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

Band: 8 (1968)

Artikel: Deformed bars as pretensioned reinforcement in partially prestressed members

Autor: Losberg, A. / Cederwall, K.

DOI: https://doi.org/10.5169/seals-8841

Deformed Bars as Pretensioned Reinforcement in Partially Prestressed Members

Emploi de barres en acier préalablement déformées comme armature pré-tendue dans des constructions partiellement précontraintes

Rippenstahl als selbstverankernde Bewehrung in teilweise vorgespannten Bauteilen

A. LOSBERG
Prof., Dr.Techn.

K. CEDERWALL
Techn.lic.

Chalmers University of Technology
Gothenburg, Sweden

The development in Sweden during the last decades in the matter of reinforcement steel has resulted in a production of deformed bars (transversally ribbed bars) with high allowable stresses, and further increase of strengh by means of cold-drawing is possible. For example, a steel with a 0,2-point of 9000 kp/cm^2 is now manufactured in Sweden. The use of such steel qualities as ordinary reinforcement is restricted owing to the risk of large crack widths and deformations. These difficultes could be eliminated by a moderate pretension of the reinforcement.

The present investigation deals with the function of such cold-drawn high grade deformed bars used as pretensioned reinforcement in partially prestressed members. It is particularly two aspects that have been studied, namely anchorage problems concerning the lengths of the stress transfer and the risk of splitting in the bar-end zone as well as problems concerning stiffness and crack formation in partially prestressed beams. Two series of tests, outlined below, have been carried out in order to study the two aspects mentioned above.

The first test-series consists of a number of long prisms centrically prestressed with a single reinforcement bar. The prestress in the steel was comparatively low, between 3000-6000 kp/cm^2. The stress-increase in the tendons from the bar-end inwards was measured with strain-guages fitted into slots along the bar, and the corresponding concrete-strains on the surfaces of the prisms were measured along and transversely to the direction of the force. In most test-prisms the end zone of the reinforcement bar was surrounded by a spiral reinforcement. In some of the prisms the stress in the spiral reinforcement was measured with glued on strain-guages.

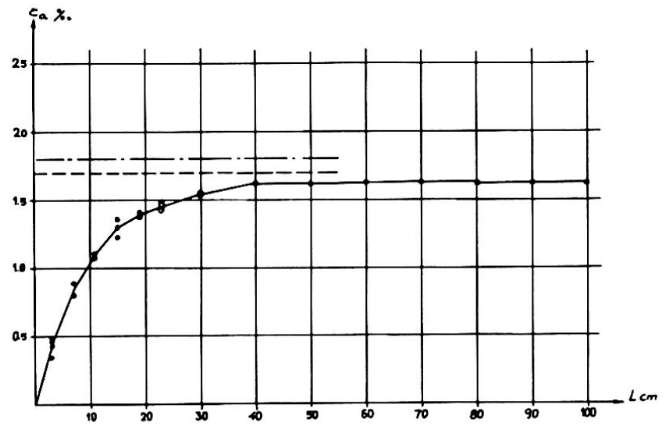

Fig. 1. Strain-increase from bar end in pretensioned bar.

Figure 1 shows the strain measurements along the steel from the bar end for one of the prisms. The transfer lengths are rather short, amounting to about 30-35 cm, fairly independent of the prestressing force and only slightly dependent of the diameter of the bar. The application of the theory of "Modulus of displacement" presented by one of the authors at the previous IABSE congress [1] gives a theoretical expression of the transfer length:

$$l_t = 3,50\sqrt{\frac{E_s \cdot A_s}{K \cdot \pi \cdot d}}$$

where E_s = modulus of elasticity of steel

A_s = steel area

K = modulus of displacement

d = diameter of the bar

The measured transfer lengths gives a value of K=15000 kp/cm^3 which is in good agreement with other tests with this kind of reinforcement.

Observations of the strain transversely to the force direction at the prism ends agree fairly well with theoretical calculations of the splitting stresses according to Hampe [2]

$$\sigma_{spl} \approx 0{,}65 \cdot \sigma_c \left(\frac{h}{l_t}\right)^2$$

where σ_c = concrete stress due to pretensioning

h = largest dimension of test prism

l_t = transfer length

This indicates, if the elements are not too extremely shaped, that the influence of the splitting tendencies does not seem to be more disturbing than if for example wires or strands are used. It seems possible to eliminate the splitting effect through a rather moderate amount of transverse reinforcement.

The expression above for splitting stress gives a total splitting force

$$F_{spl} = k \cdot F_{pre} \cdot \left(\frac{h}{l_t}\right)$$

where F_{pre} = prestressing force

k = factor depending upon the ration h/l_t, for these tests k = 0,25.

The tests indicate that a transverse reinforcement corresponding to this expression is quite sufficient.

