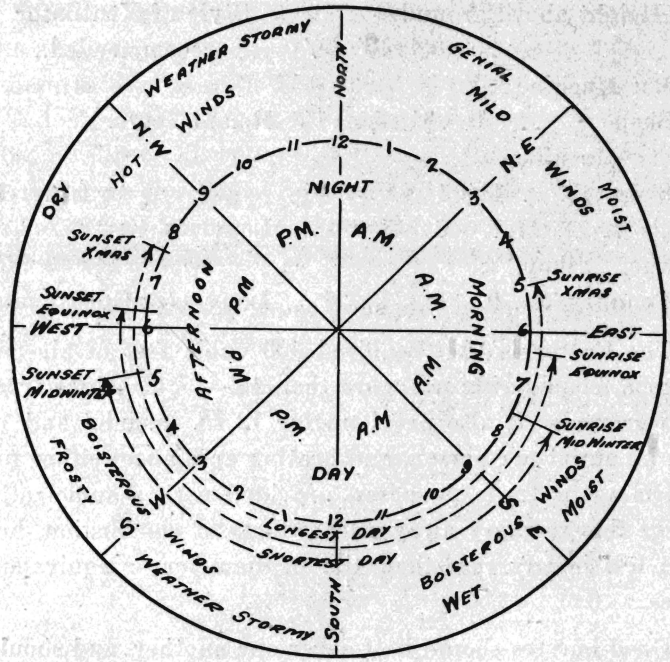
Height above ground—	20′	30′	40′	50′	Style of Ventilator recommended.
Clean Machine Shop ..	⅞	¾	⅝	½	Round Vents.
Dirty Machine Shop ..	1¼	1	⅞	¾	„ „ or Louvres.
Mills	7	6	5	4	Louvre Vents.
Forge, Shop, Foundry, &c.	9	8	7	6	Louvres or Open Vents.

The Factories' Act required 400 cubic feet of air per person, considering not more than 14′—0″ of height from the ground. It also provided for 12 sq. in. inlet and 12 sq. in. outlet per person, and heating appliances either for warming or trade purposes, provided with a sufficiently large flue to carry away all products of combustion, but not less in any case than 4in. in diameter or equivalent area.

Good louvres should half cover one another, and should be at a greater angle to the horizon than 45°.

It was impossible to keep louvres from letting in the rain when there were heavy winds. Sometimes gauze was tacked over them. This was a good plan. It was always advisable to put louvres facing away from the wind, if possible. Glass louvres supplied light as well as air, but were dearer than wooden louvres. Steel louvres were sometimes made, but were more expensive than wooden. Wooden louvres should be painted. Sometimes in foundries, etc., large openings unprotected from the weather were left. These were always objectionable.

With the wind's course as indicated, the following diagram, taken from the Sanitary Inspector's text book, indicated the weather to be expected from the various quarters, and also the hours of the sun above the horizon (see Fig. 3) :—



ASPECT COMPASS.

N.S.W.

FIG 3.

LIGHT.—The amount of light required in a workshop depended largely on the class of work done. In other parts of the world it was becoming the practice to glaze the whole of the roof. Windows should be provided in exterior walls equal to not less than 10 per cent. of the entire exterior surface in mill buildings, and of not less than 25 per cent. in machine shop factories and similar buildings. At least half the lighting should preferably be by means of skylights or sashes in the sides of ventilators. Skylights should be glazed with wired glass preferably, but if unobtainable common mill rolled glass may be used, with wire netting securely fastened beneath to guard against falling glass. Patent glazing bars are to be used with glass ¼in. thick and 2ft. wide. Glass should not exceed 10ft. in length, owing to the great care necessary for handling long lengths.

The direct glare of the sun was sometimes objected to, and in some parts of the world saw-tooth roofs were becoming very prevalent, with the glazing facing away from the sun, i.e., to the north in the Northern Hemisphere, and to the south in the Southern. If one looked round Sydney, one will see what were called northern lights facing all the points of the compass. Here they should be called southern lights, and face the south. The trusses, etc., of saw-tooth roofs were dearer than the common truss, and a modification of ventilator, indicated later, was considered as good as the saw-tooth roof. Light reflected from the sky did not cast shadows, but the saw-tooth roof had the objection that all the light came in the one direction.

