Post-buckling behaviour of webs under concentrated loads

PDF erstellt am: **21.07.2024**

Post-Buckling Behaviour of Webs under Concentrated Loads

Comportement post-critique de voilement des âmes soumises à des charges concentrées

Überkritisches Beulverhalten von Stegblechen infolge Einzellasten

ALLAN BERGFELT
Professor, Structural Engineering
Steel and Timber Structures
Chalmers University of Technology
Göteborg, Sweden

Some comments are here given on the paper [1] by M. Škaloud and P. Novák : Post-buckled Behaviour and Incremental Collapse of Webs Subjected to Concentrated Loads. This paper gives results from tests performed in order to make it possible to build up a complete theory.

It is of course interesting to compare their results with already existing preliminary formulas. In a paper [2] to the London colloquium 1972 on Design of Plate and Box Girders for Ultimate Strength, I gave a preliminary formula and a diagram illustrating the influence of flange stiffness on the ultimate bearing capacity under a concentrated load (A. Bergfelt : Studies and Tests on Slender Plate Girders without Intermediate Stiffeners. I, Shear strength and II, Local web crippling).

Putting the test results of Škaloud and Novák into my formula, fig. 1 illustrates that their results confirm at least its tendency. The curve in the figure is from fig. 14 of my London paper, completed with the influence (from fig. 11 of the paper) of a somewhat distributed load, as in the tests of Škaloud and Novák. The curve is valid for point load action combined with small bending stresses. As my investigation considered girders without intermediate stiffeners and the girders of their tests had stiffeners with the same distance as the height of the girder it is of course a slight difference in behaviour, especially for extremely thick flanges. In that case the web is not so dominating, but the girder to some extent also acts as a Vierendeel-beam consisting of the flanges and the stiffeners. Owing to this fact their result for flanges with a thickness of about 10
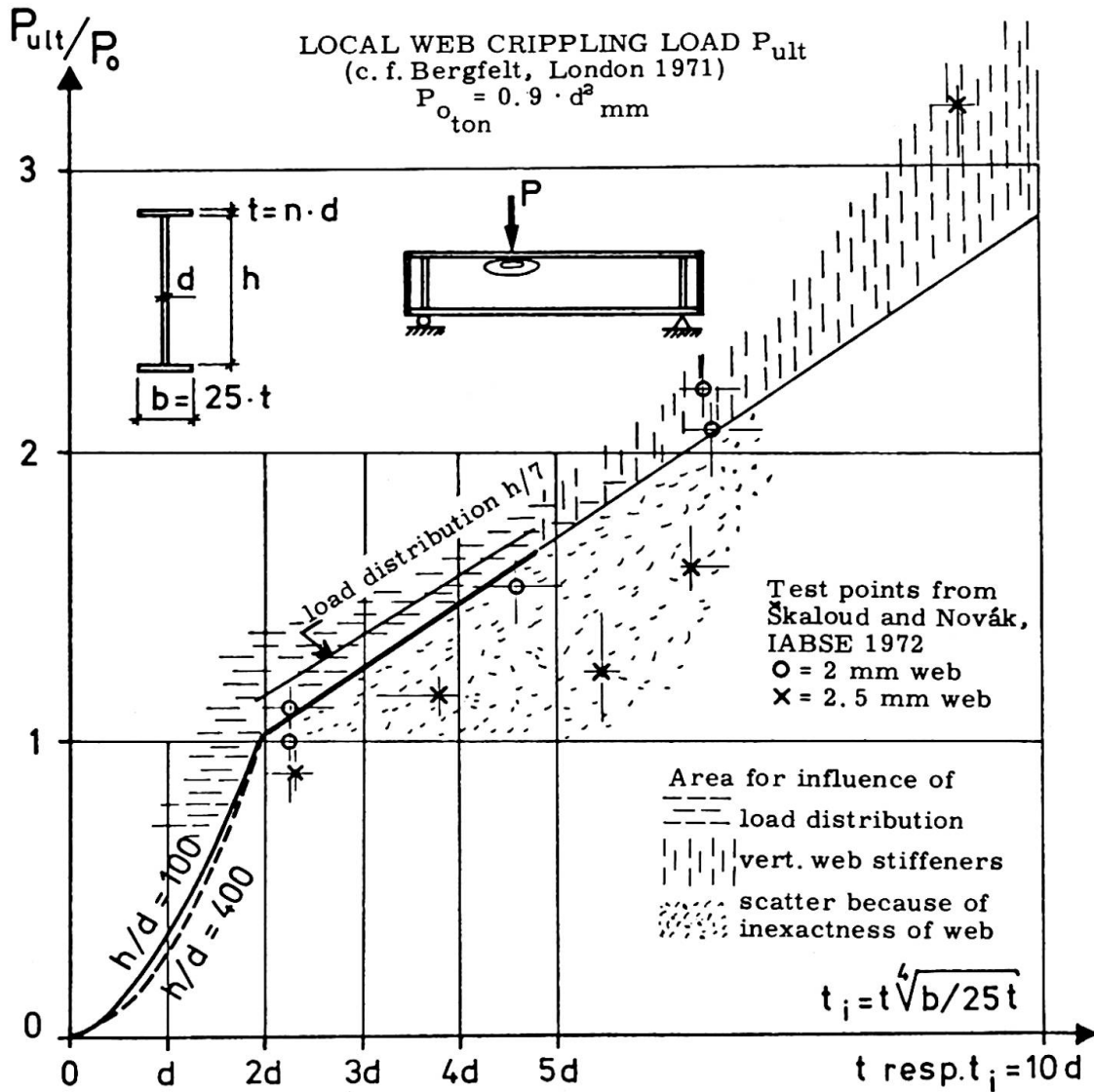
Fig. 1 Test values according to Škaloud and Novák [1] marked in the diagram from [2].

times the thickness of the web is as seen from the only test in that region, a little higher than predicted from my curve. The scatter of the test values due to fabrication and material deficiencies is within the predicted limits.

