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TENSILE LOAD-BEARING BEHAVIOUR OF CONCRETE AFTER LONG-TERM STATIC AND CYCLIC TENSILE PRELOADING

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Abstract

Experimental investigations into the tensile load-bearing behaviour of concrete after long-term static and cyclic tensile preloading are presented. The tensile strength was measured in uniaxial deformation-controlled tensile tests. An essential influence of the test duration was detected.

1 Introduction

Concrete structures are ordinarily loaded by a combination of short-term, long-term or cyclic tensile loading. Repeated loadings can cause fatigue behaviour of brittle materials which can generally be explained by changes in structure in the microsphere. The loadbearing tensile behaviour of concrete, which is only indirectly considered for the determination of load bearing capacity of reinforced concrete and prestressed concrete structural units according to accepted regulations, is, in many cases, however, an essential criterion for the determination of the load bearing capacity.

2 Investigations

Full details on the investigations are given in [Blaschke, F., Losekamp, C.und Mehlhorn, G.]. The tensile load-bearing behaviour was investigated in 45 uniaxial, deformation-controlled tensile tests as a function of

- a static tensile preloading after 14 or 28 hours with different loads (0.50 ; 0.75 f_{ctm}[1] resp.)
- a cyclic tensile preloading with different maximum and minimum loads (0.5; 0.6; 0.75 and 0.1; 0.3 f_{ctm})
- different frequencies of repeating loads (0.01; 0.1; 1 Hz)
- different amounts of repeating loads (10.000; 100.000)
- different types of cyclic repeating loads

in comparision to the results of non-preloaded tensile tests.

Fig. 1 shows the dimensions of the specimens with the used length of the measurement for the specimens surface deformations (deformations of the surface area). The grading curve was within a favourable range. The concrete strength of a B 35 [2] was achieved by using 310 kg cement (PZ 35 F) per m^3 unset concrete (green concrete). A natural unbroken aggregate was used with a maximum grain size of 16 mm and a water/cement ratio of 0.55. The age of the specimens varied between 100 and 150 days. Preliminary tests have shown that an adjustable exceeding of the maximum sustained load after certain tensile preloading and axial loading was impossible to achieve with such large test samples (Fig. 1). So, all specimens had been loaded with a defined load eccentricity e/d = 1/6. With increasing load eccentricity the defined load, which enables a longer reaction-time for the testing setup, can be distributed at the moment of an instable crack increase.

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1 f_{ctm} - minimum value of the eccentric tensile strength for the non-preloaded bodies

2 B35 - characteristic value of the cube strength of concrete under compression 35 N/mm², corresponding to a concrete cylindrical strength $f_{cd} \approx 30$ N/mm²

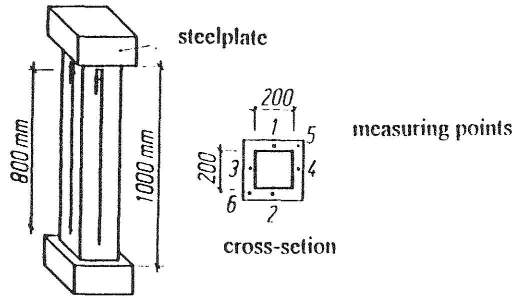

Fig. 1. Dimension of the specimens, with measuring points

3 Summary of results

The eccentric minimum value of the tensile strength of concrete f_{ctm} was determined for 75% of the minimum value of the axial tensile strength of concrete, compared to a comparative test series where the short-term tensile strength was determined without preloading. In principle, a static as well as a cyclic tensile preloading lasting essentially more than 14 hours up to a fatigue strength increases the eccentric tensile strength f_{ct}, the fracture energy G_F respectively the softening ranges of the stress-strain relationship.

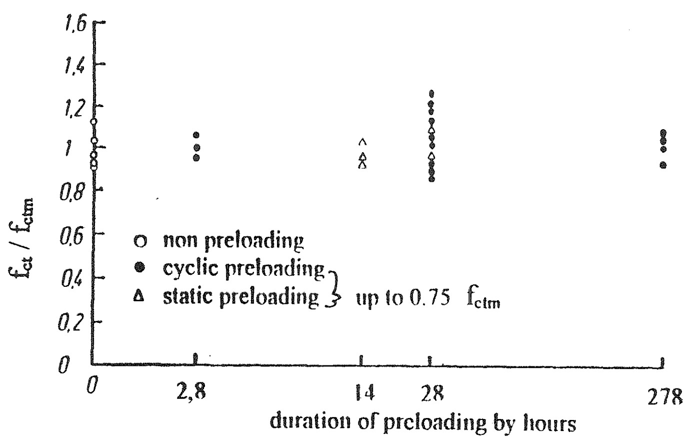

Fig. 2. Referred tensile strength as a function of the duration of tensile preloading

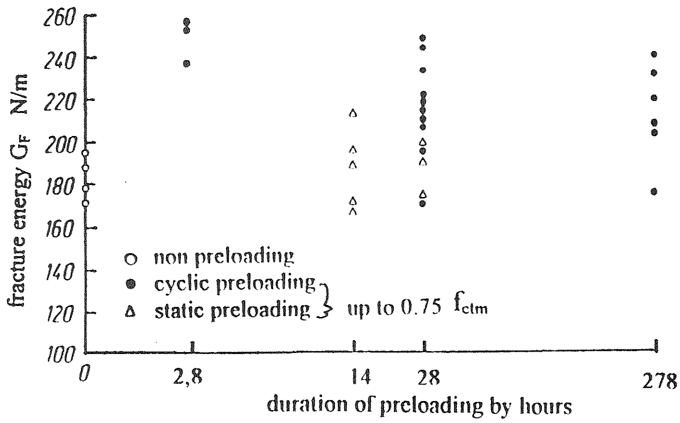

Fig. 3. Fracture energy as a function of the duration of tensile preloading

The tests have demonstrated a significant dependence of the tensile strength on the duration of preloading (fig. 2 and 3). Whereas a small resp. 10% loss of strength was determined after about 3 resp. 14 hours because of cyclic as well as static tensile preloading a longer lasting tensile preloading proved a higher tensile strength (up to 25%) after about 28 hours nearly without exception. The fracture energy G_F is approximately referred to when reviewing the residual bearing capacity of concrete and the softening ranges. Tensile preloading (load history) in principle determines higher fracture energy. The highest increase of about 35% was examined at a cyclic tensile preloading with a frequency of repeating loads of 1 Hz. The secant modulus respectively the stiffness of test specimens is largely unaffected by the chosen tensile preloading. A "training effect" because of the load history is proved. A significant difference between the amount of repeating loads of 10.000 to 100.000 and the shape of the curve of reapplication of load (in the stress-time diagram) with tensile preloading was not determined concerning the tensile bearing capacity. An increase of frequency of repeating loads from 0.01 Hz to 1.0 Hz caused a reduction of strength with almost constant fracture energy. A change of the lower limit stress at a cyclic tensile preloading of 0.1 to 0.3 f_{ctm} as well as a change of the type of preloading (static or cyclic) at a duration of preloading of at least 28 hours caused an increase of tensile strength at a constant fracture energy.

4 REFERENCES

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