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Autor(en): **Thompson, J.D.**

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II a 6

Control of Quality in the Fabrication of Welded Steel Bridges

Contrôles de qualité dans la construction des ponts métalliques soudés

Qualitätskontrolle bei der Herstellung von geschweißten Stahlbrücken

J. D. THOMPSON
The Cleveland Bridge and Engineering Co. Ltd., P.O. Box No. 27, Smithfield Road,
Darlington, Co. Durham

I. Preamble

Quality in the fabrication of a welded bridge is, for the purposes of this paper, defined as the degree of excellence in the methods and skills employed in fabrication, as will enable the designer to make correspondingly good use of all materials which he may include in such a structure.

It is the intention of this paper to show by what methods the fabricator may best achieve this object, to examine his responsibilities, his duties, and to indicate how best designer, fabricator and inspector may combine to achieve a product which is at once æsthetically pleasing, structurally sound, and of economic design.

II. Control of Raw Materials and Labour

The ultimate quality of any structure is based primarily on the uniformity of the properties of the raw materials of which it is made, and of the skills of the labour employed in its construction. The need therefore, of close control of both these factors must be of paramount importance in high quality fabrication.

The first problem to be faced is that of ensuring that the steel to be used in the structure is sound physically and chemically. Steel received from the Mills will normally receive only a nominal surface inspection, and is subject only to those physical tests specified in the appropriate British Standard. Whilst this may be satisfactory for rivetted structures, it is considered that some additional control ought to be exercised by the Mills inspection division for steels which are to be welded. Instances may be quoted where steels to B.S. 15 were found to be almost unweldable in certain conditions, as the sulphur and phosphorus content was on the maximum permissable, and there was almost total absence of silicon, while the manganese/carbon ratio was extremely low. This steel conformed nevertheless to B.S. 15 as the physical tests were satisfactory. There is little the fabricator can do about chemical unsuitability at present, until he encounters it in the process of fabrication, when special methods have to be devised to suit it.

It is recommended that all steel from the Mills be surface inspected in the works as it is unloaded or sorted. Considerable delay and corresponding costs can be avoided by thorough surface inspection on arrival, rather than by discovering faults subsequently when a proportion of work has been completed. In addition, in the author's works, it is the practice to examine ultrasonically steel rolled to B.S. 968, which is of a deep-piping nature in the ingot, paying particular attention to the end 2′ 0″ of each plate where laminations, if present, usually occur.

On the subject of electrode control, little need be said. The manufacturers exercise such close control and testing of their products that the fabricator's task is normally confined to choosing an electrode suitable for the particular purpose, and ensuring that it is adequately stored and correctly handled in use.

With regard to control over operators, there is considerable divergence of opinion as to what is expected of a welder. In the author's works a manual welder to be employed on quality fabrication is expected to have skill enough to lay welds of sound standard in any position, and to be of sufficient integrity to adhere strictly to whatever instructions are issued by the Welding Engineer to the Shop Foreman for any particular section of the work. Each individual welder is tested and graded on engagement, and periodically thereafter, to ensure that his standard is adequate for the demands of the task to be performed. Current certificates are maintained of his fitness to work on high quality fabrication.

For automatic and semi-automatic welding, machines are checked weekly by maintenance men, both electrically and mechanically, and in addition, frequent spot checks are made in the shop. Operators of these machines are regularly checked and controlled as described above for manual welding.

III. Factors Affecting Accuracy of the Product

The accuracy of the finished product may be said to be dependent on the following factors:

1. Design. The design must not only be such that it is pleasing to the eye,

but must be capable of being fabricated with a minimum of distortion and subsequent use of corrective measures. It should lend itself to ease of manufacture, as welds difficult to lay are most liable to faults of one sort or another. In the light of modern design practice, mere saving in weight must not be the only, or even the main, consideration. Cases can readily be quoted in which the saving in cost due to decreased weight is more than counter-balanced by increased cost per unit.

2. Planning. The accuracy of any structure is entirely dependent on the methods used to make it. Before any work is undertaken, it is essential that a thorough examination should precede the issue of welding instructions, which must take into account avoidance of distortion, counteracting shrinkage, and ease of workmanship generally, as quality of weld is directly proportionate to the difficulties encountered by the operator who must lay the weld. The question of pre-heating, based on C.T.S. tests, and the specification of jigs and fixtures should also be settled at this planning stage.

3. Site connections. The type of site connection has a large influence on the accuracy of the complete work. It is generally agreed that the use of bolted connections at site, employing either turned bolts or grip bolts, ensures a better accuracy than that usually found with site welded designs.

