Another condition which is equivalent to increasing the cost of material arises from the fact that a company in Australia has to carry a large amount of stock, which represents so much dead capital or which may be covered by a bank overdraft on which interest has to be paid. Assuming that a firm carries 4,000 tons of stock, costing, say £36,000, and that the annual sales amount to 6,000 tons. This means that the whole of the stock is carried on an average for 8 months before it is sold, during which period interest has to be paid which will amount to about 7/- per ton of material stocked. This amount should not, however, be added to the cost of the material but is included later as part of the "on-cost" or "establishment charges."

Suppose it is required to estimate the cost of 20 plated girders, each consisting of 1 R.S.J. 18in. x 7in. x 75lbs., and two flange plates 12ins. x ⅝ins. x 38ft. long, with ¾in. rivets spaced 6in., c to c.

The cost per ton of the R.S.J.'s would be:—

| | £ | s. | d. |
|---|---|---|---|
| Cost C.I.F. and E., Sydney, Basis Price | £9 | 0 | 0 |
| Extra for Section | 0 | 10 | 0 |
| Extra Freight for Length, say | 0 | 5 | 0 |
| Oiling (if any) | 0 | 2 | 6 |
| Duty | 0 | 17 | 6 |
| Stacking Charges at Wharf | 0 | 0 | 9 |
| Cartage to Works, say | 0 | 4 | 6 |
| Total cost per ton at Works | £11 | 0 | 3 |

The cost per ton of the plates would be:—

| | £ | s. | d. |
|---|---|---|---|
| Cost C.I.F. and E., Sydney, Basis Price | £9 | 5 | 0 |
| Extra Freight for Length, say | 0 | 5 | 0 |
| Oiling (if any) | 0 | 2 | 6 |
| Stacking Charges at Wharf | 0 | 0 | 9 |
| Cartage to Works, say | 0 | 4 | 6 |
| | £9 | 17 | 9 |

In addition to the above, there would be the cost of the rivets, which carry a duty of 25 per cent. ad valorem and would cost at the works about £15 10s. per ton.

It is evident that for a large estimate it would save considerable time to average the cost of material delivered at the works but it is liable to lead to serious error in some classes of work.

As before intimated, the architect's drawings will in general show only the main sections of the stanchions and girders;

but the connections of beams to girders and girders to stanchions and the design of stanchion bases are usually left to the steel contractor. This method of supplying information for tendering purposes would be all right if it were accompanied by information giving the loads to be carried, and by specifications giving the allowable shearing and bearing values on the rivets and the allowable pressure per square foot on the piers, or other foundations, upon which the stanchions rest. But this information is not often supplied with the result that the estimate of the quantity of material in the steelwork details, as made by different firms, will be different. One firm may assume all the beams and girders to be fully loaded and design the connections accordingly with a fair factor of safety, whilst another may allow for as little labour and material as they think they can persuade the particular architect to accept. It is evident that, other things being equal, the latter firm will submit the lowest tender, and it is in the interests of the contractor to accept it. Such conditions as the above emphasise the need of a revised city building law in which definite specifications for this class of work should be incorporated. A clause is sometimes included in the specifications requiring the detail shop drawings to be submitted to the architect before the work is placed in the shop—a clause which is apt to be more honoured in the breach than in the observance. But the position is unsatisfactory, because the steel manufacturer should know definitely what he is to supply when he is asked to tender and not be required to submit his design for approval after his price has been accepted. The position would be different if the tenders were submitted direct to the architect, in which case each tenderer would have the opportunity of specifying the standard of work that he proposed to supply and the architect would not be prejudiced financially to the acceptance of any one of them. For a safe estimate, the only system to follow is to allow for an end reaction, assuming the girders to be fully loaded. The system of loading, whether concentrated or distributed, will generally appear from the plans, although not always, as, for instance, in the case of partition walls for office buildings, which are frequently located to suit the tenant after the building is completed. In such cases, the full carrying capacity of the girder with a uniformly distributed load is all that can be assumed.

