Bond Behavior of Plain Round Bars Embedded in Concrete Subjected to uniaxial Lateral Tension

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Outlines

- Introduction
- Experimental procedure
- Experimental results
- Bond stress-slip relationship
- Conclusions

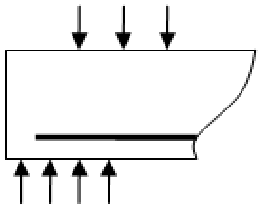
Introduction

- Research significances
  - The evaluation and rehabilitation of historical buildings reinforced with plain round bars have become more highlighted.
  - The bond-slip relationship between reinforcement and concrete should not be neglected in precise nonlinear analysis, which is the basis of historical structural evaluation.
  - Thus it is necessary to investigate the bond behavior of plain round bars, especially under complex stress state.

Introduction

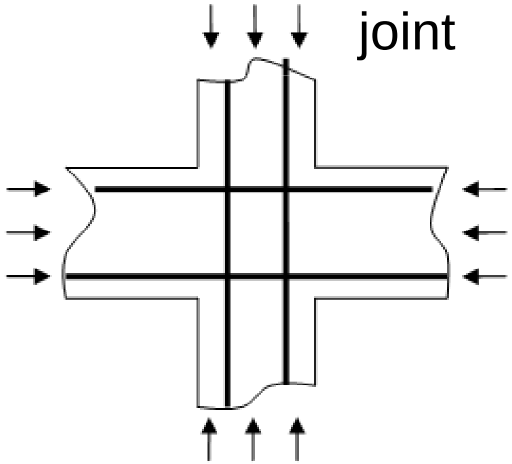
Complex stress state for anchorage

Simple support beam



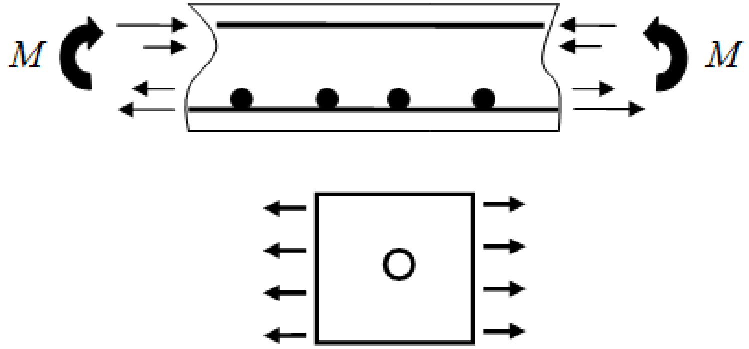
Uniaxial pressure

Beam-column joint



biaxial pressure

Slab



Uniaxial tension

A few studies showed that the lateral tension has an adverse effect on the bond behavior, the information about the influence of lateral tension on bond mechanism and bond-slip relationship is limited.

Introduction

- Research highlights
  - Initially study the effect of uniaxial lateral tension on plain round bars' bond behavior through pull-out tests.
  - Empirical expression for ultimate bond strength, residual bond strength and the slip corresponding to ultimate bond strength are obtained.
  - Model of local bond stress-slip relationship with the effect of lateral tension is proposed.