4. Shop Erection. The amount of shop erection performed is largely a matter of shop practice, and will vary from one works to another. This question is largely a corollary of item (3) above. In the author's works all work having turned bolt site connections would be fully assembled and all site holes reamed in position. In grip bolted work, connections in which are normally bush drilled or jigged, at least a substantial portion would be tried out to prove accuracy, and similarly with site welded connections, though the latter are more difficult to prove due to absence of suitable means of holding the members in their respective positions.

IV. Fabrication Methods to Ensure Accuracy

1. The first essential for accurate fabrication is necessarily accurate preparation of material to ensure close tolerance fits of the various components. Planing is a pre-requisite for all web plates, stiffeners etc. to give a close and square bearing. Attempts are sometimes made to use universal flats for webs or stiffeners without subsequent planing — these are almost without exception failures either because of distortion due to the round edges of the flats, or because of defective welding due to the same cause. Edges must be planed true in their length, and all flange plates or other sections must be straight and flat and of correct length before assembly. This may seem to be a recital of elementary precautions, but it is surprising how often bad quality work can be the direct result of slovenly preparation.

2. Having achieved accurately prepared material, it is necessary to proceed with the utmost care in the order in which pieces are assembled and welds are laid. Correct welding sequence can, without any form of restraint, eliminate distortion almost entirely in a well-designed girder. It is indeed considered that any form of restraint employed in the fabrication of a girder is a confession of failure on the part of either designer or maker. This operation sequence must be carefully pre-planned before work starts, and equally carefully checked for correctness on the first section to be welded. The intelligent use of jigged subassemblies too can materially assist accurate assembly.

3. In the majority of cases it is essential for one reason or another that flange plates shall be flat after fabrication and steps must be taken to counteract the normal set which occurs during the web to flange welding. This is done in one of two ways, either by pre-setting the plates upwards in a press if of heavy section (say over 5/8th-inch in thickness) or by rolling in the pre-set on thinner plates (see sketch). Control can also be exercised by the use of "strongbacks" and wedges to induce a counterset, though this is of necessity quite a laborious process, and can, if an insufficient number of strongbacks is used, lead to kinking and buckling of the flange in between points of application. Where flange plates are butt welded in their length, suitable methods of welding must be employed, and the welding properly balanced to avoid either side camber or kinking in a vertical plane at the butt. If the butt is designed for welding by "*U*" preparation from one side only (e. g. the top) the flanges should be clamped with an upward kink to account for subsequent welding shrinkage. The same remarks apply where butt welds occur in web plates — preparation must be good enough to maintain straightness and tacks strong enough to hold all parts in alignment, and in all cases laid with a large gauge rod and a minimum of 2″ in length to avoid cracking.

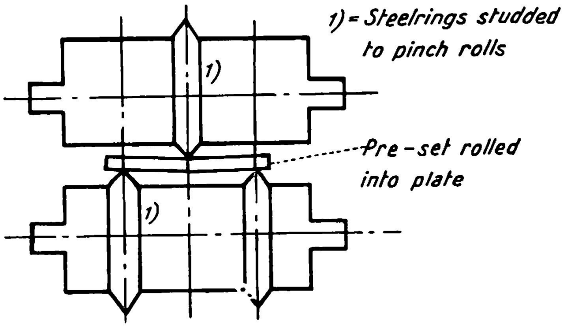


Fig. 1. Rolling Pre-Set in Flanges.

The amount of pre-set to be put into flange plates is a matter to be decided in the light of experience. As far as the author is aware, there has been no attempt to devise a formula to determine the degree of pre-set. However it has been found possible to devise and issue a table of pre-sets, taking into account the width of flanges, the thickness, and the size of the connecting weld. This table is based on data obtained from actual experiments in the shop. It is known that steel above 500° C ceases to have any elastic properties and it is assumed that any expansion above this temperature distorts the metal in its inelastic state. This metal on cooling causes distortion in the flange when welding is complete. Taking the case of a 1″ thick flange, 12″ in width, being welded to a $^1/_2$″ thick web by means of two $^5/_{16}$th″ fillets (see sketch) the following condition is assumed to occur.

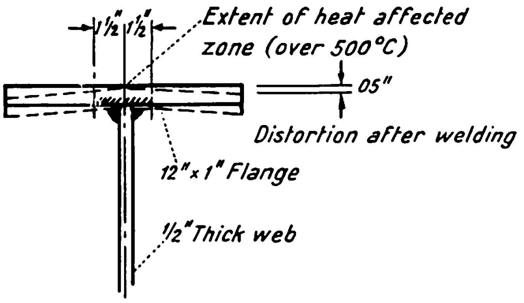


Fig. 2. Extent of Flange Distortion.