In regard to the working stresses for connections, when not specified the following are to be recommended:—

| | |
|---|---|
| Shearing on bolts, with the customary 1/16-inch clearance in bolt holes | 7,500 lbs. per sq. in. |
| Shearing on hand-driven rivets and on fitted bolts, and on all field rivets | 9,000 lbs. per sq. in. |
| Shearing on shop-power-driven rivets | 10,000 lbs. per sq. in. |

In all cases the allowable bearing stresses to be double the shearing.

In cases where the rivets are not in pure shear, as in stanchion connections where filler plates are used, it is better to employ the working stresses a grade lower than those given above. The exact method would, of course, be to calculate the bending on the rivet and allow for the same in the usual manner; but the above method is sufficient for estimating purposes and is frequently adopted in the final work. The above working stresses assume the material in the bolts and rivets to be the best quality steel and the workmanship first-class.

It is evident that the estimator will not have sufficient time to figure out the weights of the various connections, and some firms merely allow a certain percentage of the weight of the main sections to cover the weight of the details. The method certainly has simplicity to recommend it but nothing else. The better way is to provide the estimator with a table giving the weights and carrying capacities of standard connections suitable for various rolled steel joists, showing also the limiting span for which each should be used under a uniformly distributed load. He then takes off the number and character of each connection, obtaining the weight direct from the table. The following table illustrates a set of standard connections designed for a shear of 7,500 lbs., and bearing of 15,000 per square inch.

Some people advocate the use of diagrams instead of tables, but a diagram indicates a continuous variation in weight, whereas, if standard connections are used, the same connection may be employed for several girders to simplify the shop work.

Where two beams frame into opposite sides of the same girder the connections will probably be governed by the bearing capacity of the bolts or rivets on the web of girder, in which case connections heavier than the standard may be required. In the case of one or two connections, the difference would be immaterial for estimating purposes, but it would not be so if the connections were repeated throughout the building. The last four columns in the preceding table indicate the value of the connection with the bolts in single shear, and with bearing on a ⅜in., ½in., and ⅝in. web respectively.

The weights and carrying capacities of seatings for supporting beams and girders at the stanchions will evidently vary with the width of the stanchions, as well as with the end reaction of the girder. A table will therefore be required for each width of stanchion flange. This means a little expenditure of time and labour, but once prepared they are always available for instant reference. The following table is given as an example, the shear on the rivets being taken at 9,000 lbs. per square inch.