SASHES.—should be made of pine, 2in. thick framing, 16oz. glass. Sashes were classed by the number and dimensions of lights. The most common size of lights are 10in. x 8in., 10in. x 12in., 10in. x 14in., 10in., x 16in., 12in. x 14in., and 12in. x 16in.

All woodwork on sashes should be given two good coats of paint.

DOORS.—Doors should be preferably sliding. 2½″ finished pine was a reasonable thickness.

Balanced upward sliding doors should not be used on account of the danger of them falling.

PURLINS AND GIRTS.— Purlins and Girts were to be spaced to suit the following table for sheets of iron:—

Length of sheet in feet.	Number of supports for gauges.					
	16	18	20	22	24	26
5	2	2	3	3	3	3
6	2	3	3	3	3	4
7	3	3	3	3	4	4
8	3	3	3	4	4	4
9	3	3	4	4	4	5
10	3	3	4	4	5	5
12	3	4	4	5	5	6
Maximum spans	6′—0″	4′—9″	3′—9″	3′—0″	2′—9″	2′—3″

They were to be of oregon 4″ x 2″ for 12′—0″ span, and should span two truss panels. If there was an odd number of panels the short lengths of purlins were not be used near the end of the building. The joints were to be scarfed and bolted to the junk pieces. In any minor bracing with oregon the equivalent of a factor of safety of four should be adopted.

PROPORTION OF PARTS.

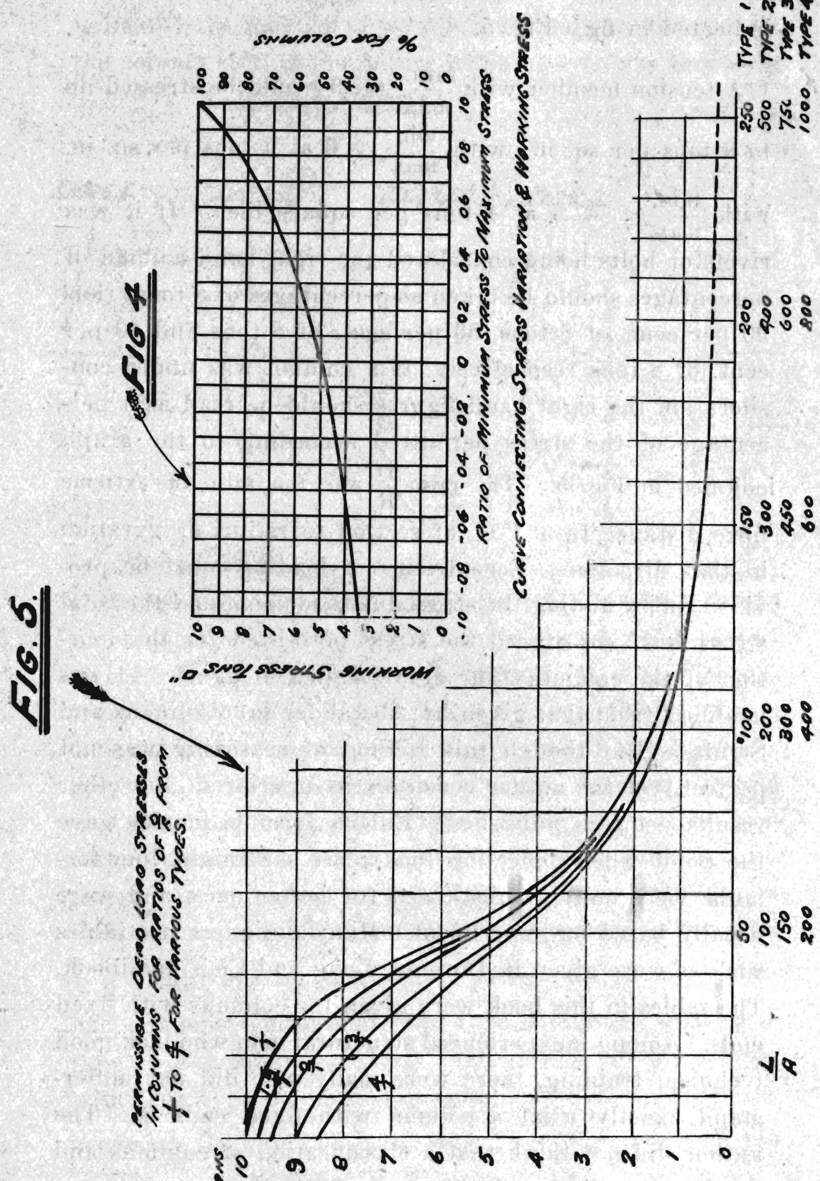
When proportioning the various parts it was usual to allow for the effect of change of stress as provided for in the formula.