Experimental procedure

- Material
  - Bars

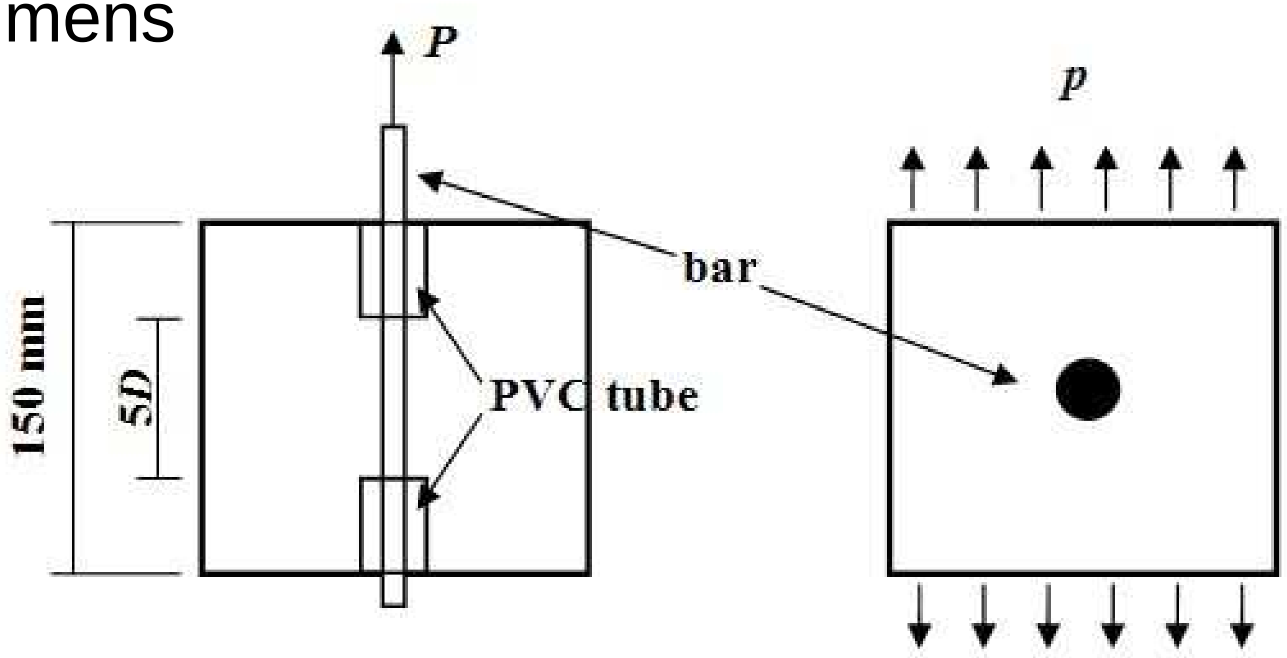
Diameters and mechanical properties of plain round steel bars

Type of steel bars	P12	P16	P20
Nominal diameter D, mm	12	16	20
Yield strength f_y, MPa	295	261	247
Elastic modulus E_s, GPa	210	210	210
Poisson's ratio υ_s	0.3	0.3	0.3

  - Concrete
    - The average compressive strength and tensile strength were 40 MPa and 3.1 MPa, respectively. The average elasticity modulus and Poisson's ratio were 32.1 GPa and 0.24.

Experimental procedure

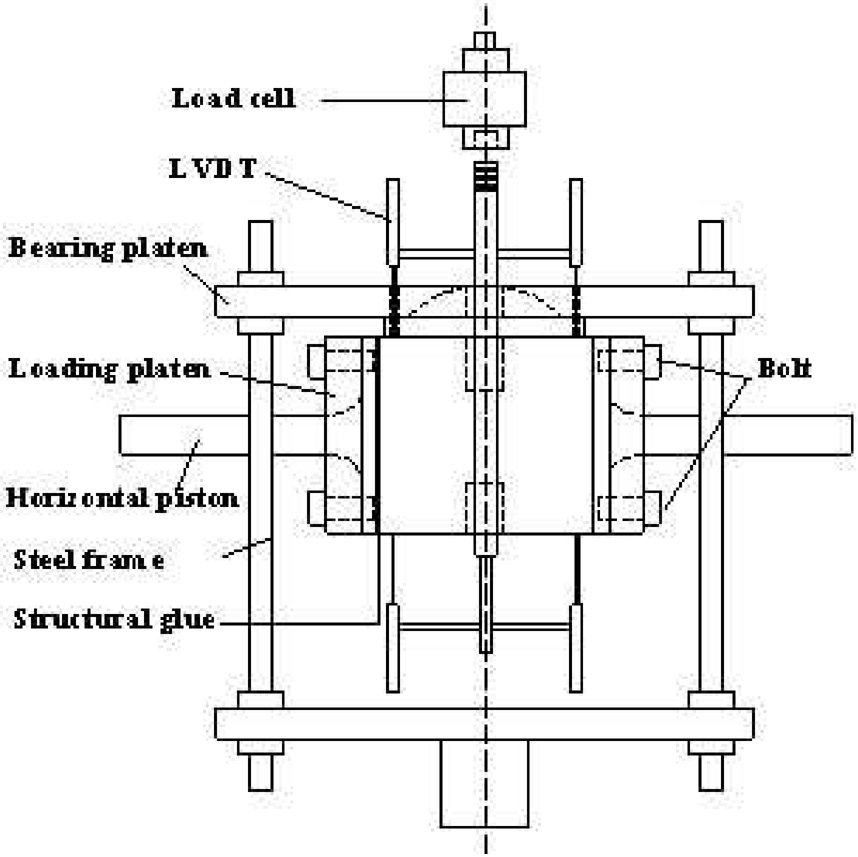
- Specimens



- The dimensions of specimen is 150×150×150 mm
- The embedded length is five times the bar nominal diameter
- PVC tubes were used to separate the nonbonded parts of the bar and concrete

