized batches of a range of different products (a 'continuous' operation).

Basic Layout Types

Once the type of operation has been selected (jobbing, batch or continuous) the basic layout type needs to be selected. There are three basic types:

- Process layout
- Cell layout
- Product layout

Jobbing operations (high variety/low volume) tend to adopt a process layout.

Batch operations (medium variety and volume) adopt either a cell or process layout.

Continuous operations (low variety/high volume) adopt a product layout.

1. Process layout

In a process layout, similar manufacturing processes (cutting, drilling, wiring, etc.) are located together to improve utilisation. Different products may require different processes so material flow patterns can be complex.

An example is machining parts for aircraft engines. Some processes (such as heat treatment) need specialist support (e.g. fume extraction), while other processes (e.g. machining centres) need technical support from machine setters/operators. So the factory will be arranged with heat treatment together in one location and machining centres in another. Different products will follow different routes around the factory.

2. Cell layout

In a cell layout, the materials and information entering the operation are pre-selected to move to one part of the operation (or cell) in which all the machines to process these resources are located. After being processed in the cell, the part-finished products may go on to another cell. In effect, the cell layout brings some order to the complexity of flow that characterises process layout.

An example is specialist computer component manufacture. The processing and assembly of some types of computer components may need a dedicated cell for manufacturing parts to the quality requirements of a particular customer.

3. Product Layout

Product layout involves locating the machines and equipment so that each product follows a pre-arranged route through a series of processes. The products flow along a line of processes, which is clear, predictable and relatively easy to control.

An example is automobile assembly, where almost all variants of the same model require the same sequence of processes.

Detailed Design of the Layout

Once the basic layout type has been decided upon, the next step is to decide on the detailed design of the layout to determine:

- The exact location of all facilities, plant, equipment and staff that constitute the 'work centres' of the operation.
- The space to be devoted to each work centre.
- The tasks that will be undertaken by each work centre.

General Objectives

The general objectives of detailed design of factory layouts are:

- *Inherent safety*. Dangerous processes should not be accessible without authorisation. Fire exits should be clearly marked with uninhibited access. Pathways should be clearly defined and not cluttered.
- *Length of flow*. The flow of materials and information should be channelled by the layout to fit best the objectives of the operation. This generally means minimising the distance travelled by materials.

- *Clarity of flow.* All flow of materials should be clearly signposted, for example using clearly marked routes.

- *Staff comfort.* The layout should provide for a well ventilated, well lit and, where possible, pleasant working environment.

- *Management coordination.* Supervision and communication should be assisted by the location of staff and communication equipment.

- *Accessibility.* All machines, plant and equipment should be easily accessible for cleaning and maintenance.

- *Use of space.* All layouts should make best use of the total space available (including height as well as floor space). This usually means minimising the space for a particular process.

- *Long-term flexibility.* Layouts need to be changed periodically. Future needs (such as expansion) should be taken into account when designing the original layout.

Mapping the Process

In order to comprehensively compile all the intricacies of operation it is necessary to map each of the relevant processes by flow-charting. Process flow charts are a diagrammatic representation of individual processes that show:

- Each work-centre (ie piece of machinery, storage area or inspection area).

- Sequencing of operations.

- Material and information flow.

Creating a Relationship Chart

Optimising the layout requires an understanding of the relationships between the various work-centres within the factory. To create a relationship chart, first take the various work-centres from your Process Flow Charts and list them in the left-hand column of the Relationship Chart. The matrix to the right of that list provides a cell for the relationship (or proximity rating) between every pairing of work centres. Within those squares you write a rating for each of those relationships.