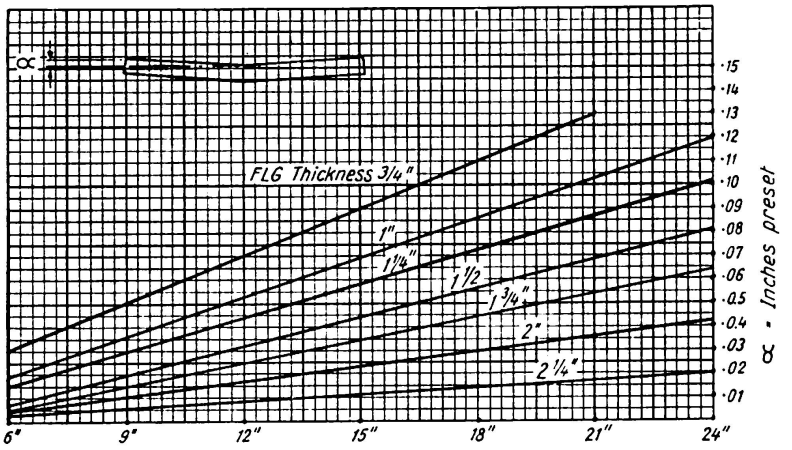


Fig. 3. Flange Width in Inches.

The amount of flange width affected by the welding operation, and heated by it to over 500° C is found to be about $1^1/_2$″ on either side of the centre line. This length is assumed to be semi-plastic during welding and will contract on cooling from say 500° C to 20° C = a range of 480° C. Taking the coefficient of contraction of steel at 0.0000067 the underside of the flange plate will contract by 0.009″ on each side of the web. This contraction in turn causes the outer edge of the flange to distort in a downward direction to the extent of 0.05″. Similar observations and calculations on a series of plates enabled the following graph to be drawn up.

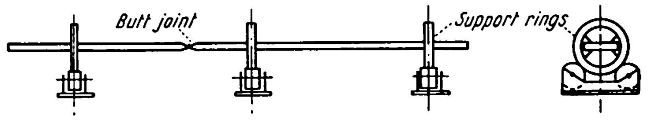
It will be noted that the graph has been standardised on $^5/_{16}$th″ fillet welds. There is of course variation if larger or smaller fillets are used, but surprisingly little increase takes place until the fillets reach unusual proportions (say $^3/_4$″ leg length). The graph is therefore used as a standard irrespective of fillet size unless the fillets are unusually large when special allowance is made.

4. A further important feature in quality fabrication, particularly in bridge work, is control of camber. Normal procedure is to plane the required camber into web plates on the assumption that the complete girder will follow the pre-planed shape. This condition will occur when both flanges of the girder are of equal section, or very nearly so. When flanges are unequal, or when use is made of stiffeners which extend half-way or less up the web, then the pre-planed camber will be upset. This can be overcome by planing in extra camber in the web, where the top flange is thinner than the bottom, or by planing in less camber when extra stiffeners are employed on the bottom half of the girder. In either case the same result could be obtained by restraint, but this may lead to undesirable stresses in the welds both while welding and after cooling off. No proper calculations have yet been made with regard to allowances to be made in pre-planing, but experience has shown that loss of camber due to the use of a thinner top flange is approximately the difference in thickness between the two flanges for girders normally proportioned at about 12 : 1 length to depth ratio, i. e. when using a $^3/_4$″ thick bottom flange, and a $^3/_8$″ thick top flange, the camber loss after welding would be about $^3/_8$″ per 50 ft. This rule would apply up to flange thicknesses of 1″, above this thickness the rapid cooling effect of the thicker metal, and its greater rigidity appears to reduce loss of camber to minor proportions. Where additional stiffeners are employed on the bottom half of the girder, the extra camber induced may be calculated in a manner similar to that described for the avoidance of side camber in para. 6.

5. Stringent control of butt welds is vital if full advantage is to be taken of the savings in weight offered by welding. This means that the physical properties of the welded butt must be equal to that of the parent metal. To ensure this, the exact sequence of welding must be specified, together with electrode type, size, number of runs etc., and the actual work controlled by skilled supervision making periodical checks on amperage used. Scrupulous cleaning of each successive run must be enforced, and adequate back chipping to ensure complete fusion. It is recommended that all butts over 1″ in thickness should be pre-heated to at least 100° C before welding starts, and maintained while welding to make sure of a ductile deposit which is crack-free and non-porous. Controlled cooling, particularly where thicker plates are concerned, is an additional precaution.