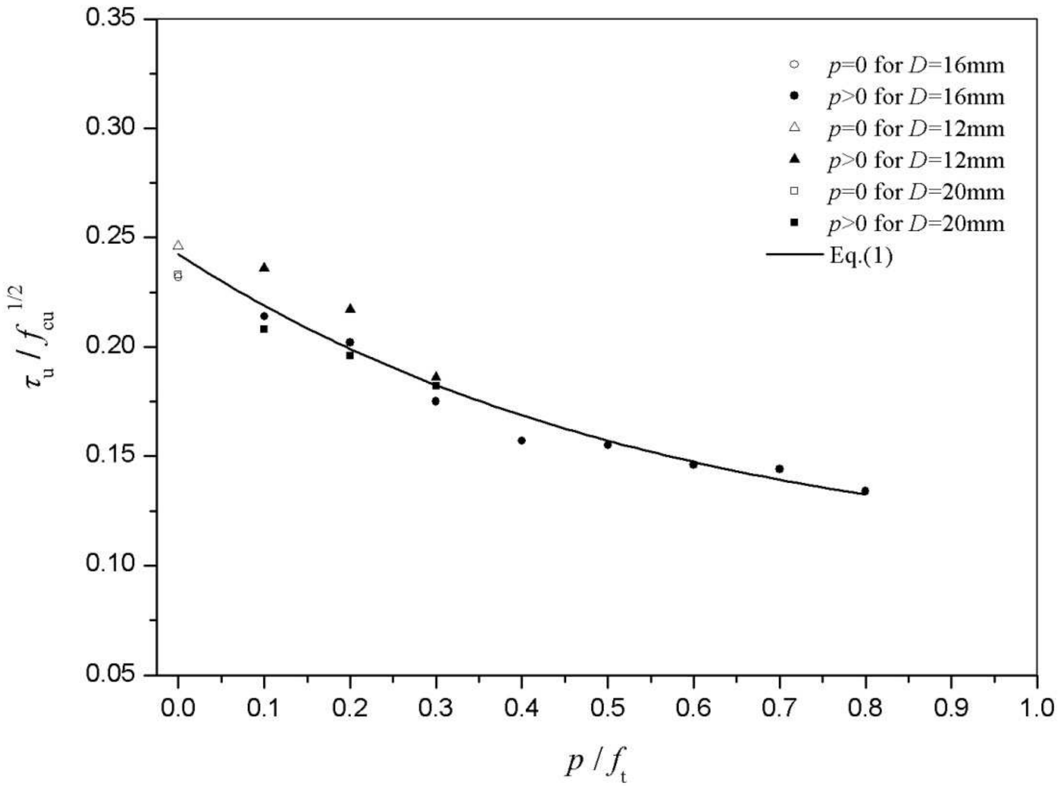
Experimental procedure

- Test devices



Experimental results

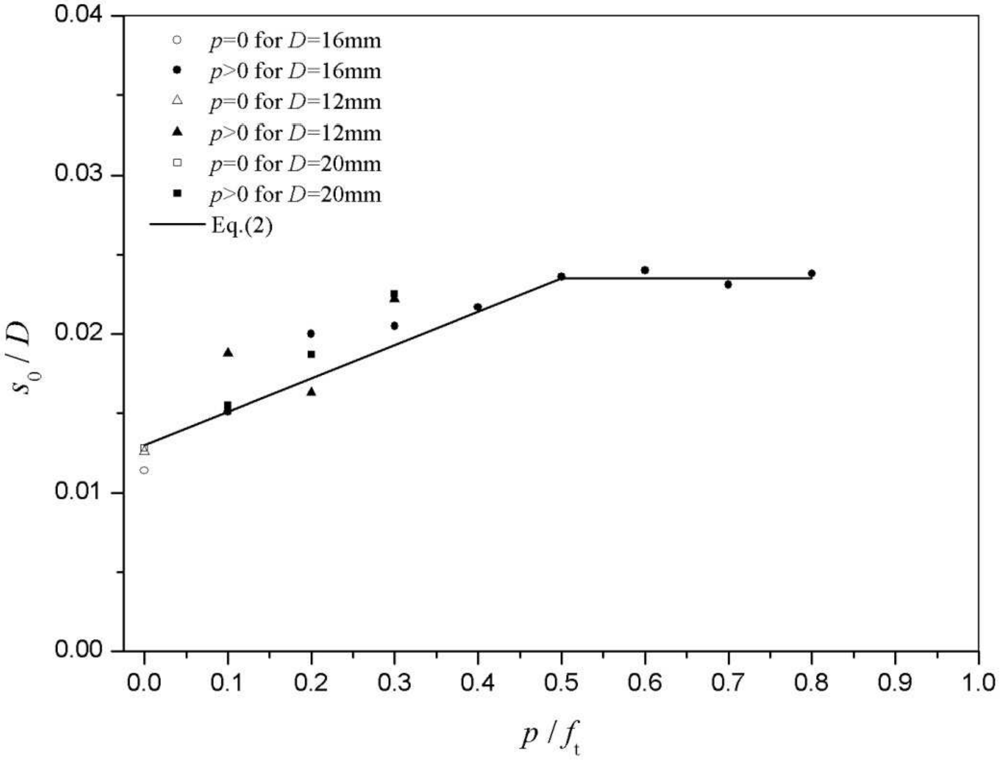
The relationship between $\tau_u/f_{cu}^{1/2}$ and p



The ultimate bond strength decrease exponentially as the lateral tension increases.

