THE EFFECT OF CREEP DUE TO TENSILE STRESS ON COMPOSITE STRUCTURES

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1. Introduction

The action of creep due to tensile stress is still a less investigated field of research. This is probably caused by the difficult conditions of research and the expected small results. In spite of the often occurrence of that phenomenon, for example at the upper concrete slab of composite bridges above the intermediate support there is no calculation method up to now which gives exact results for that effect.

In the Eurocode the Tension Stiffening (TS), the contribution of concrete overtaking tensile stress between the generated cracks, is already integrated in the calculation procedure. By taking this tension stiffening effect only into consideration, the stiffness of the girder above the bearing is assumed to high, consequently the deflection in the field becomes bigger than expected.

2. Creep under Tension

If a reinforced concrete bar is set under tensile stress, so the first crack occurs at the axial force Nr at the weakest point over the length. If the tensile force is gradually increased, further cracks will occur in equal distances a_m over the length of the test piece. The crack picture will be finished with the axial force Nrn. If the tensile force would now be further increased no more cracks will occur but only the crack width of the existing cracks will be widened. Fig. 1 illustrates the tensile force-strain-interaction curve of the reinforced concrete bar under tensile stress. It should be mentioned that if transverse reinforcement is also installed the cracks will not occur at the distances a_m but at the chosen pitch of the transverse reinforcement because of the smaller concrete cover. At the crack all tensile stress is in the reinforcement. But between the cracks the concrete is also overtaking tensile stress. In Fig.1 the tension stiffening effect is shown.

By taking the long time effect of tensile creep into account this amount is getting smaller, because of the redistributed forces from concrete to reinforcement. In [2] the β is determined to be 0,4. In a precalculation, by applying the creep factor of ϕ=2 the effect of tensile creep has been taken into account: β was calculated to be 0.22. So the realistic σ-ε-line is between the nowadays assumed σ-ε-line, taking only TS into account, and the condition II.

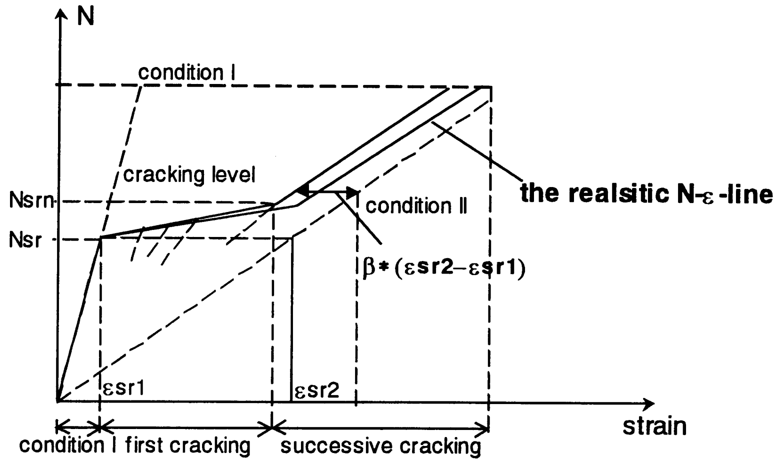

Fig.1: N-ε line of the reinforcing bar under tensile stress

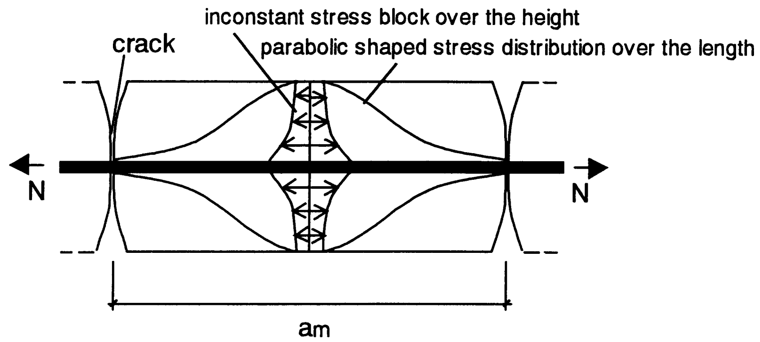

Fig.2: Assumed stress distribution over the length and the height

3. Tensile Test

Besides the crack pitch, the distribution of axial stress over the height and the length of the test piece (Fig.2) and the distribution of the shear

