Zeitschrift: IABSE congress report = Rapport du congrès AIPC = IVBH Kongressbericht

Band: 6 (1960)

Artikel: General report

Autor: Dubas, Pierre

DOI: https://doi.org/10.5169/seals-7031

wo pneumatische Schlüssel verwendet werden, welche sich zu einer genauen Ablesung des Anziehmomentes wenig eignen. Im Beitrag von BEER wird darauf hingewiesen, daß diese Methode sich nun auch in Europa einführt.

Wie wir schon im «Vorbericht» erwähnten, muß man sich hingegen doch fragen, ob man ohne weiteres eine so starke Vorspannung der HV-Schrauben zulassen darf. STEINHARDT weist in seinem Beitrag darauf hin, daß es sich in Deutschland als nötig erwies, die Pressung zwischen Schraubenkopf (oder Schraubenmutter), der Unterlagscheibe und dem Grundmaterial zu begrenzen, um ein allmähliches Abnehmen der Vorspannkraft zu verhindern. Es wird somit interessant sein zu sehen, wie sich auf die Länge die amerikanischen Verbindungen verhalten, welche teilweise nur 1 Unterlagscheibe pro Schraube aufweisen. Eine gewisse Vorsicht scheint uns auf diesem Gebiet angebracht, wenn man Enttäuschungen vermeiden will.

Wie dem aber auch sei, wir haben in den hochfesten Schrauben ein neues Verbindungsmittel, das sich bewährt hat, sofern es korrekt angewendet wird und welches die Reihe der klassischen Verbindungsmittel glücklich ergänzt.

General Report

a) Welding

Effect of Longitudinal Stresses in Fillet Welds

This problem is the subject of two interesting papers. In the first of these, Mr. LOUIS describes the bending tests carried out on built up girders assembled by means of fillet welds located, on the one hand, at mid-height of the web, and on the other hand, at the junctions of the web and the flanges. The flange welds, subjected to longitudinal stresses and to shearing stresses, are always the first to be disrupted, before the web welds which are, practically speaking, only subjected to shearing stresses.

With regard to the further contribution by Mr. FALTUS, it forms a most satisfactory supplement to his paper which appeared in the Preliminary Publication. In this paper the author describes some additional tests carried out with great care on test-pieces in which the ends were bevelled and lap-welded.

All the tests we have just mentioned prove quite clearly that the longitudinal stresses considerably reduce the shearing strength of fillet welds. The problem therefore appears to have been solved from the qualitative point of view; this is not the case, however, for the criterion to be applied in order to make allowance for this effect of the longitudinal stresses or, in other terms, for the formula expressing the comparative stress in the weld. The latest results obtained by Mr. Faltus do undoubtedly show good agreement between the measured values and those deduced from the Huber-von Mises-Hencky criterion. However, as Mr. Louis points out, the distribution of the longitudinal stresses over the width of the test-piece is not uniform as the calculation assumes. In order to reach a valid conclusion as to the criterion to be applied, it would be necessary to determine the state of stress in the weld experimentally.

It may be observed in passing that the method of estimating the comparative stress has, as a general rule, only a very slight effect upon the size of the welds and hence on the economy of a structure.

Brittle fractures

Although this problem was not dealt with at the Congress, we venture to revert to the matter briefly here on account of its importance.

What is the present state of our knowledge in regard to the brittleness of steels? A very large number of experimental results on notched test-pieces, that is to say, of resilience tests or other more or less similar tests, are available. On the other hand, adequate data are lacking on the behaviour of the members of welded structures, or more precisely on the behaviour of the steels under the conditions to which the structural members are subjected. Furthermore, we do not know the underlying causes of the phenomena connected with brittleness and the laws which govern them, although a great many theories have already been suggested.

For the engineer concerned with practical considerations, the problem of brittleness obviously arises under a more restricted aspect: for him it is mainly a question of selecting the grade of steel to be employed in a given case.

In the metallurgical field, highly satisfactory progress has been achieved during the last few years and for each type of steel the user now has available different grades, characterised by a varying degree of reliability in regard to brittle fracture. Classification is usually effected by means of resilience tests of increasing severity, such as are prescribed, for example, in various standard specifications which have recently come into force. Although the present position is far better than that which existed previously, it must nevertheless be questioned whether it is entirely satisfactory that the classification of steels should be based solely on resilience tests carried out on metal not affected by welding. We are, in fact, fully aware that other properties of the metal may, more or less directly, exert an influence. Supplementary tests, in particular on the weld and the transition zone, will consequently often be necessary.