## Standard Connections for British Standard R.S. Joists.

| R.S.J. | Span | Conn. No. | Total Weight. | Strengths in Tons | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Rivets. | Bolts. | | | |
| | | | | | Single Shear. | Bearg. on ⅜ Web. | Bearg. on ½ Web. | Bearg. on ⅝ Web. |
| in. in. tons. | | | | | | | | |
| 24 x 7½ x 100 | 18 ft. - 25 ft. | C 1 | 62·2 | 32·9 | 32·2 | 35· | 46·8 | 58·6 |
| | 25 ft. up. | C 2 | 38· | 21·9 | 24·1 | 26·4 | 35·2 | 43·9 |
| 20 x 7½ x 89 | 17 ft. - 23 ft. | C 3 | 49·4 | 25·6 | 24·1 | 26·4 | 35·2 | 43·9 |
| | 23 ft. up. | C 4 | 30·7 | 18·3 | 20·1 | 22· | 29·3 | 36·6 |
| 18 x 7 x 75 | 14 ft. - 20 ft. | C 3 | 49·4 | 23·1 | 24·1 | 26·4 | 35·2 | 43·9 |
| | 20 ft. up. | C 4 | 30·7 | 16·5 | 20·1 | 22· | 29·3 | 36·6 |
| 16 x 6 x 62 | 12 ft. - 18 ft. | C 5 | 37·2 | 19·8 | 20·1 | 22· | 29·3 | 36·6 |
| | 18 ft. up. | C 6 | 24·3 | 13·2 | 12·1 | 13·2 | 17·6 | 22· |
| 15 x 6 x 59 | 14 ft. - 18 ft. | C 7 | 29·2 | 14·6 | 16·1 | 17·5 | 23·4 | 29·3 |
| | 18 ft. up. | C 6 | 24·3 | 11·7 | 12·1 | 13·2 | 17·6 | 22· |
| 15 x 5 x 42 | 12 ft. - 16 ft. | C 8 | 21·5 | 11· | 11·8 | 15·1 | 20·1 | 25·1 |
| | 16 ft. up. | C 9 | 16·6 | 8·8 | 8·9 | 11·3 | 15·1 | 18·8 |
| 14 x 6 x 57 | 16 ft. - 22 ft. | C 8 | 21·5 | 12·5 | 11·8 | 15·1 | 20·1 | 25·1 |
| | 22 ft. up. | C 9 | 16·6 | 10· | 8·9 | 11·3 | 15·1 | 18·8 |
| 14 x 6 x 46 | 16 ft. - 20 ft. | C 8 | 21·5 | 9·8 | 11·8 | 15·1 | 20·1 | 25·1 |
| | 20 ft. up. | C 9 | 16·6 | 7·9 | 8·9 | 11·3 | 15·1 | 18·8 |
| 12 x 6 x 54 | 18 ft. up. | C10 | 16·2 | 12·5 | 8·9 | 11·3 | 15·1 | 18·8 |
| 12 x 6 x 44 | 15 ft. up. | C10 | 16·2 | 10·2 | 8·9 | 11·3 | 15·1 | 18·8 |
| 12 x 5 x 32 | 10 ft. - 17 ft. | C10 | 16·2 | 8·6 | 8·9 | 11·3 | 15·1 | 18·8 |
| | 17 ft. up. | C11 | 11·6 | 5·2 | 5·9 | 7·5 | 10· | 12·5 |
| 10 x 8 x 70 | 14 ft. up. | C12 | 18·2 | 11·6 | 11·8 | 15·1 | 20·1 | 25·1 |
| 10 x 6 x 42 | 12 ft. - 18 ft. | C10 | 16·2 | 10·2 | 8·9 | 11·3 | 15·1 | 18·8 |
| | 18 ft. up. | C11 | 11·6 | 6·1 | 5·9 | 7·5 | 10· | 12·5 |
| 10 x 5 x 30 | 8 ft. - 15 ft. | C10 | 16·2 | 9·4 | 8·9 | 11·3 | 15·1 | 18·8 |
| | 15 ft. up. | C11 | 11·6 | 5·7 | 5·9 | 7·5 | 10· | 12·5 |
| 9 x 7 x 58 | 12 ft. up. | C12 | 18·2 | 11·3 | 11·8 | 15·1 | 20·1 | 25·1 |
| 9 x 4 x 21 | 8 ft. - 15 ft. | C13 | 11·4 | 6·3 | 5·9 | 7·5 | 10· | 12·5 |
| | 15 ft. up. | C14 | 7·8 | 3·1 | 5·9 | 7·5 | 10· | 12·5 |
| 8 x 6 x 35 | 11 ft. - 16 ft. | C13 | 11·5 | 8·8 | 5·9 | 7·5 | 10· | 12·5 |
| | 16 ft. up. | C14 | 7·9 | 4·4 | 5·9 | 7·5 | 10· | 12·5 |
| 8 x 5 x 28 | 9 ft. - 16 ft. | C13 | 11·5 | 6·9 | 5·9 | 7·5 | 10 | 12·5 |
| | 16 ft. up. | C14 | 7·9 | 3·5 | 5·9 | 7·5 | 10· | 12·5 |
| 8 x 4 x 18 | 6 ft. - 12 ft. | C13 | 11·4 | 5·7 | 5·9 | 7·5 | 10· | 12·5 |
| | 12 ft. up. | C15 | 7·8 | 2·8 | 3· | 3·8 | 5 | 6·3 |
| 7 x 4 x 16 | 6 ft. - 11 ft. | C13 | 11·4 | 5· | 5·9 | 7·5 | 10· | 12·5 |
| | 11 ft. up. | C15 | 7·8 | 2·5 | 3· | 3·8 | 5· | 6·3 |
| 6 x 5 x 25 | 12 ft. up. | C16 | 5·7 | 4·1 | 3· | 3·8 | 5· | 6·3 |
| 6 x 4½ x 20 | 9 ft. up. | C16 | 5·7 | 3·8 | 3· | 3·8 | 5· | 6·3 |
| 6 x 3 x 12 | 7 ft. up. | C16 | 5·6 | 2·5 | 3· | 3·8 | 5· | 6·3 |
| 5 x 4½ x 18 | 8 ft. up. | C16 | 5·6 | 2·8 | 3· | 3·8 | 5· | 6·3 |
| 5 x 3 x 11 | 6 ft. up. | C16 | 5·6 | 2·2 | 3· | 3·8 | 5· | 6·3 |
| 4¾ x 1¾ x 6½ | 4 ft. up. | C16 | 5·6 | 1·9 | 3· | 3·8 | 5· | 6·3 |
| 4 x 3 x 9½ | 4 ft. up. | C16 | 5·6 | 2·2 | 3· | 3·8 | 5· | 6·3 |
| 4 x 1¾ x 5 | 3 ft. up. | C16 | 5·6 | 1·6 | 3· | 3·8 | 5· | 6·3 |
| 3 x 3 x 8½ | 3 fi. up. | C17 | 3·7 | 1·6 | 2·1 | 3·1 | 4·2 | 5·2 |
| 3 x 1½ x 4 | 2 ft. up. | C17 | 3·7 | 1·3 | 2·1 | 3·1 | 4·2 | 5·2 |

