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Remarks on the Quality Assurance of Steel for General Structural Purposes

Remarques sur l'assurance de la qualité des aciers de construction

Anmerkungen zur Qualitätssicherung allgemeiner Baustähle

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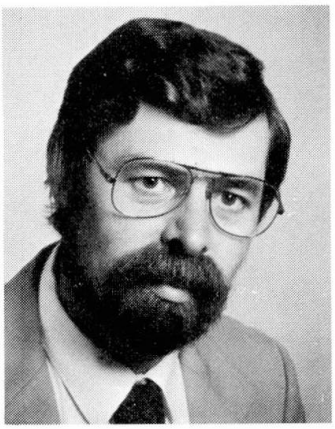

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SUMMARY

The quality assurance of structural steel takes place almost exclusively outside the constructional engineering part of the building process. There are some indications that the scope and the nature of present quality assurance measures are not satisfying the requirements of steel structures, especially with regard to the increasing importance of plastic design. A systematic research is necessary.

RESUME

Les examens visant à assurer le niveau de qualité défini pour les aciers de construction ont lieu à peu près exclusivement en dehors du génie civil. Certaines indications montrent que le mode et l'ampleur des contrôles actuels sur la qualité ne satisfont pas aux exigences de la construction métallique, en particulier si l'on considère les calculs à la charge ultime qui prennent de plus en plus d'importance. Il est nécessaire d'effectuer une recherche systématique.

ZUSAMMENFASSUNG

Für die allgemeinen Baustähle findet die Qualitätssicherung fast ausschliesslich ausserhalb des Bauwesens statt. Es gibt Hinweise, dass Art und Umfang der derzeitigen Qualitätssicherung nicht zufriedenstellend für die Erfordernisse des Stahlbaues sind, insbesondere im Hinblick auf die zunehmend bedeutend werdenden Traglastberechnungen. Eine systematische Erforschung ist notwendig.

1. GENERAL REMARKS AND PRESENT STATE

The following remarks are restricted to common steel structures covered by structural standards. Welding problems are not considered.

Certified steel assortments and quality classes are completely listed in the structural steel standards.

The quality control, however, is not regulated in structural standards, but in quality standards - irrespective of the intended application.

Quality standards specify the following properties:
- deoxydation method
- chemical composition
- properties in the tensile test: minimum tensile strength, upper yield strain and strain to failure
- properties in the folding test and notch shock test.

The steel producer is almost free in the choise of number and nature of quality assurance measures. With respect to the material, certificates of material tests issued by the producer are the only measure of quality assurance within the building process. According to the certificate, some or all guaranteed properties listed above are testified.

It may be pointed out that some technological properties can be significantly altered during the construction process (e.g. by heat treatment).

2. EXCHANGED MATERIAL CERTIFICATES BY MISTAKE

There is a danger that material certificates may be exchanged by mistake. This happend, e.g. with the metal sheets ordered for the cable anchoring of a 360 m high guyed mast. In consequence of a damage during erection it was revealed that brittle material had been used because of exchanged material certificates.

3. UPPER LIMIT OF THE YIELD STRESS

Ultimate load analyses using plasticity theories are gaining more and more importance in structural analysis. According to a plastic design, internal forces of one structural member can depend on the yield stress of other members. An example is given in Fig. 2. A plate girder is supported by a central column. According to elastic theory the girder behaves like a continous two-span beam. Once the yield stress of the girder is reached at the support, a plastic hinge develops an the structural system changes to that of two simply supported beams. Therefore the normal force in the column depends on the yield stress of the overlying plate girder. Higher yield stresses give rise to higher column loads. Consequently, actual yield stresses which significantly exceed the guaranteed minimum values may not always lead to a safe overall structure.

Tensile tests in connection with experimental investigations often show yield stresses which are much higher than the guaranteed minimum values.

It may be supposed that - in some cases - steel, originally produced as St 52, which does not comply with all quality standards of that class, is later sold as St 37. The resulting overqualification with respect to the required properties of steel class St 37 is not always specified in the producer's certificate.

Since more quality may be less quality with regard to the overall safety of a structure, upper as well as lower limits should be specified.