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stress next to the crack is still unknown. Within a first tensile test, investigating short time effects, these are the aims of research.
The distribution of the strain gauges is difficult, because it depends on the cracks occuring. So by using the formulas of [1] the crack pitch is calculated and the strain gauges are arranged.
Two kinds of test pieces are investigated which defer from each other because of the length: The small test piece has the length of the crack pitch (so no crack will occur), calculated with the given formula of [1], the long test piece has the length of 4 times this crack pitch. Strain gauges are put on the reinforcement, inside the concrete and on the surface. Because of the negative effect of the strain gauge wires, as less strain gauges as possile are installed. The strain gauges are used in symmetric order to avoid additional effect due to imbalance. Additionally the strain gauges on surface, inside the concrete and on the reinforcement surface (researching axial stress and shear stress) are installed in one test piece each. Next, the three in bridge constructions most often applied diameters of reinforcement are used for the test pieces: D13, D16, D19. So all together the test is performed with 12 long test pieces and 12 short test pieces.
The tensile force is increased gradually from 0 kN up to the yield strength. The important parameter, the percentages of reinforcement of the D13, D16, D19- test pieces are 0,012, 0,0128 and 0,0144, respectively, so a comparison between the test pieces is possible.

4. Results and Discussion

The evaluation of the test results gave the following concrete strain distribution over the height of the concrete section (Fig.3).
Furthermore Fig.4 shows the strain distribution of the concrete stress betweeen the cracks. Because the short test piece gets no crack an exact arrangement of the strain gauge in the center and in the quaters of the length is possible. The test data proof that the assumption of a parabolic shaped curve for further considerations is correct: The simplified curve in Fig.2 is in accordance with the test data. Besides, the occuring crack pitches correspond generally with the proposed formulas of [1].

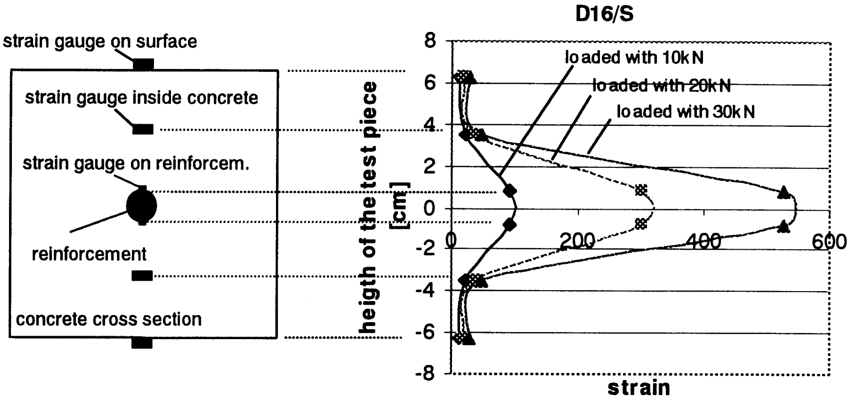

Fig.3: Strain distribution over the height

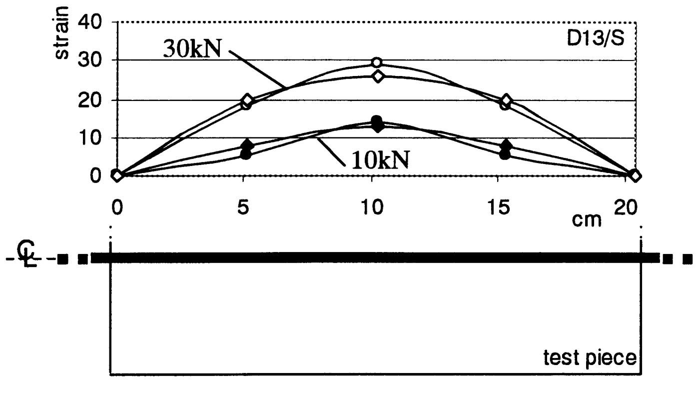

Fig.4: Strain distribution of concrete surface and inside concrete over the length

5. Conclusion

The above described phenomenon of creep under tension also occurs in the area of intermediate support due to the sustained bending moment. Here the upper concrete flange gets tensile stress. The reinforced concrete slab can be compared with the reinforced bar and generally the phenomenon of creep under tensile stress also occurs. However, in contrast to the reinforced concrete bar under centric tensile load, the concrete is additionally fixed on the upper steel flange and the tensile stress is not constant over the heigth of the concrete section.After establishing an analytical method to calculate creep under tension for the reinforced concrete bar under centric tensile load, a further test should be performed in order to investigate this time dependent phenomenon at the composite girder with its effect on the whole structure (deflection, flexural stiffness).

References

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