**Note.**—When beams frame opposite each other into another beam, it may be necessary to increase the number of bolts, so that bearing on the web of that beam does not become excessive.

WEIGHTS IN LBS. OF GIRDER SEATS ON FLANGES OF 9″ x 7″ STANCHIONS.

Rivets ¾″ for all Beam Seats up to and including 15″ x 5″, shear 1·7 tons per rivet.

Rivets ⅞″ for Beam Seats 15″ x 6″ and upwards, shear 2·4 tons per rivet.

Top cleats 4″ x 3″ x ⅜″ and stanchion bolts allowed for.

| R.S.J's. | Spans in feet. | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 |
| 6 x 3 x 12 | 13 | 13 | 13 | | | | | | | | | | | | | | | |
| 7 x 4 x 16 | 15 | 13 | 13 | | | | | | | | | | | | | | | |
| 8 x 4 x 18 | 15 | 15 | 13 | 13 | 13 | | | | | | | | | | | | | |
| 8 x 5 x 28 | | 15 | 15 | 13 | 13 | | | | | | | | | | | | | |
| 8 x 6 x 35 | | 33 | 18 | 18 | 18 | 15 | | | | | | | | | | | | |
| 9 x 4 x 21 | | 15 | 15 | 13 | 13 | | | | | | | | | | | | | |
| 10 x 5 x 30 | | 33 | 18 | 18 | 18 | 18 | 15 | | | | | | | | | | | |
| 10 x 6 x 42 | | 41 | 33 | 33 | 18 | 18 | 18 | | | | | | | | | | | |
| 12 x 5 x 32 | | 41 | 33 | 33 | 18 | 18 | 18 | 18 | 18 | 15 | | | | | | | | |
| 12 x 5 x 39 | | 41 | 33 | 33 | 18 | 18 | 18 | 18 | 18 | 18 | | | | | | | | |
| 12 x 6 x 44 | | 49 | 41 | 41 | 33 | 33 | 33 | 18 | 88 | 18 | | | | | | | | |
| 12 x 6 x 54 | | | 49 | 41 | 41 | 33 | 33 | 33 | 18 | 18 | | | | | | | | |
| 14 x 6 x 46 | | | 49 | 41 | 41 | 33 | 33 | 33 | 18 | 18 | 18 | | | | | | | |
| 14 x 6 x 57 | | | | 49 | 41 | 41 | 33 | 33 | 33 | 33 | 33 | 18 | | | | | | |
| 15 x 5 x 42 | | | | 41 | 33 | 33 | 33 | 33 | 18 | 18 | 18 | 18 | 8 | | | | | |
| 15 x 6 x 59 | | | | 44 | 36 | 36 | 36 | 36 | 20 | 20 | 20 | 20 | 20 | | | | | |
| 16 x 6 x 62 | | | | | 44 | 36 | 36 | 36 | 36 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | | |
| 18 x 6 x 55 | | | | | 44 | 36 | 36 | 36 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | | |
| 18 x 7 x 75 | | | | | 52 | 52 | 44 | 44 | 36 | 36 | 36 | 36 | 36 | 20 | 20 | 20 | 20 | 20 |
| 20 x 6¼ x 65 | | | | | | 44 | 44 | 36 | 36 | 36 | 36 | 36 | 20 | 20 | 20 | 20 | 20 | |
| 20 x 7½ x 89 | | | | | | 62 | 53 | 53 | 45 | 45 | 45 | 45 | 37 | 37 | 37 | 37 | 37 | 37 |
| 24 x 7½ x 100 | | | | | | | 71 | 62 | 62 | 53 | 53 | 53 | 45 | 45 | 45 | 45 | 37 | 37 |