Where butt welds are specified to be made with a gap at the root face, this gap should be ignored when calculating the prepared length of each half of the flange: it has been found in practice that the shrinkage at butts is the same or very little less than the specified gap.

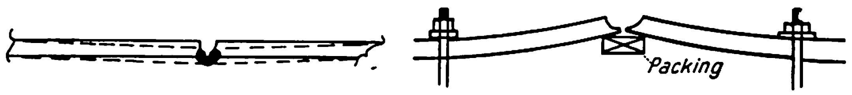
Balanced welding sequence will generally control longitudinal straightness, and provided that welding is balanced on both faces of the butt there should be no "kinking". Suitable gear can easily be made for quick turning of butt-welded plates (see sketch).



Manipulator For Flange Butt Welds. Elevation Showing Rollers

Fig. 4.

Where butt welds are specified to be welded from one side only, it is sometimes necessary to pre-set the plates in an upward direction (see sketch).



Distortion of Flange Due To Welding From Top Only. Flange Glanded Down About 18″ Back From Each Side of Weld.

Fig. 5.

Plates can be glanded down at a distance of 18″ or so from the centre line of the weld, and an approximate rule for pre-set so induced would be the thickness of the plates being welded e.g. $^3/_4$″ in 18″ for a $^3/_4$″ thick butt, an average of nine runs of weld being used to complete the joint. It should be noted however that pre-heating has a considerable affect on the amount of pre-set required, particularly where heats over 180° C are used, this amount of pre-heat reducing very markedly the pre-set figure.

On completion of welding all butts should be checked visually, and also by the use of dye penetrants to discover surface faults. (Incidentally this form of check is extremely useful during fabrication to determine exactly whether sufficient back chipping has been done at the root of a butt. Any trace of unfused plate shows up as a clear line.) Further examination of all important butts should then be made radiographically either by x-ray or gamma-ray equipment, — preferably the former on account of speed. There should be no tolerance of faults such as slag inclusions, lack of fusion, or piping on any important joint and only minor patches of porosity should be accepted. Physical checks should also be taken on all highly stressed butts; these consist of coupon plates cut from the parent metal identical to that being welded, which are clamped on eitherside of the butt in question, and welded simultaneously with the butt (see sketch).

Tensile and bend tests, the latter being of major importance, are taken after severance from the completed joint.

The practice of removing "re-inforcement" from butt welds is becoming increasingly widespread, and there is no doubt that this results not only in a better finish, but gives a stronger joint. Grinding should be done so that little marking of the surface ensues, and any remaining surface scratches must run in a longitudinal direction i. e. at right angles to the butt.

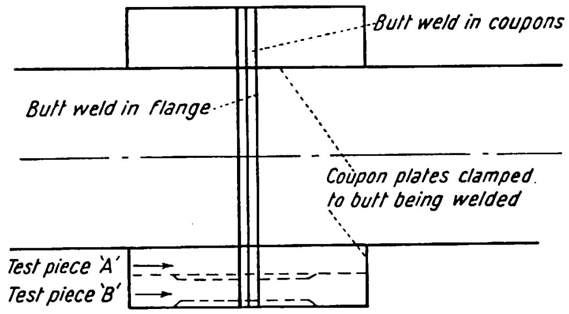


Fig. 6. Coupons Cut to Give Test Piece "A" For Bending Test Piece "B" For Tensile.

6. Control of lateral straightness in a well designed girder can generally be accomplished by correct welding sequence, and methods of restraint should be avoided where possible. Other things being equal, balance of heat input will result in a straight and true product. It is of course, under certain conditions of design, impossible to balance heat input. A case in point would be a plate girder with stiffeners on one side only. If no precautions are taken, considerable side camber can result from this form of construction. One method

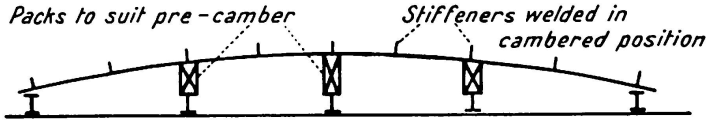


Fig. 7. Cambering Web to Counteract Stiffener Distortion.

