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Strain Capacity of Reinforced Concrete Members Subjected to Uniaxial Tension

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Abstract

The aim of this paper is to set up a method to determine the strain capacity of tension bars of reinforced concrete (RC) subjected to pure tension. Due to the interaction between reinforcement and concrete and due to the presence of cracks, the stresses in both reinforcement and concrete are varying along the length of the tension bar. The strain capacity of the tension bar is seen as the average strain in the reinforcement at the load level corresponding to the ultimate stress capacity of the reinforcement at the cracks. The result of the approach is in overall good agreement when comparing with 24 tests.

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Keywords: Reinforced concrete, strain capacity, tension bar, crack patterns, crack spacings.

1. Introduction

Figure 1 illustrates the stress-strain curve for both a reinforcement bar and a tension bar. The reinforcement is modelled as bilinear. The stress-strain curve for the tension bar is sketched as a dotted line. This is due to the fact that the presented method only aims to estimate the strain capacity, and not the stress-strain relation from the stress free state to the ultimate state. The strain capacity of the tension bar is affected by a number of factors. In order to determine the strain capacity it is not important to know the exact stress/strain level at which the individual factors becomes dominant but only to know in which order they becomes dominant.

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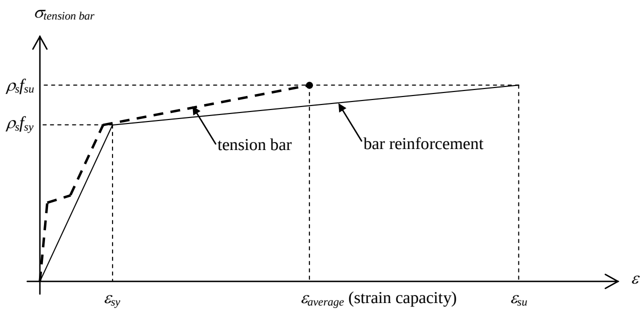
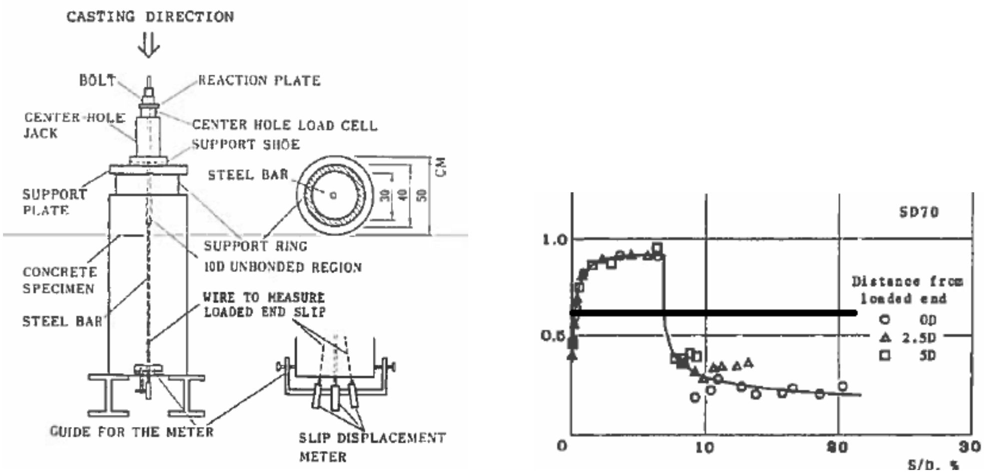


Fig. 1. Modelled stress strain curve for reinforcement together with principle relation for a tension bar.

The modelling can be split into three overall subtopics, that is:

a) determination of the crack distances
b) bond behavior locally at the cracks where minor conical cracks are formed. Hereby is formed a minor zone where there is no, or almost no, contact between concrete and reinforcement. The reinforcement is debonded in this area
c) bond between reinforcement and concrete at larger distances away from the cracks. That is outside the zone of the minor conical cracks

Concerning the later subtopic Fernandez *et al.* [1] has proposed analytical expressions for the modeling of the strain in the steel as function of the distances from cracks which convincible agree with experimental results by Shima *et al.* [2]. The analytical expressions are based on simple physical relations combined with non-linear FEM modelling. The test setup used by Shima *et al.* [2] is shown in Figure 2a. As can be seen in the figure a slip free zone with a length of 10∅ has been used to avoid the local effects. In Figure 2b is shown the relation between the measured shear stress (relative to $f_c^{2/3}$) as function of the ratio between the slip (*S*) and diameter of the reinforcement (in this figure denoted as "*D*"). The higher shear stress level (S/D < ≈7% in Figure 2b) represent the shear stress applicable for the reinforcement being in the elastic range, and the lower shear stress level represent the shear stress applicable for the reinforcement being in the plastic range. The FEM modelling by Fernandez et al indicates that the primary reason for the drop in shear stress are due to the transverse contraction of the reinforcement (as a v. Mise material the volume of the reinforcement is constant in yielding).



a b

Fig. 2. (a) test setup, [2] (b) bond strength as function of the relative displacement [1], [2].