In regard to stanchion bases, these cannot be so readily standardised, as they vary both with the section of the stanchion, the load on the same, and the allowable unit pressure on the foundations. However a very useful set of tables, sufficiently accurate for estimating purposes, can be devised. For a close estimate the actual material required under any given circumstances can be readily formulated by an experienced estimator if he has also a fair knowledge of design.

Our estimate sheet will now show all the material that is required in the work, giving the sections, lengths, weights, and cost per ton of the various items. It remains to compare the material in the estimate with that in stock, or which is on order and will probably be in stock when it is required for the work. It may be found that the available material is of such lengths as to necessitate a considerable amount being cut to waste. This waste material should be included in the estimate, but as a separate item, as it should not carry profit and would be charged at a rate a little above cost to cover handling and other incidental expenses. On the other hand, some of the material required, not being obtainable from stock, may have to be procured in the local market at higher rates. Such extra cost must be allowed for, but the material would carry a lower rate of profit than that finally adopted for the general estimate.

Finally, $2\frac{1}{2}$ per cent. should be added to the estimated weight of the material, to cover variation in rolling.

We have next to consider the *direct labour* costs, which includes the wages of all the men directly employed in the shop in producing the article under consideration. Such labour would, in general, include the wages of template-makers, markers off, drillers, punchers, riveters, fitters, blacksmiths and their assistants, and also the wages of the under-foremen. The salary of the general foreman, whose time should be employed in general supervision, cannot well be charged to the separate contracts. The direct labour will depend largely upon the wage system adopted in the workshops. In Australia the system is almost universally that of the daily wage, the disadvantage of which is that there is no definite equation between the time spent and the work accomplished. To give an illustration that came under the writer's personal observation. An order was placed with a firm for some blacksmith's work and the same order was repeated twice. The actual wages paid out upon the three contracts were almost exactly in the ratio 1:2:3. This is, of course, exceptional; but the cost of ornamental blacksmith's work will vary considerably and is difficult to estimate. In this particular case the first man was an exceptionally good workman, the second was a steady man but slow, and the third, I believe, was a new hand who was shortly afterwards numbered with the unemployed. This however is the inevitable result of the system of day wages, where the minimum wage is high and the difference between the wage of the good and the bad workman is small. The above case is, as has been said, exceptional, and also seems to indicate lack of proper supervision. But where a contract extends over some time and several men are employed upon it, the wages costs for any particular class of work will be found to be fairly consistent. Still however variations in cost will always appear where men are paid weekly wages which are seldom proportional to the work accomplished. A temporary grievance of the men with some conditions of their employment may be the cause of a big increase in the cost of production. It appears that this can only be eliminated by the adoption of some type of bonus system which will ensure to the more efficient workman a return more nearly proportional to the work performed and thus act as an incentive for each man to do his best. Such systems generally benefit the employer as well as the employee.

For the purpose of obtaining a return from the shop of the time spent on each contract each workman is supplied with a time card upon which he enters the time that he has worked upon each job during the day and the contract number of each job.

In some shops each contract is given a separate contract number and all the time spent upon that contract is returned under that number. This system, if it may be so called, is of very little use for estimating purposes as the records only show the average cost per ton of the whole of the work. In order to obtain a return that will be of any value each contract should be sub-divided into a series of separate jobs, each of which is given a reference mark or number. As an illustration we might have a contract divided as follows:—

General Contract, No. C207.