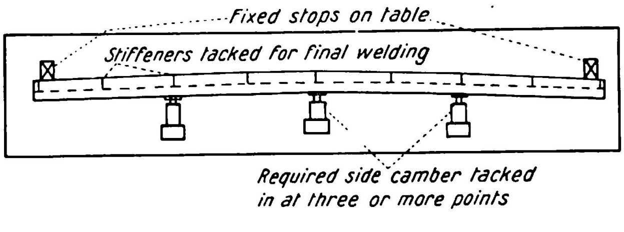


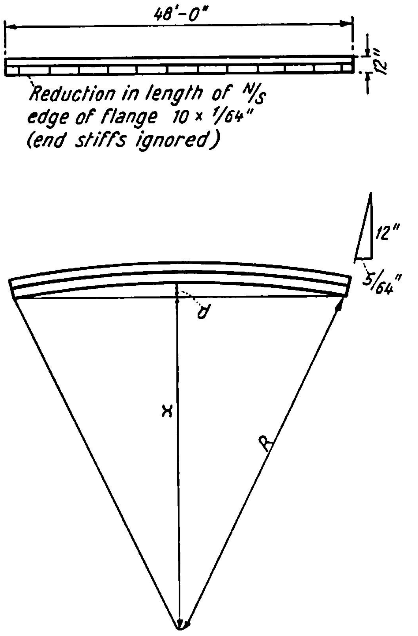
Fig. 8. Side Camber Induced to Counteract Distortion.

of avoiding this side camber is to weld the stiffeners to the web while the latter plate is supported on packings in a cambered position (see sketch).

This method of assembly precludes the use of conventional automatic machines for web/flange welding due to the short runs involved. Semi-automatic machines of the Lincoln ML 3 type can of course be effective here. If web/flange welding is done first by automatic methods, then it will be necessary to side camber the girder in a rig before welding the stiffeners (see sketch).

The amount of side camber to be so induced is largely a matter of practical experience and trial and error. So many factors effect the issue that even an empirical rule is difficult to formulate, but a simple calculation is given for a girder 48′ 0″ in length having a 12″ wide flange plate and stiffeners on one side only at 4′ 0″ pitch.

Each stiffener will shrink one side of the flange and the web by $^1/_{64}''$ = a total of $^5/_{32}''$ on the affected flange. This gives a slope on the end of the girder of $^5/_{64}''$ in 12″. From this slope the radius r and dimension x can be calculated, which gives a distortion d at the centre of the girder of 0.936″, which is found in practice to be approximately correct. Again, slight adjustments may have to be made for very thick flanges, e. g. $1^1/_2''$ and over in thickness.



$$x = \frac{24 \times 12 \times 64}{5} = 3686.4 \text{ ft.}$$

$$R = \sqrt{24^2 + 3686.4^2}$$

$$= \sqrt{13{,}590 + 120.96} = 3686.478$$

$$\therefore\ d = 0.078 \text{ ft.} = 0.936''$$

Fig. 9.

7. Reduction in length of girders due to shrinkage after welding is yet another important factor in the production of high quality welded work. It has been observed in practice that longitudinal welds affect girder lengths comparatively little, and can usually be ignored except when dealing with weldments of extreme length, for example over 60′ 0″ long. The welds which cause most shrinkage are those which run transversely at right angles to the

longitudinal axis of the girder, such as connections to stiffeners or cleats. A table has been drawn up for use in the author's works showing the amounts by which such welds tend to shorten weldments, and the allowances thus made necessary when preparing material. The table is based on observations made when welding stiffeners to webs of normal thickness, e. g. $^1/_2''$ or $^5/_8''$ thick, and flanges up to $1^1/_4''$ thick. Referring to sketch below, it will be seen that there is a heat-affected zone about $2^1/_2''$ in length which is raised above 500° C when welding with a standard $^5/_{16}''$ fillet weld.

The welding of stiffener *A* is assumed, on the heat-affected zone mentioned, to cause a contraction of 0.014″ to 0.016″ in the web and flange. The subsequent welding of stiffener *B* would cause contraction to a similar degree, or a total contraction of between 0.028″ to 0.032″ for the double operation, or say $^1/_{32}''$ per pair of stiffeners. The fillet welds used as standard are $^5/_{16}''$, but the author has not found that differences of $^1/_{16}''$ up or down on the fillet leg length has any noticeable affect on the result. The use of a full strength butt weld, with a prepared edge to the stiffener, as specified on certain bridges would certainly affect the shrinkage, and special experiments are necessary in these and similar instances.

