PRELIMINARY PROBLEMS IN THE DESIGN OF MANUFACTURING BUILDINGS.*

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The actual design of a manufacturing building, as a structure which is to be built of certain materials, to carry given loads, does not, as a rule, present any engineering difficulties which cannot be satisfactorily solved by the usual methods given in books that treat on this subject. It resolves itself simply into the problem of ascertaining, as nearly as possible, the stresses which the loads produce, and of proportioning the materials to take care of these stresses. The preliminary problems, however, which fix the nature of the building, its size, shape, arrangement, the materials to be used, and the loads to be provided for, all form an immensely broader subject, extending beyond the bounds usually set for the engineer, and touching the very heart of the world of business and manufacturing.

These preliminary problems bear the same relation to the detail design that the work of the locating engineer, on a new railroad, bears to the work of the man who stakes out the line, only in the case of manufacturing buildings they are more complexed. In the following discussion, the writer will endeavor to show how exceedingly complex the designing of a manufacturers' building may be, and the relation of the engineer to this only partially developed field of work. Older members of the Engineering Society will probably find little in it of interest or profit, for it is written for the purpose of stimulating the minds of the younger members by suggesting lines of thought which will tend to broaden their ideas of the profession they have chosen.

Before one can appreciate the complexity of the problems which the design of manufacturing buildings presents it is necessary that he have a thorough knowledge of building materials and the special use for which they are adapted.

With all this data at his finger tips, he is in a position to consider the preliminary problems relating to the design of any particular plant. These problems may be discussed under their heads.

1. The problems of utility.
2. The problems of location.
3. The problems of finance,

but while the discussion may be thus separated, in an actual case, the problems are so interdependent that they must be weighed, one against the other, in order to attain the highest possible efficiency. Efficiency in this case means the greatest ultimate value for every dollar expended.

Some of these problems can be handled by means of mathematics, with precision. Some can be settled by the obtaiiing of definite data. The facts once known, the question is settled beyond discussion. Some conclusions are reached instinctively, or through natural habit without conscious thought. But by far the larger part are a matter of judgment and the more highly this faculty is developed in the designer, the greater his knowledge, the wider his experience, the more accurate will be the solution.

The use to which the building is to be put, will, of course, largely determine the general type of design. In many lines of manufacture the building is virtually a tool or machine, and as such it should have the same careful attention of an expert as is given to any part of the equipment. Many a plant with the latest and most expensive machinery is handicapped for all time by the poor design of the building that contains it.

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Plants for the manufacture of similar products will probably resemble each other, but need not necessarily be alike, for different methods, different ideas or special conditions may mean an entirely different lay-out. Fortunately the designer is not usually called upon to design the process of manufacture, but it is essential that we have a thorough understanding of the routine through which the materials have to pass.

The amount of floor space, head room, light, ventilation, etc., that each process will require must be decided upon. The question of light receives a great deal more attention these days than formerly, and the effect on the design is quite marked. The different rooms or buildings must be so arranged that the materials may pass from one to the next with the minimum amount of handling or transportation. Provision must be made for the receiving of raw materials and for the shipping of the finished product. Necessary store rooms must be provided at convenient locations. The power plant should be so located as to make the distribution of power convenient and economical. The same rule applies to the heating and lighting plants and waterworks system, and all this must be done with an eye to the health, convenience and safety of the employes.

The method and order of erection must always be kept in mind. The cost of putting certain materials in place may be greatly increased unless the work can be done in a certain order, or at a particular time.

Problems of Location.

The actual location of a manufacturing building is usually determined by the owner from business consideration with which the designer has nothing to do, but the site once fixed, the effect on the design of the building or plant is far-reaching.

For every line of manufacturing there is an ideal lay-out, but to realize it one would have to have an ideal site, ideal facilities for obtaining power, labor, materials and transportation, an ideal climate, and an ideal balance in the bank. Since such conditions are seldom, if ever, obtainable, it becomes the designer's aim to adapt his design to the special conditions and circumstances, and make the best use of what he has.

The nature of the climate where the building is to be erected must be taken into consideration. The extremes of heat and cold, the violence of storms, the possibility of cyclones and earthquakes, the maximum snow fall the roof will have to sustain, the depth of the frost line for foundations, etc., are some of the questions that depend on the climate. If the plant is to be operated throughout the winter in a northern locality, the problem of heating becomes an important item. As a rule it is poor economy to put up a cold building and then install an expensive heating system to keep it warm. Apart from the mistakes made in this particular, nearly all the other questions will be taken care of by following local customs which have been found to give the most satisfactory results after long years of trial.

The locality in which the building site is situated also has a very important bearing on the design. The very nature of the building will depend upon the facilities for obtaining building materials and their cost. The conveniences for transportation and handling heavy girdles, etc., must often be considered. The designer must not only have a knowledge of the cost of brick, lumber, cement, stone, steel, terra-cotta, etc., at the place where they are produced, but must know the nearest source of his supply, the transportation charges, duty, etc., and the cost of labor required for placing the materials in the building. These latter considerations often prohibit the use of what would otherwise be economical and desirable construction.