C 207 / J1—Basement to first floor stanchions, with gussetted bases and plated R.S.J. shafts.
,, J2—Stanchions, 1st to 5th floors, plated R.S.J. shafts.
,, J3—Stanchions, 5th floor to roof, plain R.S.J. shafts.
,, J4—Plated girders.
,, J5—Compound beams.
,, J6—Plain R.S.J.'s, with end connections.
,, J7—R.S.J.'s, drilled in flanges at ends.
,, J8—R.S.J.'s, plain.
,, J9—Fire escape stairs.
,, J10—Internal stairs and elevator work.

The multiplicity of job numbers entails a considerable amount of extra clerical work in the office, and is also liable to lead to mistakes in the shop returns due to the workmen putting their time down to the wrong number. The latter can be avoided by the sub-foreman carefully checking the time sheets at the end of each day. The former can be minimised by proper systemisation of the work. There is a strong temptation to a workman who considers that he has exceeded a reasonable time on any particular piece of work to charge some of that time to another job that he thinks can stand it. This of course only vitiates results and every means should be employed to prevent it. One method that tends to decrease these false returns, and at the same time can be made a means of reducing the clerical work in the office, is to provide the workmen with several cards, a separate card being used for each job. As soon as the workman has finished a job he fills out his card, has it initialled by the sub-foreman, and drops it into a box, several of which should be placed in convenient positions throughout the works. Thus, the time of one job is recorded before the next is started, and this will give the workman less opportunity of manipulating his returns, as he can do when all of his time is entered upon a single card at the end of the day. Office work is saved, because instead of the clerk having to analyse the different time sheets to obtain the labour spent upon the various contracts he merely has to sort out the cards under the various contract numbers. It is advisable that the time cards be so arranged as to give the workman as little writing as possible. If the card be made to show the hours of the day, divided into halves, or quarters, all the workman needs to do is to put a cross against the particular intervals of time during which he has been employed on the job, and at the same time record his name and number, the number of the job upon which he happens to be employed, the class of work, and the date.

The following is an example of a workman's time card arranged to record the above information:—

## WORKMAN'S TIME CARD.

To be filled in and dropped into the nearest box directly the job is finished. Make out a separate card for each job number worked on during the day.

**WORKMAN'S NO.** *126* **DAY** *Tuesday* **DATE** *Oct 7* **19***15*.

**ORDER NO. OF JOB** *C207 / J5* **CLASS OF WORK** *Drilling*

**Time Record.**—Mark with a Cross each quarter-hour worked.

| 7.15 | 7.30 | 7.45 | 8 | | 8.30 | | 9 | | 9.30 | | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | X | X | X | X |

| 10 | | 10.30 | | 11 | | 11.30 | | 12 | | 12.30 | | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X | X | X | X | X | X | X | | | | | | |

| | 1.30 | | 2 | | 2.30 | | 3 | | 3.30 | | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |

| 4 | 4.15 | 4.30 | 4.45 |
|---|---|---|---|
| | | | |

**ENTER ANY OVERTIME SEPARATELY HERE.**

**FOREMAN'S SIGNATURE** *A. Jones*

**ENTERED IN COST BOOK. DATE**........................**19**...... **SIGNED**..............................

In my opinion the sub-division indicated above is not carried far enough, as all plated stanchions come under the same number independent of their weight per foot, and the same is true of each of the other items. Evidently the further the subdivision of the contracts is carried the more useful will the information become for estimating purposes, and a few such records would enable a curve to be plotted, with the weight per foot as abscissa and the labour cost per ton as ordinates. Such a curve would evidently be continuous, but it would not be a straight line as labour costs are not directly proportional to the weight but decrease with increase in weight and vice versa.