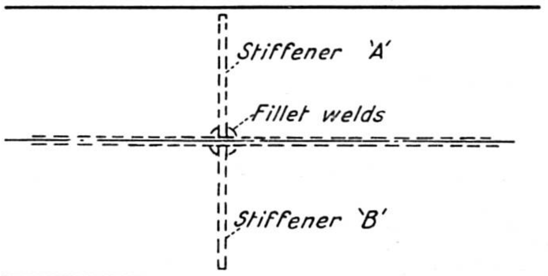


Fig. 10.

8. All the allowances mentioned have been calculated or observed for manual welding, usually with rutile coated electrodes, sometimes with low-hydrogen types. Considerable differences result from the use of automatic or semi-automatic welding. This is considered to be due to the fact that a similar amount of metal is deposited with a smaller heat-affected zone when welding automatically. For instance, using a $^5/_{64}''$ wire, a semi-automatic machine would lay 12″ of $^1/_4''$ fillet weld in 36 seconds using current at 340 amps and 28 arc volts. This gives a rate of energy input of 28.5 kilojoules per inch. A manual weld of the same size using a $^1/_4''$ dia. rutile electrode would be laid at the rate of 12″ in 93 seconds using 310 amps and 23 arc volts, giving a rate of energy input of 55 kilojoules per inch: in other words the energy input, and consequently the area of heat-affected zone will only be about half that of manually laid welds. Therefore all figures for shrinkage and distortion may be reduced by that amount when automatic methods are employed.

9. The marking off and milling ends of butting members on truss or arch spans is an essential factor in the maintenance of correct geometrical dimension. Chord and web members should be set up level on a surface table, on which is marked all the special centre and intersection lines required. These lines are then transferred to the section being marked either by a special level square (see diagram) or by the plumb straight edge (see diagram). The use of these methods of line transfer render it unnecessary to have the surface table absolutely flat, and it can be made up of structural sections and plate as shown in the photograph.

Milling of ends of members to the marked lines must be extremely carefully done, and as a further check on marking, scribed lines square to the machine face, or laid off at the necessary bevel, are used on a surface table at the machine similar to that used for marking. Check setting is done in a similar manner. Subsequent trial erection usually proves the accuracy of the methods specified, which will be in the order of $^{1}/_{16}''$ out of line in 50′−0″, and within 0.006 in 2′−0″ out of square at the butt.

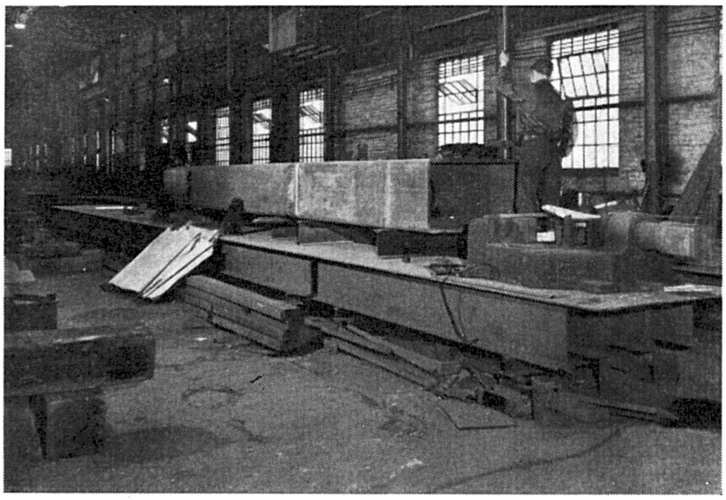
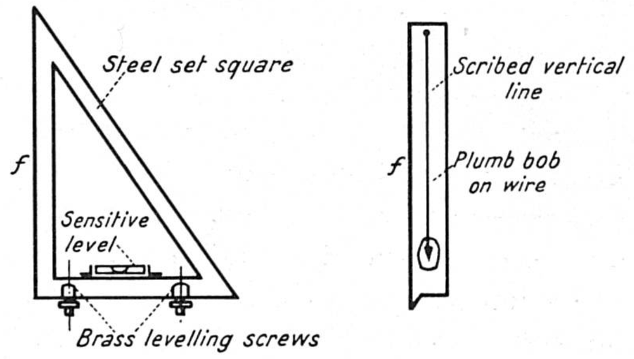


Fig. 11. Girder Being Levelled on Surface Table Prior to Marking.



Line Transfer Square. Line Transfer Straight Edge.

Fig. 12.