$$\text{Breaking strength} \quad \frac{\frac{1}{2}\ \text{breaking strength}}{1 - \frac{1}{2}\ \dfrac{\text{maximum stress}}{\text{minimum stress}}}$$

This was Prof. Lilly's formula, and it was based on Wohler's endurance tests. Allowing a factor of safety of 3 on breaking strength or 1½, on elastic limit covered approximation in calculation. Allowing for 30 tons breaking strength and 15 tons at elastic limit the formula then became—

$$\text{Working stress} = \frac{5}{1 - \frac{1}{2}\ \dfrac{\text{min.}}{\text{max.}}}$$

The allowable stresses for various ratios of minimum to maximum were found from the following curve:—Fig. 4.



If the member be a column, the figures to the right should be taken as a percentage of the stress allowed as indicated in fig. Fig. 5.

A tension member with $\frac{\text{min.}}{\text{max.}} = .9$ would be stressed up to 9 tons per sq. in., with $\frac{\text{min}}{\text{max}} = 0$ at 5 tons per sq. in. with $\frac{\text{min.}}{\text{max.}} = -.5$ at 4 tons per square inch. If it was rivets or bolts being considered the right hand column of percentages should be taken as percentages of 8 tons; thus 90 per cent. of 8 tons, 50 per cent. of 8 tons and 40 per cent. of 8 tons respectively. If a column was under consileration the right hand figures should be read as a percentage of the stress permitted according to the graph indicated in Fig. 5. The ratio $\frac{D}{R}$ was the ratio of extreme fibre distance from C.G. of section to radius of gyration in that direction. Eccentricity of loading must be provided for by adding the stress due to moment and the total stress must not exceed the stress permitted for that portion of the column. The curve shown in figure (4) was modified from that given by Alexander in "Columns and Struts." But though this method of reasoning was not perfect, yet the author considers it superior to any other results yet seen published. Euler's formula merely gave the point when deflection took place. Straight line formulæ were merely substituted for better ones, and were usually based on experiment. Many designers use tables such as were given in Dorman, Long and Co.'s handbook. The tables in this book were given for columns with fixed ends. Among inexperienced structural men who lack good technical training, there were many who did not understand exactly what a column with fixed ends is. The author did not think that a classification of columns and possible practical references would be amiss. Columns were classified in four definite types according to the nature of the end fixings as indicated in the fig. 6. These indicated the manner of side flexure, and the divisions of the column suiting the nature of fixing. It was thus seen