For architectural steelwork in a well organised shop the direct labour costs for different classes of work may be expected to average somewhat as follows:—

| Class of Work. | Labor cost per ton. | | |
|---|---|---|---|
| Plated R.S.J. Stanchions, with Gussetted Bases | £3 | 10 | 0 |
| Other Plated R.S.J. Stanchions | 2 | 15 | 0 |
| Channel Stanchions, with Plates | 3 | 10 | 0 |
| Plain R.S.J. Stanchions, with Gussetted Bases | 2 | 10 | 0 |
| Other Plain R.S.J. Stanchions | 2 | 0 | 0 |
| Plated R.S.J.'s, Girders | 2 | 5 | 0 |
| Plate Web Girders | 3 | 0 | 0 |
| Box Plate Web Girders | 3 | 10 | 0 |
| Plain R.S.J.'s, with Angles Riveted to Webs, to Carry Timber Floor Joists | 1 | 13 | 0 |
| Compound Beams, i.e., Two or More R.S.J.'s, Bolted Together with Distance Pieces | 0 | 10 | 0 |
| Plain R.S.J.'s, Cut to Length, and Drilled in Flanges at Ends | 0 | 7 | 6 |
| Plain R.S.J.'s, with End Connections Riveted on | 1 | 0 | 0 |
| Roof Trusses of Medium Span, say 30 feet to 60 feet, of Angles or Tees and Bars, with Riveted Connections | 4 | 0 | 0 |
| Fire Escape Stairs | 8 | 0 | 0 |

The above figures refer to material of medium weight and length, and should be increased for light work and decreased for heavy work, except for very heavy work, the cost of which may increase when the weight is beyond the capacity of the shop cranes to conveniently handle. In making use of figures, such as the above, it must be borne in mind that they refer to particular rates of wages. Increase or decrease of the wage rate will vary them, and they may be materially increased by lack of shop organisation and supervision.

The overall rate per ton for direct labour is probably the best for estimating most classes of structural steelwork, such as stanchions, girders, etc., for buildings, roof and bridge trusses, plate girder work, and the like, on which the cost per ton does not vary to any great extent, or when it does, it can be foreseen and allowed for. For more complicated structural work the labour cost may be much more variable and not in proportion to the weight of the structure; this is true, for instance, of tank work. It is especially true of structures in which blacksmiths' work is involved. In such cases the only safe method is to estimate the labour in detail, allowing so much time for each operation, such as template work, marking off, cutting, drilling, riveting, forging, etc., and multiplying each by the standard wage rate as paid in the workshops. Structural workers in New South Wales come under the Boilermakers' award and the Amalgamated Society of Engineers' award, and the Ironworkers' Assistants' award, the minimum rates of pay being as follows:—

Boilermakers: 1s. 4½d. per hour.
Fitters: 1s. 5½d. per hour.
Turners: 1s. 5½d. per hour.
Drillers: 1s. 0½d. per hour.
Smiths: 1s. 6d. per hour.
Angle Iron Smiths: 1s. 6d. per hour.
Pattern-Makers: 1s. 6½d. per hour.
Forgemen: 1s. 7d. per hour.
Ironworkers' Assistants: 1s. per hour.
General Labourers: 11¼d. per hour.
General Labourers: 11¼d. per hour.*

As each workman has returned the class of work, i.e., drilling, punching, etc., upon which he has been engaged, the office has the information for analysing the cost of the various operations on any particular piece of work; and comparison of these with the drawings will serve as a guide to the estimator as to the time that he must allow for each operation in his estimate. Even then it requires sound judgment on the part of the estimator. It will be a great advantage to him if he has had previous shop experience, but if this is not the case the drawings might be referred to the shop foreman for a time estimate as a check upon the estimator's figures.

The shop time required for the performance of any particular mechanical operation can readily be obtained by

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*Since this was printed, a new award has been issued, applying to Boilermakers employed in Structural Steel and Ironwork, as follows:—

(A) The minimum rate of wages to be paid for the work usually done by the journeymen hereunder mentioned shall be as follows:—

(a) Template maker, setter-out and marker-off; plater; angle-smith, 1s. 6d. per hour.

(b) Hand-riveter; caulker, 1s. 4½d. per hour.