10. Corrective treatment of girders which have distorted due to welding will in most cases consist of post-heating. It should be emphasised that post-heating treatment should only be employed as a last resort, when normally correct welding sequences have failed to give the desired result. The application of heat to correct twist or wind is an art for which no hard and fast rules can be given. The principle of post-heating is that if a girder is restrained in direction, and heat be applied locally, expansion and flow of metal must take place in the thickness of the section, and having expanded, on release of the restraint the girder will tend to become straight on cooling.

V. Costs of High Quality Work

Cost control of high quality welded structures can best be obtained by the use of modern methods of fabrication and by means of incentive payments which aim at preserving quality whilst maintaining output.

Modern fabrication methods may be summarised briefly as follows:

a) Correct and meticulous planning.
b) Scrupulous control of raw materials.
c) Employment of modern welding techniques.
d) Extensive use of jigs for assembly and sub-assembly.
e) Free use of manipulators, even for very large weldments (see photo).
f) Jig drilling of connections before or after welding.

The above factors should not only assist in achieving quality, but will keep its cost within reasonable bounds. It is in the long run, just as cheap to produce good welded work as bad.

The incentives offered to operators must be such as do not lead them to

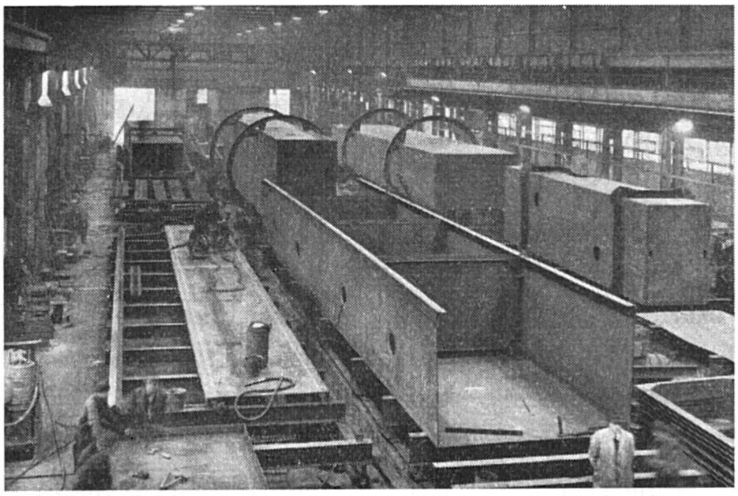


Fig. 13. Purpose Made Manipulators in Use for Welding Pontoons.

strive after quantity at the expense of quality. Quality must always be the deciding factor and quantity a secondary inducement. Scrapping of expensive work, or cutting out defective welds is a costly remedy for scamped or hurried processes. The numbers of incentive schemes are legion, but without exception, the best are based on the efficient production of high quality work.

VI. Reduction of Incidence of Notches

An important function of the fabrication of high quality work is the elimination as far as possible of notches, and the minimisation of residual stress in completed members. In these matters the fabricator is often in the hands of the designer and must in the end produce what is on the drawing. In England there is to-day a growing desire on the part of designers to work extremely closely with fabricators, with the aim of utilising to the full the undoubted savings which high quality welded work can give. If a design is produced which is difficult to fabricate, obviously its quality must suffer, and in such cases it is not possible for either party to have full confidence in the result. It will, in addition, be most expensive to produce.

Notch brittleness of steels is still not fully understood, but sufficient is known to indicate the necessity of avoidance of sharp breaks in section, sudden changes in direction of stress, and faults in welding which will sooner or later lead to the initiation of fractures. It is to this end that the fabricator must ensure that his work does not fail, and that supervision techniques and inspection are such that as far as he is able, his work is as near perfection as he can achieve. The increasing use of modern notch ductile steels to the new British Standard 2762 specifications (ND 1 etc.) is a further incentive to fabricators to bring their welding methods into line with improved materials.

VII. Inspection

Inspection plays a major part in the production of high quality work, and most works now realise that the day of the old fashioned inspector is rapidly passing. The modern inspector must of necessity be a highly trained man, capable of realising what faults are minor, and what might cause the collapse of a complete structure. He is required now to work to exacting specifications, mostly based on the efficient British Standard 1856 which the Consulting Engineer draws up. It is important that inspection starts early in the progress of a contract, namely with the raw materials, and from then onwards at each stage the inspector must be satisfied that the best practice is being followed.

It is an erroneous idea that a shop inspector is only concerned with the finished product. Far more can be observed and known if each stage of fabrication is seen and checked, and the inspector's ability should be such that he can criticise in a constructive manner, and if necessary, offer advice on procedures to be followed.