Experimental results

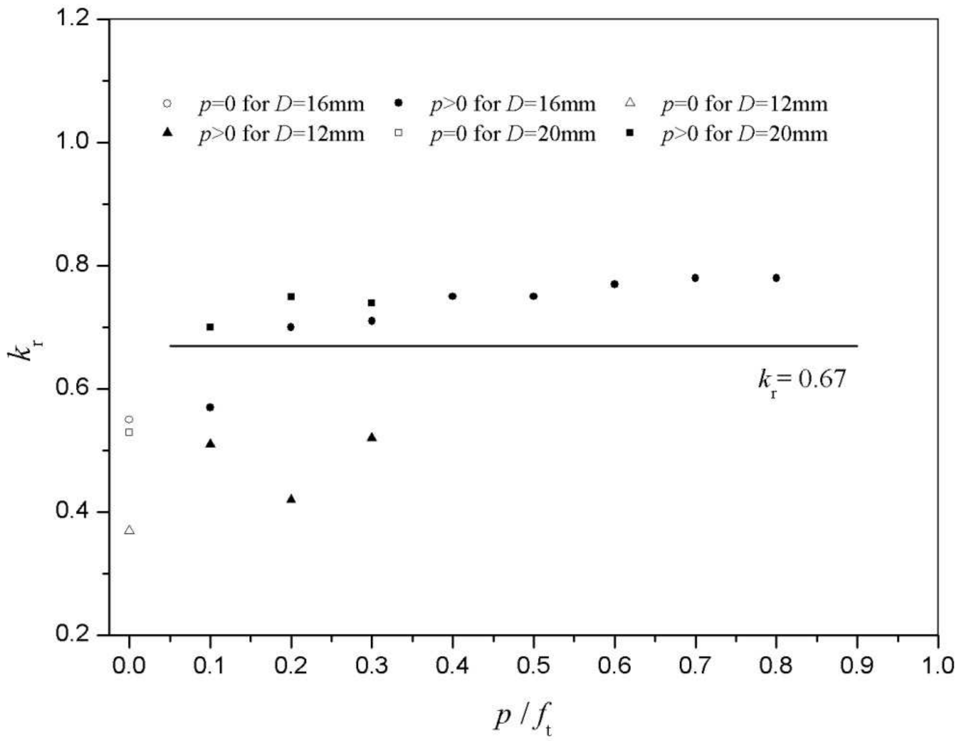
The relationship between s_0/D and p



The slip corresponding to the ultimate bond strength first increases and then remains an almost constant value with the increase of lateral tension.