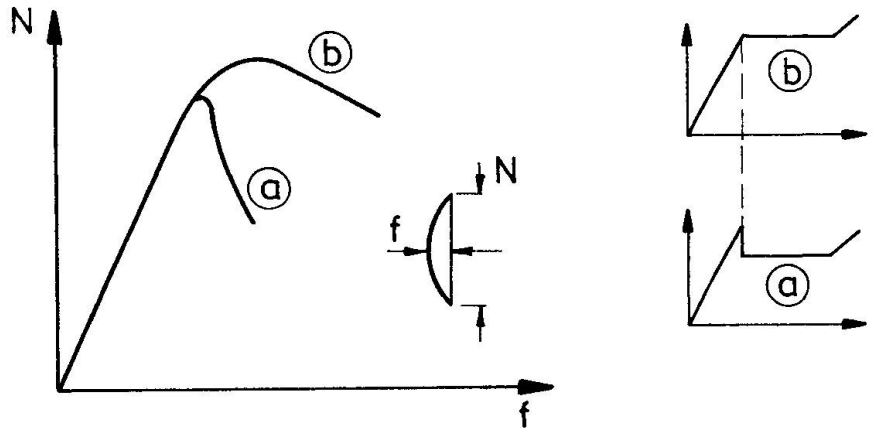

Fig. 1 Load-Deformation-Diagram of an eccentrically loaded column and its correlation with the Stress-Strain-Diagram

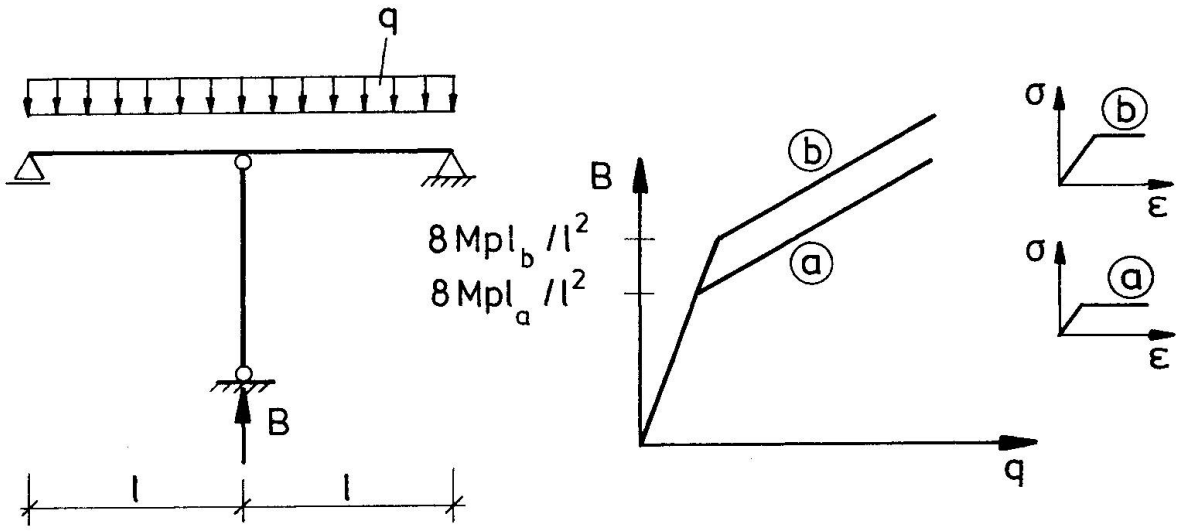

Fig. 2 Column load as a function of the plastic bending moment of the overlying girder

4. STRESS-STRAIN-DIAGRAM

The behaviour of a structure or structural element close to the plastic limit load does not only depend on the yield strength but also on the shape of the stress-strain-diagram.

Structural steel of the same type and quality class may show a more or less distinct upper yield stress level. The lower (static) yield point may deviate up to 40% from the upper yield point, and the strain corresponding to the start of the hardening part of the stress-strain curve shows large scatter. Fig. 1 illustrates that the load capacity of some structures (especially those which are susceptible to stability failure) can be markedly affected by the shape of the stress-strain-diagram.

However, only lower limits of the upper yield stress are specified in the quality standards.

5. CONCLUSION

There are distinct indications that it is possible to modify scope and nature of quality assurance measures in such a way that reliability and economy of steel structures can be improved. The present measures of quality assurance employed by the producers do not satisfy the requirements of steel structures.

Particularly with regard to plastic limit design research should be encouraged in the following fields:

- Which properties of structural steel affect the reliability of steel structures?
- What is the range of scatter of these properties within one type and quality class of steel, and what correlations exist between them?
- What is the present state-of-the-art concerning quality assurance?
- Which modifications of quality assurance measures are possible, and what are the consequences with respect to reliability and economy of steel structures?