The methods which modern inspection must employ range from surface and ultrasonic examination of raw material; tests of electrodes, welders and automatic machines; checking of prepared material, spot checks of currents and speeds, radiographic and dye penetrant inspection, to the final examination of the completed structure for dimension and appearance. All that is best in modern practice is the result of close collaboration between designer, inspector and fabricator — for they are all in the end aiming at achieving the same result.

VIII. Protective Treatments for High Quality Work

Any paper on high quality production would be incomplete without a passing reference to protective treatment. Everyone is only too well aware of the inadequacies of the obsolete idea of wire brushing steelwork followed by the application of a couple of coats of red lead or even red oxide, on top of adherent mill scale. Experiments have clearly demonstrated the superiority of modern techniques, the most important of which is shot blasting followed by painting, or shot blasting, metal spraying and painting. So rapidly have these ideas taken hold that at the time of writing this paper, 100% of the output in the Author's works is shot blasted, and 60% sprayed with zinc, before final painting. This has necessitated the laying down of a new fully automatic centrifugal wheel blasting plant capable of handling girders up to 6′ 6″ in depth and 21″ in width, which will produce a surface suitable for metal spraying at the rate of three lineal feet per minute, and will clean ready for painting at the speed of eight lineal feet per minute.

The introduction of new types of paint with a calcium plumbate base has given startling results, and while it is still too early to pronounce final judgment, it is felt that there must be tremendous possibilities for this medium. There has of late been some controversy over the efficiency of metal spraying zinc or aluminium coatings, and experiments in conditions of dense smoke pollution by the British Transport Commission have induced them, at any rate for the present, to abandon metal spraying; but it may well be that the future will see all important structures protected by metal sprayed coatings, themselves covered by calcium plumbate based paints, which may well astonish by the length of protection afforded to the structure so treated.

Summary

The aim of controlling quality in welded steel bridges is to produce as economically as possible structures of sound material to correct geometric outline, eliminating as far as possible defects, due to notches and residual stress, and presenting a finished product which is of a clean and attractive appearance.

This paper considers the steps to be taken to ensure that materials used are sound, that fabrication is such that errors in dimension are minimised, and that the completed bridge is as far as possible free from injurious defects which might lead to failure or partial failure in service.

Indications are given of the standards likely to be achieved, of the inspection problems involved, and included is a brief examination of various types of finish to ensure easy maintenance of the completed structure in good condition over a long period of service.

Résumé

L'objet des contrôles de qualité sur les ponts métalliques soudés est de permettre la réalisation aussi économique que possible d'ouvrages à la forme et aux dimensions précises, constitués par des matériaux parfaits, d'éliminer aussi largement que possible les défauts qui peuvent résulter de l'effet d'entaille et des tensions résiduelles et de produire un ouvrage définitif qui se présente sous une forme correcte et attrayante.

L'auteur expose les dispositions à prendre pour s'assurer de la qualité des matériaux, pour maintenir aussi faibles que possible les écarts de cotes au cours de la fabrication et pour éviter les défauts graves, qui pourraient conduire à un effondrement total ou partiel en service du pont terminé.

Il donne des indications sur les exigences de qualité à imposer et sur les problèmes de contrôle corrélatifs. Il passe enfin brièvement en revue divers modes de protection anti-rouille, assurant la facilité de l'entretien de l'ouvrage terminé et son excellent état pendant une longue durée de service.

Zusammenfassung

Das Ziel der Qualitätskontrolle geschweißter Stahlbrücken besteht darin, bei größtmöglichster Wirtschaftlichkeit Konstruktionen aus einwandfreiem Material mit genauen Abmessungen zu liefern und mögliche Fehler infolge Kerbwirkung und Restspannungen auszumerzen, so daß damit ein Endprodukt mit einer sauberen und ansprechenden Form geschaffen werden kann.

Dieser Bericht beschreibt die zu treffenden Maßnahmen, um einwand-

freies Material zu gewährleisten, um Maßabweichungen bei der Fabrikation möglichst klein zu halten und um gefährliche Mängel, die zu einem totalen oder teilweisen Versagen im Betrieb der fertigen Brücke führen können, zu vermeiden.

Es werden Angaben über die zu erreichenden Qualitätsanforderungen und über die damit zusammenhängenden Prüfprobleme gegeben. Zusätzlich wird noch eine kurze Betrachtung über verschiedene Anstrichsarten aufgestellt, damit ein einfacher Unterhalt des fertigen Bauwerks für eine lange Betriebsdauer in gutem Zustand sichergestellt ist.