A proximity rating is a simple weighting that reflects the desirability of physical proximity between any two work-centres. Production entities that have complicated or high volume material flow between them acquire a high proximity rating. Conversely, those entities which have undesirable interaction, (e.g. one process introduces contaminants into the other), have a negative proximity rating applied. Whether such work-centres are separated by distance or a physical barrier can be determined later. Standard proximity ratings are listed below:

A   Absolutely necessary: High rate of material transfer or materials that are cumbersome to handle

E   Extremely important: Moderate rate of material transfer or materials that are somewhat cumbersome to handle

I   Important: Would be nice to have them close together, but proximity is not vital

O   Ordinary: Would be handy on occasions or for minor jobs to have them close together

U   Unimportant: Doesn't matter if they are near or not; the entities are unrelated

X   Undesirable: Would be better if they could be kept separated

Z   Extremely undesirable: Dangerous if near or likely to be highly disruptive to one or both of the operations

Criteria that can be used to determine proximity ratings are requirements for shared supervision, shared personnel or equipment, ease of service, personnel travel and communication requirements and presence of contaminants (e.g. noise, dirt, oil and vibration). Once a proximity rating has been assigned between all of the entities you can begin redesigning the plant layout to satisfy these requirements.

Developing a Block Layout

The next step in the design process is to assign areas and in some cases (e.g. very tall equipment) volumes to each of the given entities based on current and expected needs. These are then positioned on a diagram of the building to produce a "block layout".

The block layout is really a concept level layout that assigns sufficient space for each work-centre so the operator can then work to locate them to optimise the flow of materials and address other constraints that are captured in the relationship chart. The goal is to move the various entities around until the relationship chart is best satisfied. The best way to do this is modifying a CAD drawing of the layout. This allows simple modification, accurate measurement of distances and areas, and the ability to create several different proposed layouts.

The way to satisfy the constraints of the relationship chart is to address all the 'A' relationships first and try to locate work-centres such that all the work-centres with an 'A' relationship have a minimal distance to their related work-centre. i.e. If Packing and Dispatch had an 'A' relationship as they often would, you want to minimise the distance between those two work-centres. You then work on each of the other relationship weights in order of importance; 'E', 'I', etc.

Trends in Factory Construction and Design

Technology

Whether it is a room that has the capacity to sense carbon dioxide, changing ventilation accordingly to reduce energy usage, building in accordance with green standards, or utilising technology to better manage resources, including time and money, the construction industry, as well as end-users, stand to benefit from increasingly innovative tools and materials.

The three biggest themes impacting on the construction industry are:

- The adoption of big data and data driven design.
- Increased use of virtual reality and visualisation applications in the field, utilising digital technology to capture reality.
- Construction intelligence, which looks horizontally across operations to optimise unit costs and minimise wasted time and money.

Sustainability

Incorporating sustainability initiatives into factory design is a win-win proposition, mitigating harmful effects to the environment, encouraging worker safety and comfort and winning respect from customers and the community. Moreover, sustainable measures also lower operating costs, ultimately improving a company's financial performance.

Initiatives can include energy efficient lighting and occupancy sensors, using recycled materials and implementing recycling practices, installing solar panels and smart building or energy management systems and using high-volume, low-speed networked fans to cool indoor temperatures instead of air-conditioning.

Space Saving

Efficient use of space is essential to successful factory design and operation, lowering construction costs and facilitating ease of operations. One area where new innovations in design can save space is the fitting of more efficient industrial doors.

Compact sectional folding doors meet the requirements of designers and building owners by providing more usable space for services, loading bays, crane gantries and vehicle maintenance equipment. On opening, the compact door folds upwards within the side tracks above the door space. The rail system, without the use of balancing springs and with a smooth and quiet movement, also uses little energy, guaranteeing a long life cycle.

Conclusion

You want your factory to run like a well-oiled machine – and it will, if both you and your design/construction team cover all the bases with care and immaculate attention to every detail. Good design is about problem solving and, in the end, is good for business on every level – from efficiency to safety, cost reduction to waste reduction and from productivity to workplace satisfaction.

In fact, with the right experts to guide you through the whole process your plant may be so successful you could soon be considering expansion – so ensure flexibility and the ability to grow are worked into the preliminary design at the outset.

Over time, factors such as equipment, machinery and personnel numbers will inevitably change, so be sure to undertake a review at least annually of workflow and other essentials to guarantee your well-planned and efficiently run facility continues to operate smoothly and productively.

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