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THE DESIGN OF STEEL WORKSHOP BUILDINGS TO SUIT COLONIAL CONDITIONS

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INTRODUCTION.

To describe fully the method of design and the reasons for departure from the American, British and Continental orthodox methods of design and construction of steel workshop buildings, required more time than was at the author's disposal. He therefore described the most important details; important from the fact that they were so often neglected, or that they were departures from orthodox practice. He also assumed that the members present had a general knowledge of the theory of braced structures.

GENERAL SURVEY.

Here in the Colonies there seemed to be two distinct types of design, the one type one might say to be foreign, the other too Colonial. These types were produced in several ways. Frequently one met with engineers who had come from other parts of the world, who, when requiring some new workshop or extension, had designs prepared and structures built, which, though they might be the most economical in the place whence the engineers came, were not at all economical here. Sometimes, though seldom, the structures were imported ready for erection. This also accounted for the foreign type. Here where so few draftsmen were employed, as compared with the number of workmen, a mechanical draftsman may be called upon to design some extension to the workshops, and, perhaps, having had but little experience in such design, he immediately consulted British or American textbooks, with the result that a foreign type of structure was erected. At other times, a manager or designer ignorant of the loads on, and strengths of the various parts of a structure, half designed and half judged the dimensions of the various parts, with the result that there was a great waste of material in some parts, and insufficient material in others, and often the nature of the stresses was unknown, judging by the style of structure erected.

There were several distinct reasons for departure from British and American practice. These might be classed under the following headings:—

(a) Different social conditions;

(b) Difference in cost of material;

(c) Different labour conditions;

(d) Difference in climate.

(a) Social Conditions.—The social conditions of this country were very different from those of both Britain and America. An investor of money in workshop buildings should always count on the co-operation of workmen, but as this co-operation was so necessary and yet so uncertain, investors would not put their money into any but the cheapest type of structure. Again, the policy of the present Government to monopolise all industries, made the investor mean as regards first cost. Under the Government's policy the various departments must build the cheapest structures, otherwise the interest on the capital invested in building would exceed the profit of the department, should there be any. These social conditions, therefore, made it advisable to build cheap and short-lived structures, designed to save labour, at the expense of a little more material.

(b) Cost of Material.—The steel used in building was largely imported, either from Britain or America. The variety of sections obtainable was limited, thus further limiting the prospect of economic design. Limited quantities of a limited number of sections were obtainable of Colonial production. The cost of steel on the market here was considerably higher than in either America or Britain, but in the distant future this might, to a great extent, be modified. The duty on structural work was higher than the duty on plain rolled sections. This should assist in promoting Australian manufacture of structures. In Britain labour was cheaper. This would possibly account for the cheapness of the product. In America the wages were higher, but, owing to the perfect and up-to-date system of management, the production was cheap. There was no reason why, in the future, the Australian product should not be cheaper than the imported, if the social conditions prevailing were rectified. This increased cost of material was not so great, relatively, as the cost of labour here.

(c) Cost of Labour.—Here, there was very little difference between the cost of skilled and unskilled labour, and the professional staff had not the status, either socially or financially, that they have in either America or Britain. This caused a large number of most promising engineers to leave the country, and some the profession, thus leaving the design in the hands of poorly paid men. It was often proved, as Americans recognise, the highest paid man was the best.

It will thus be seen that plans should be full, so as to minimise the amount of time required for thinking by the workmen. Also more skilled and less unskilled workmen should be employed.

(d) CLIMATIC CONDITIONS.— In this State there were but few places that necessitated an allowance for snow, and the buildings here considered were not designed to suit these places. Again, the rate of rainfall here was much higher, for the most part, than either Britain or America. The hours between sunset and sunrise differ. The direction and magnitude of wind storms, and the temperatures and range of temperatures differ.

AESTHETICS.