Even assuming that steels could be classified reliably by means of simple resilience tests and that, furthermore, there is a well-defined relationship between the behaviour of steel characterised by test-pieces and its tendency to brittleness under the conditions prevailing in the structure, it would still remain necessary, in order to determine the choice of the steel with full knowledge of all the facts, to establish that relationship in a precise manner. Since we have no theoretical bases, we must have recourse to experimental methods in order to determine *quantitatively* the effect of the various factors which exert an influence. Let us hope therefore that research in this field will be intensified. We should point out, however, that the problem of the choice of the grade of steel cannot be solved in a quasi-mathematical manner and that, in our opinion, a certain latitude must always be left for discrimination by the engineer in the light of his experience.

Quality and Control of Welded Constructions

In his paper, Mr. Faltus gives some further information to complement the papers published in the Preliminary Publication and confirms their conclusions. The importance and, indeed, the urgent need of an appropriate design, careful preparation and thorough inspection of welded constructions, would therefore appear to compel recognition. It remains, however, to determine the extent to which these principles are employed in practice. We cannot conceal a certain degree of scepticism in this matter and we consider that much still remains to be done in this field.

In the Preliminary Publication, we raised the problem, which is partly economic, of the relationship between the requirements of inspection (or more generally of the care exercised in fabrication) and the permissible stresses. It is well known, for example in boiler-making, that it is current practice to make the welding coefficients depend upon the extent of the radiographic examinations, upon whether or not a stress relief heat treatment has been carried out, etc. It would be interesting to learn the opinions on this matter of the experts belonging to the various member countries of our Association.

b) High-Strength Bolts

In the Preliminary Publication we attempted to give a brief survey of the problems arising from connections fastened by means of bolts of high tensile strength; here we shall confine ourselves to emphasising certain particularly important points which have been the subject of papers read at the Congress.

We shall consider, first of all, those connections which are subjected to stresses acting *perpendicularly to the axis of the bolts*, that is to say, joints subjected to shear stresses.

There are two ways of conceiving the mode of action of these connections, or more precisely of calculating them and of estimating their safety. They may first of all be regarded as acting only by *friction;* the stresses are then transferred solely by frictional forces acting between the contacting surfaces, which are clamped tightly together as a result of powerful pre-stressing. In this case the clamping and frictional forces are the basic data of the problem and the safety of the connection is determined in relation to the load which causes slipping of the assembly. The permissible load on a bolt therefore amounts to the product of the clamping force multiplied by the coefficient of friction; this product must be divided by an adequate safety factor.

This method of calculating the strength is the only method applicable in the case of connections subjected to fatigue stresses or for which considerable slip would be undesirable for other reasons.

When the stresses are static, on the other hand, slip does not correspond to the ultimate strength of the connection; after slip, the bolts come into contact with their holes and are subjected to shear stress and to lateral pressure, like rivets or ordinary bolts. At the limit, the breaking load, appreciably greater than that causing slip, will be practically independent of the value of the pre-load to which the bolt is tightened and of the coefficient of friction. The calculation of the permissible stress is therefore carried out in this case as for rivets and ordinary bolts; the permissible shear-stresses of the bolt shafts will, however, be greater, because we are dealing with a steel of high tensile strength.

This distinction between *"friction type"* connections and *"bearing type"* connections has been adopted in the new American regulations relating to high strength bolts, based partially on tests conducted at Lehigh University which are described by Mr. THÜRLIMANN in his paper.

On the continent of Europe, a more reserved attitude seems to be adopted which is satisfied to regard the increase in strength between slip and break as a welcome margin of safety, which would, if necessary, in the case of static stresses, justify a relatively low safety coefficient in relation to slip.

In order to facilitate understanding of these two points of view, it is advisable to draw attention to the analogy existing between the characteristic diagram for the tensile test on a mild steel test-piece and that which represents the relative displacement of a connection made with high strength bolts, subjected to a gradually increasing static stress. To the elastic range of the elongation of the test-piece there will correspond the range of pure friction of the connection: to the yield level corresponds the slip level and to the strain hardening the range of strength of the connection after slip (see fig. 5 and 6 in the article by Mr. THÜRLIMANN). The American procedure for calculating high strength bolts would therefore correspond, on the foregoing analogy, to the determination of the permissible stresses for the steels on the basis of their breaking strength and not on their elastic limit, which is often considered as a criterion in steel construction on account of the considerable elongations which are characteristic of the yield level.