The curve in the original figure was based on tests on girders with flanges about b = 25 t, which is commonly used. When the ratio of flange dimensions differs very much from that mentioned it is of course necessary to adjust t — as single variable for stiffness — to $t_i = t \sqrt[4]{b/25 \cdot t}$ as in fig. 1.

The test points of Škaloud and Novák are marked in fig. 1 as if the web thickness was really the nominal values 2 and 2. 5 mm given in their paper. When their careful measurements are published and used some adjustments can of course be motivated. The steel quality is not reported but seems to have some influence, which is for the moment the scope of tests at my laboratory.

In order to illustrate the influence of stiffeners when the flanges are very thick the bearing capacity of the flange can be computed as if there was no web at all. Considering the flange 250 x 30.88 mm, which corresponds to t_i near 10, its bearing capacity is 12.5 ton (plastic design and σ_Y = 2200 kg/cm^2).

As the test load was 18.0 ton, the influence of the web is only 5.5 ton (which in this case happens to be just about the 5.6 ton taken by the web with a very weak flange only).
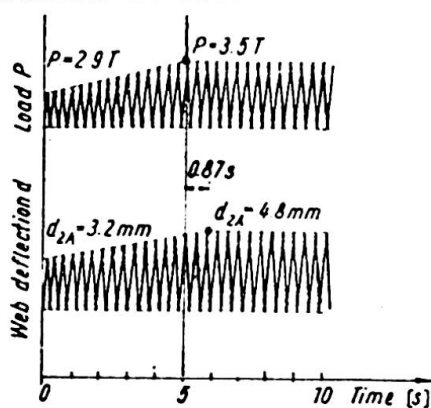
As pointed out in the paper much work remains to be done and it is considered favourable that several laboratories are interested in the problem.

*

The second part of the paper by Škaloud and Novák deals with cyclic load tests. They state that the maximum loads in several cases were higher than in the static tests and that the cyclic loads did not cause any reduction in ultimate strength.

The reason for this result is, as I think, the short loading times which result from 3 loading cycles per second. There is no time for yielding.

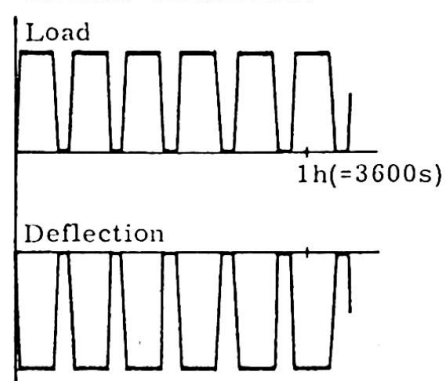MIROSLAV ŠKALOUD – PAVEL NOVÁK   ALLAN BERGFELT

Fig. 2 Load-time dependency as used in the tests of [1] and [2]

As mentioned in my London paper 1971 I have made loadings with longer pe-
riods, for instance with so long periods that there are only 5 cycles per hour
Now test girders have been loaded up to about 1000 such cycles, which could
be called repeated statical loads, and there are of course no increase in ul-
timate strength. It ought to be a reduction which was, however, in our tests
very small. I have performed tests with 1000 cycles to more than 90% of the
ultimate statical load without collapse. It is called attention to the fact that
ultimate loads are meant, which as also observed in the paper by Škaloud and
Novák could be 2-6 times higher than some elastic critical load for the dimen-
sions of our test girders.

The comparison with statical loading tests holds true even in tests with
combined action of bending stresses and stresses caused by the point load.
Tests have been performed with bending stresses in the girder up to about
half the yield stresses.

In order to obtain a well-founded general formula for cyclic loads it is ne-
cessary to test both slow and rapid cycles. So extremely slow loadings as
corresponding to only 5 cycles per hours as mentioned above is probably
not necessary. Perhaps for instance one cycle per minute is satisfactory.
The rapid tests of Škaloud and Novák are necessary for machine foundations
and bridges, while my slow tests are needed for roof structures. Anyhow it
is very positive that testings at different laboratories complete each other.

References

[1] ŠKALOUD, M., and NOVÁK, P.: Post-buckled Behaviour and Incremental
     Collapse of Webs Subjected to Concentrated Loads. IABSE, Ninth Con-
     gress Amsterdam 1972, p. 101.

[2] BERGFELT, A.: Studies and Tests on Slender Plate Girders Without In-
     termediate Stiffeners. I, Shear strength and II, Local web crippling.
     IABSE Colloquium on Design of Plate and Box Girders for Ultimate
     Strength, London 1971.

SUMMARY

The test values according to Škaloud and Novák (1) for local web crippling under a concentrated static load, are compared with a preliminary formula given in (2). Comments are given on the influence of the rates of loading on the collapse under cyclic loadings.

RESUME

Dans ce travail, les valeurs obtenues lors d'essais par Škaloud et Novák (1) pour la ruine locale de l'âme soumise à une force statique concentrée, sont comparées à celles déterminées théoriquement dans (2). Ensuite l'auteur commente l'influence de la fréquence de charge sur l'état de ruine dans le cas de charges périodiques.

ZUSAMMENFASSUNG

Die Versuchsergebnisse nach Škaloud und Novák (1) für lokales Stegblechbeulen unter statischer Einzellast werden mit einer vorläufigen Formel aus (2) verglichen. Ueber den Einfluss der Laständerungsrate auf den Kollaps unter Wechsellasten wird berichtet.

Leere Seite

Blank page

Page vide