The second test-series consists of partially prestressed beams reinforced with a single deformed bar, diameter 16 mm, as well as beams with two bars, diameter 12 mm, placed near the bottom surface of the beam. The prestress in the steel varied between 3000-6000 kp/cm^2. The beams were loaded in the one-third points with a short-time load to an appreciated working-level and after unloading, the beams were loaded to failure. The stress distribution along the bars was measured with strain-guages in the same way as for the prisms, and the strain distribution in cross sections as well as the curvature was measured.

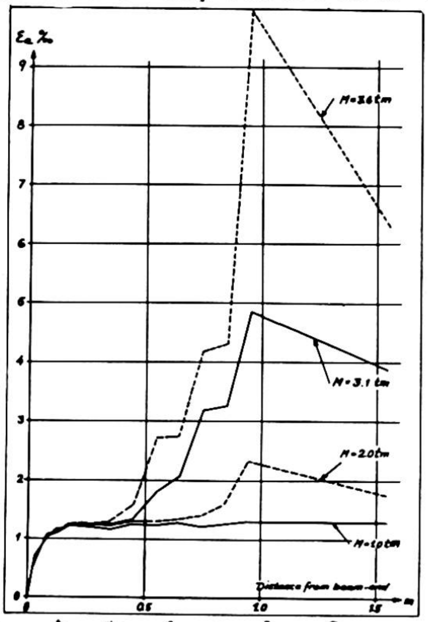

Fig. 2. Steel-strains for two loading stages under and two above the working level.

Figure 2 shows the measured steel-strain for some of the loading stages. It is obvious that the length of transfer is rather short, about 30 cm, and remains the same up to the ultimate load. The peaks in the strain diagrams are due to cracking. The stiffness was as favourably effected by the prestress as expected. The crack formation was moderate with fine and well distributed cracks; the crack formation for one of the beams is shown in figure 3.

A comparison with the standard methods of calculating the bending stiffness for uncracked and cracked stages agreed well with the results.

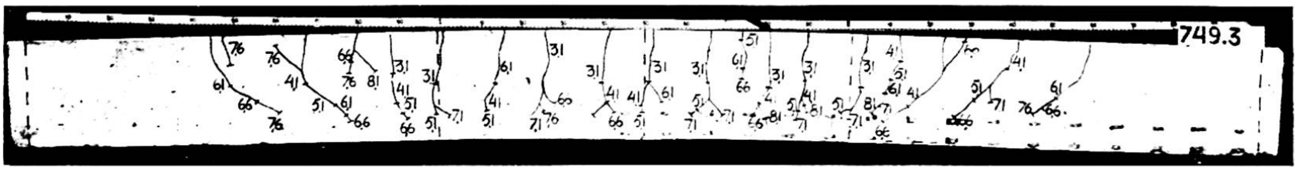

Fig. 3. Crack formation for one test-beam

The crack-widths can also be reasonably well predicted through standard calcualtion methods for loading stages close to working-level. The ultimate load is also fairly well predictabel through standard ultimate theory. It is evident that the cooperation between concrete and reinforcement is very good during the whole loading process.

These tests have shown clearly that deformed bars of the described above type can be used as self-anchoring tendons, and that even quite moderate prestress gives satisfying possibilities for making full use of a very high-grade steel as reinforcement. On account of prestress losses it is, however, desirable to use a higher value of the prestress, and for the kind of steel used in these tests the prestress should at least amount to about 5000 kp/cm^2.

|1| A Losberg: Anchorage of Beam Reinforcement Shortened According to the Moment Distribution Curve, IABSE 7th Congress, Final Report.

|2| E Hampe: Vorgespannte Konstruktionen, Berlin 1964.

SUMMARY

The present investigation deals with the function of cold-drawn high grade deformed bars used as pretensioned reinforcement in partially prestressed members. The tests have shown that this steel can be used as self-anchoring tendons and that even a rather moderate prestress effectively decreases deformations and crack-widths.

RÉSUMÉ

Le présent ouvrage étudie l'usage de barre en acier doué de haute résistance, écroui à froid et préalablement déformé, comme armature tendue dans des constructions partiellement précontraintes. Les résultats montrent que cet acier peut être employé comme tenseur à ancrage propre et qu'une légère pré-tension diminue de façon effective les déformations et la largeur des fissures.

ZUSAMMENFASSUNG

Diese Untersuchungen behandeln die Funktionen kalt gezogenen hochwertigen Rippenstahls, der als selbstverankernde Bewehrung in teilweise vorgespannten Bauteilen angewandt wird. Die Resultate haben gezeigt, dass dieser Stahl als ein selbstverankernder Stab angewandt werden kann, und dass sogar eine ganz geringe Vorspannung die Verformungen und Rissbildungen effektiv verringert.

Leere Seite
Blank page
Page vide