(B) The minimum rate for all adults working machines for drilling, screwing, sawing, punching, shearing, cropping, ending, notching, beam bending and straightening, grinding, hydraulic and pneumatic riveting; all adults chipping by power or hand, ratchet drilling, marking-off from templates, operating rolls, mangles, or hydraulic-power presses, steam or other power hammer; all adults cement washing or painting with one primary coat structural work at the factory (other than doors, window-sashes, window-frames, verandah posts, friezes, and railings), 1s. 1½d. per hour.

direct observation, but this information is only of value in certain cases, as, for instance, when a large number of holes are to be drilled in one piece, as in compound girder work. In other cases the time occupied in setting up the work may be several times that occupied in the actual mechanical operation. The thickness drilled per minute by a high-speed twist drill of diameter "d" can be roughly expressed by the formula

$$t = \frac{3}{d^{\frac{4}{5}}}$$

According to this, a ¾in. drill will pass through a ¾in. plate in about 12 seconds. This supposes, however, that the machine is operated at the speed and with the feed necessary to do the work. In other words, the formula expresses the capacity of the tool rather than the machine, and it will be found that many of the machines in which high-speed twist drills are employed were originally designed for carbon drills, and the tools are therefore not being used to their best advantage.

In regard to riveting the operation itself only occupies a few seconds, and the number of rivets put in by a riveting gang per day will depend principally upon the nature of the work.

In straightforward work rivets can be inserted and driven at the rate of about three per minute, but this rate of work is seldom maintained.

The "*on-costs*" or "*establishment charges*" are next added to the estimate as a percentage of the direct labour. Under the heading "on-costs" will be included all the costs of the establishment that have not already been included in the direct material and the direct labour such as rent, taxes, insurance, depreciation, repairs, salaries, office expenses, power, light, tools, etc., as well as general labour that has not been charged direct to the job. The percentage of the direct labour to be added is a very variable quantity, and may be as low as 80 per cent. in a well organised business with a large turnover, or as high as 120 per cent. when the opposite conditions exist. It will be noticed that many of the charges included in the "on-costs" are constant and independent of the amount of work passing through the shop. This means that in any one shop the percentage to be added to the direct labour will be greater the smaller the turnover. The actual figure to be adopted in estimating should be fixed from time to time by the manager, who obtains it from the general business records.

In most shops the same "on-cost" percentage is adopted for all classes of work, but a little consideration will show that this should not be done. It is better to adopt a system of "departmental on-costs" in which all costs that can be so charged are charged directly to the departments, other costs being distributed over the departments in proportion to the value of their outputs. If this is not done the department in which the general "on-cost" percentage is lower than that which it would carry if the system of "departmental on-costs" were adopted will show a higher profit than it is really entitled to, and this at the expense of some other department. In structural engineering works the number of departments will generally be small and may consist only of a structural and a blacksmith's shop. It is evident that these two departments should not bear the same percentage of "on-costs" if any reliance is to be placed in estimates based thereon.

The sum of the three items, viz., direct material, direct labour, and "on-costs," gives us then the total costs to which it remains to add the profit. This will generally be done by the manager. A rate of 15 per cent. upon the total estimated cost is generally considered a fair thing. This allows something for possible underestimating, and still leaves a fair margin of profit. The selling price may however be fixed by other considerations, such as known local market rates, when the estimates merely indicates the percentage of profit that is obtainable.

In the above paper I have merely laid down the simplest system that I consider should be adopted in a structural engineering works to obtain results approximating to accuracy. Other more complicated systems have been devised that give more accurate results, but they increase the expense and it is doubtful whether local conditions warrant it. Such systems aim at charging a greater proportion of the costs directly to each contract. Each machine may be "rated" at so much per hour, and machine time as well as workman's time is charged directly to the job. To fix the machine "hour-rate" every item connected with the machine is taken into account, including initial cost, foundations, depreciation, repairs, power, oil, and other supplies consumed by the machine; and also a charge, due to rent, taxes, lighting, etc., in proportion to the space occupied. The sum of these charges, divided by the number of hours that the machine actually works during the time over which the charges are calculated, will give the "hour-rate" of the machine. The system is unnecessarily complicated for a structural shop, and its accuracy is questionable due to the uncertainty in the amount of "idle time" upon which the rate adopted largely depends.

To conclude, many of you will no doubt be disappointed with the contents of this paper because it gives no definite detailed information as to the various items of shop costs. As was mentioned at the beginning, this is due to the fact that, as far as I am aware, no such information based on Australian conditions has yet been collected.