With reference to aesthetics, it would seem that judges of "appearance" and schools of engineering and architectural art, considered that curved forms were almost essential to artistic design, and that straight framing lacked beauty. Curved forms were for effeminate and emotional beauty, and straight forms for masculine and intellectual beauty. The two bridges proposed for North Shore showed this difference. The one approved by the Committee was more effeminate, the other more masculine. The author did not wonder at the difference of opinion on the matter between Mr. Bradfield and the Committee. It was purely a matter of the temperament of the observers. To a woman shown through the engine-room of a large steamer, with reciprocating engines, the cranks and connecting rods might look cruel and merciless, and thus depress her. To the engineer they might look powerful, yet subordinate, and no depression, but the reverse, might be experienced. This was purely a matter of temperament and knowledge. So-called artistic treatment of engineering structures was often a prostitution of a masculine art. Structures that appeared pleasing to the eye of an architect or artist who did not understand their design, might be most repulsive to engineers. Economy of material was beauty to the engineer. To make this economy would be an aim of this paper. Usually, what a manager wanted was a cheap building; what the workman wanted was a comfortable building, and what the designer wanted was a safe, cheap, healthy, comfortable building of good appearance.

The author considered that perhaps the best scheme of explanation was to draft a rough specification, and comment on the more important matters.

GENERAL DESCRIPTION.

DIMENSIONING BUILDINGS.—

(a) In putting the dimensions of a building on a plan of its site, or in supplying same to the estimating clerk, the dimension over-covering should be given for the length and breadth of a rectangular building, and the mean height from the ground floor. The reason for these dimensions being given was that on a site plan the space occupied by a building was required, while the estimating clerk usually wanted to find the cubic content. The dimensions should be written thus:—"a ft. — b in. × c ft. — d in. × e ft. — f in. mean height." The cost per cubic foot of buildings to some extent depended on the proportions of length to breadth to height. But length and breadth were often fixed by the dimensions of the site and the height was often fixed arbitrarily. (Of course always as low as was considered advisable.) Also, as the number of bays, the capacity of the cranes, the arrangement and nature of the machines, are all factors in fixing the most economical dimensions of the shop, no attempt was made to give economical proportions, but a brief survey of the advantages of the various proportions would be made. As regards height; the higher a building, the better the ventilation, and the cooler it would be in hot weather, but there was more material required in covering, more material in columns to withstand the extra wind pressure, and also to make up the extra height. High gable ends in buildings were also difficult to brace cheaply. In the case of buildings with travelling cranes, the height was fixed by the necessary lift of the crane or, maybe, the height to clear some high machine, plus the headroom clearance of the crane. Also an increased height might be chosen so as to provide side light. As regards length and breadth, the covering on the wall would be cheapest if the building was square and the walls of equal height, but the higher gable end would make it more economical to increase the length slightly. The increase of length made more covering necessary, a large number of columns in the length, and more trusses, but reduced the number of columns in the gable end. Large flat surfaces, especially when high, were costly to brace, and might take up considerable floor space. The cost of trusses per foot of span did not increase much up to 60 ft., and very little even up to 80 ft. The disadvantage of the larger span was to be seen in shops where machines are belt driven. Also large spans increased the cost of travelling cranes, especially of cranes of small power. The most up-to-date method of power supply to machines was to drive direct with variable speed motors, and thus eliminate all the expense in shafting pulleys, countershafts, belting, friction, oiling, etc. This method also had the advantage that a machine could be placed in any part of the shop, facing any direction, and be cheaply connected to the power supply.

This system of power supply would tend to increase the spans of the shops. The advantage of several bays was that the one sheltered the others from the wind, and there was less wall covering. There were, however, disadvantages in the case where cranes were provided, and heavy weights were required to be taken from one shop to th other; also when the roofs were of the same height, all light must come from the roof.

(b) In the general arrangement, the capacity and span of the crane, if any, and the height of the crane track should be given, the centre to centre of roof truss bearing and height to underside of truss tie, and the length of the buildings, and number of columns and spacing centre to centre.