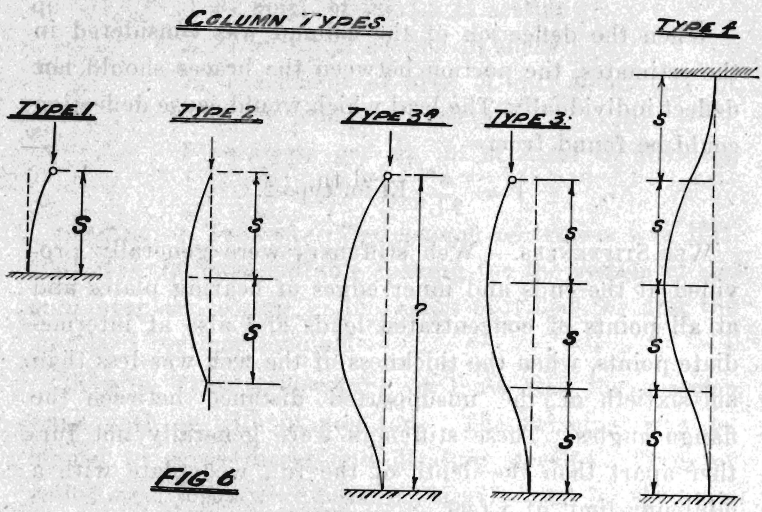


FIG 6

that for columns of equal length the ratio of the strengths of columns of type 1, 2, 3, 4, was not as 1:2:3:4 respectively. If the strengths were uniform then the lengths were for type 1, 2, 3, 4 as 1:2:3:4: respectively. Types 1 and 2 were common. The ideal form of 3 was seldom met with, but a modification as in 3a was common. Type 4 was sometimes used, but its type number in practical conditions seldom was better than 3.5. Type 3a could be considered as equivalent to type 2.5. Columns with square ends had type number from 2 to 4 according to the ratio of $\frac{L}{R}$ The greater this ratio was the nearer the square end columns approximated to type 2 and the smaller to type 4. But square end tests were suitable for comparison with true type columns. In columns where rigidity was necessary the value of $\frac{L}{R}$ for type 2 should not exceed 150 and its equivalent for other type numbers.

The net section of members and parts whether in tension or compression was considered in estimating stresses. The compression flange of girders and the portion between braces on columns were to be figured as columns.

When the deflection of the column was considered in the estimates, the portion between the braces should not deflect individually. The load which would cause deflection could be found from—

$$P = \frac{\pi^2}{2\,L^2}\,EI \text{ for type 2.}$$

WEB STIFFENERS.— Web stiffeners were generally provided at the ends and inner edges of bearing plates and at all points of concentrated loads and also at intermediate points, when the thickness of the web was less than one-sixtieth of the unsupported distance between the flange angles. These stiffeners were generally not further apart than the depth of the full web plate with a minimum limit of 5 feet.

DEPTH OF BEAMS.—When great deflection was undesirable, the depth of rolled beams became less than one-twentieth of the span, and the depth generally did not exceed one-thirtieth of the span.

CRANE TRACKS.—60 lbs. B.S. rails were to be used for cranes up to 30 tons and 80 lbs. for cranes up to 60 tons.

Rolled steel joists were to be used and the rails are to be riveted to same with a sufficient number of rivets to form a compound beam. The joints in the rail and the beams were to come over the same support and the girder was not to be considered as continuous. The shear between the rails and joist was found from the following formula:—

$$P_s = \frac{S}{I\,Z}\int_{y}^{y'} y\,Z\,dy \text{ for shear at any plane.}$$

which when modified to suit present conditions:

$$P^s = \frac{S\,X}{I\,Z}$$

Where S = total shear in section
I = mom. of inertia of section
Z = width of section in shear
X = moment of area of rail about C.G. of compound section.
P^s = stress per sq. in. in shear or dividing plane.

SPACING OF TRUSSES.—The spacing of trusses was 12ft. This was the most suitable spacing for the system of design proposed owing to the loads provided for and the standard sections available.

TYPE OF TRUSS.—The type of truss was the common truss with or without monitor. The principal was designed to carry direct and bending stresses. Tees or rolled steel joists were to be preferably used for the principal according to the requirements.

SLOPE OF ROOF.—The pitch of the roof was 1/5th. The steeper slopes sometimes used were to prevent snow from lodging and to prevent rain from driving up the laps in the iron. No snow was allowed for, so that the flat roof had no objections on that account. 1/5th pitched roofs were found to be satisfactory in driving rain, and as it was cheaper to keep the slope as small as possible the pitch of 1/5th had been adopted.

TRUSS BEARINGS.—The truss bearings were to be considered as fixed. Trusses were seldom adopted with roller bearings for this class of work, as they were dearer and the extra expense was not warranted.

COLUMNS.—The columns were to be rolled steel joists braced together with longitudinal ties and diagonal braces in every third panel.