The essential difference between the American specifications and those hitherto established in Europe does not, after all, reside in this method of calculating safety; a comparison of the stresses permitted in the bolts shows, in fact, that the American and German values, for example, are not very far apart. The difference between them consists far more in the *requirements regarding the state of the contacting surfaces* — a state which largely determines the coefficient of friction. In the United States, for bearing type connections, little importance is attached to friction and the precautions prescribed are somewhat sketchy; even for friction type connections only painting and galvanizing are prohibited. In Europe, on the contrary, a treatment by sand-blasting or the removal of scale with an oxy-acetylene torch is required in the existing standard specifications, in order to ensure a high and uniform coefficient of friction.

It is not our province to settle the problem. Only the future — and the experience gained — will make it possible to say whether the European regulations are too severe or whether, from the moment that the advantages of a connection without slip are deliberately abandoned, it is not simpler and more economical to have recourse to ordinary bolts.

In the Preliminary Publication, some mention has already been made of the great rigidity of connections made by means of high strength bolts; the deformability of a bolt acting by friction is much less than that of a rivet subjected to shear forces and the distribution of the stresses in a line of bolts is far from being uniform. A certain degree of equalisation can only result from slight relative slidings between the bolts. In the Preliminary Publication we raised the question of the possible effect which these small slips might have upon the *fatigue strength* of a connection. The problem is treated in the paper by Mr. Beer. Tests carried out in Austria, on connections subjected to repeated stresses, close to the stress causing slip, showed neither gradual "walking", nor progressive reduction in strength. As the tests in question were very rapid pulsating tests, it might be assumed that slow application and removal of the load would give less favourable results; in course of time the asperities which, according to Mr. Beer, seem to ensure the clamping together of the contacting surfaces, might break as a result of fatigue, and this would reduce the coefficient of friction. Obviously this is only an hypothesis and an extension of our knowledge regarding the *actual mechanism of friction* is urgently required.

Let us now consider fastenings comprising bolts subjected to external forces acting parallel to their axes, that is to say to fastenings subjected to tensile or bending stresses. The papers by Mr. Beer and by Mr. Steinhardt bring fresh developments on this subject. The connections in question are mainly joints subjected to bending stresses, constructed by means of butt straps fastened with high strength bolts. Since the bolts are tightened with a considerable pre-load, these fastenings are much less deformable that the usual fastenings of the same type made by means of ordinary bolts which, for practical purposes, may be regarded as hinges. Fastenings by means of high strength bolts make it possible, on the contrary, to reckon on a certain degree of fixed-end effect. As Mr. STEINHARDT points out, continuity is not, however, complete and it is necessary to introduce into the calculations a factor characterising the actual deformability of fastenings subjected to bending[1]). It may be questioned whether the constantly increasing application of welding in the work of erection will not restrict the use of this kind of bolted fastening; welding enables perfectly rigid joints to be constructed.

In conclusion, let us direct our attention to the method of tightening by the "turn of the nut". This consists, as is well known, in forcing the shaft of the bolt to undergo an elongation corresponding to a stress exceeding the conventional elastic limit but, owing to the plastic properties of the steel, considerably below the elongation at break. This process is mainly employed in the United States where wide use is made of pneumatic wrenches which are not well adapted to the accurate determination, necessitated by the conventional method, of the moment of tightening. The paper by Mr. BEER shows that the "*turn of the nut*" method is now being introduced into Europe.

As we have already indicated in the Preliminary Publication, it is, however, open to question whether such high claims for high strength bolts can be accepted without demur. We have in mind, more particularly, the problems of relaxation and creep, both as regards the bolt itself and the assembled parts. As Mr. STEINHARDT points out in his paper, it has proved necessary, in Germany, in order to avoid a loss of clamping force, to limit the pressures between the head — or the nut —, the washer and the base material. It will consequently be interesting to see how American joints, sometimes fastened with a single washer, will behave in course of time. In our opinion, a degree of caution is essential in this field if disappointing results are to be avoided.

However, this may be, prestressed high strength bolts constitute a new means of fastening which has successfully stood the test of practical experience when correctly applied and which forms a useful addition to the range of older methods of joining members.

---

[1]) The connections in question are therefore semi-rigid, like those, obtained by riveting, which are described in the article by Mr. MAUGH (Theme III).

Leere Seite
Blank page
Page vide