The particulars mentioned here were obviously those most frequently required, and they should be placed beneath the title thus when there was no crane:—

"A Shop."

Length=B columns c′—d″ centres =r′—s″
Height to truss=E′—f″
Span of truss=G′—h″

When there was a crane:—

"A Shop."

Length=B columns c′—d″ centres=r′—s″
Span of truss=M′—N″
e′—ton crane f′—g″ span. Track height H′—J″
Headroom K′—L″

Type of Structure.—The type of structure recommended had a galvanised iron covering on oregon purlins, with steel framing.

Galvanised corrugated iron was the cheapest form of fireproof covering, but it had the disadvantage of making a hot building in summer, and a cold one in winter. Possibly fibro-cement may in the future to some extent take the place of iron, but not at present when cost was considered. In some particular cases where acid fumes are given off in the shop, other covering materials are necessary, but these would not be considered here. Some roofs are quite good after forty years. Oregon purlins were chosen because they are cheaper than steel, also the fastening of the corrugated iron to them was much cheaper than to the latter. There was no danger from fire, as there was insufficient connection to assist a fire in spreading.

LOADS.

DEAD LOADS.—Dead loads should consist of the weights of all permanently fixed parts of a structure or attachments.

24 gauge iron, with 4in. x 2in. oregon purlins, was taken at 2.5lbs. per square ft. projected area on roof.

¼in. glass at 3½lbs. per square foot.

Concrete at 150lbs. per cubic foot.

Oregon at 32lbs. per cubic foot.

Steel at 490lbs. per cubic foot.

Sand, clay, and earth, dry, 100lbs. per cubic foot.

Sand, clay and earth, wet, 120lbs. per cubic foot.

Weight of glazing and bars with purlins, 6½lbs. per square foot.

Weight of glazed sashes	2 lbs. per. sq. ft.
Weight of glazed louvres	10 " " " "
Weight of wooden louvres	8 " " " "
Minimum dead load allowed on roofs	10 " " " "
Weight of trusses may be assumed as 35lbs. per ft. run.	
Load per square foot of factory floors not less than	150 " " " "
Do. do. foundry floors	300 " " " "

SNOW LOADS.—No snow load was allowed, as the buildings were not intended for districts where snow was possible.

WIND LOADS.—On the sides and ends of buildings not exceeding 30ft. in height, and not in particularly exposed positions, 15lbs. per square foot was allowed. In exposed positions and higher buildings, 20lbs. per square foot. No allowance was made for partial loading, unless reasonable stiffness was not supplied. But stiffness was not to be considered as taking uniform wind pressure loads. The normal wind pressure on roofs would be computed by Duchemin's formula:—

$$Pn = \frac{P2 \sin A}{1 + \sin^2 A}$$

Where P = 20lbs.
A = angle roof makes the horizon.
Pn = pressure normal to roof.

and was taken as 13lbs. per sq. ft. for 1/5 pitched roofs.

It should not be presumed that, in stating the above allowance for wind, that these were the maximum wind pressures possible on a building. What was meant by supplying these pressures was that provision should be made for this pressure with the tresses per sq. in. given.

Opinions of different engineers on wind pressure were so varied that the author considered it deserved considerable thought. At one time 56lbs. per square foot for wind was considered the proper allowance, and in some countries at home this provision was enforced. The Board of Trade allowance was 56lbs. per square foot, but the wind pressure allowance had been greatly reduced in later years, as the result of experiment and observation. The wind pressure was a big item in the design of some structures as bridges, towers, buildings, etc. In workshop buildings it sometimes happened that 75 per cent. of the material was to resist wind pressure. It would thus be seen that while we must make a safe allowance, we must, at the same time, not over-estimate the pressure to be allowed for. It had been for some years common to allow 30lbs. per sq. ft. wind pressure. The building