Experimental results

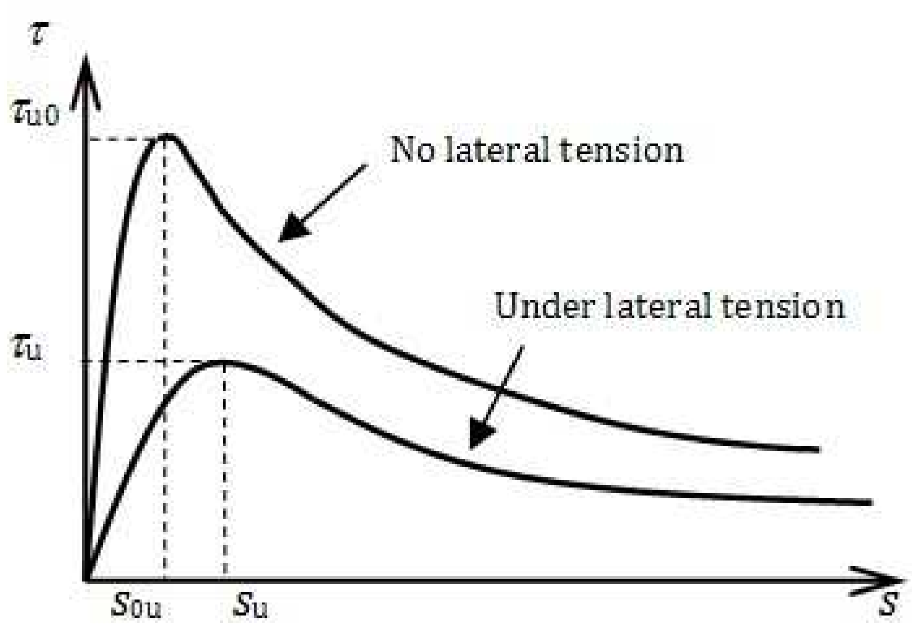
The relationship between k_r and p



kr represent the ratio of residul and untimate bond strengths.
Under no lateral tension, the mean value of *kr* = 0.46.
When the lateral tension is applied, *kr* = 0.67 despite of the scattering

Bond stress-slip relationship

Typical constitutive relationship of bond stress-slip



Expression

$$\tau = \begin{cases} \tau_u (s/s_0)^{\alpha}, \ \text{for } 0 \le s \le s_0 \\ \tau_u \{k_r + (1-k_r)\exp[\beta(s/s_0 - 1)^2]\}, \ \text{for } s > s_0 \end{cases}$$

Bond stress-slip relationship

- The parameters involved in the expression can be calibrated as follows:

$$\frac{\tau_u}{\sqrt{f_{cu}}} = 0.09 + 0.15\exp\left(-2\frac{p}{f_t}\right), \quad \text{for} \quad 0 \le \frac{p}{f_t} \le 0.8$$

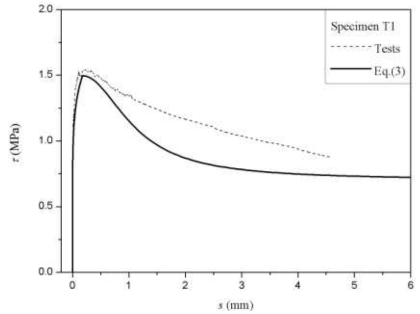
$$\frac{s_0}{D} = \begin{cases} 0.011 + 0.05\frac{p}{f_t}, & \text{for} \quad 0 \le \frac{p}{f_t} \le 0.5 \\ 0.024, & \text{for} \quad 0.5 < \frac{p}{f_t} \le 0.8 \end{cases}$$

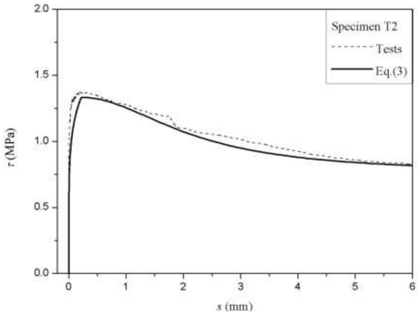
$$\alpha = \begin{cases} 0.15, & \text{for } p = 0 \\ 0.13, & \text{for } 0 < p \le 0.8 f_t \end{cases}$$

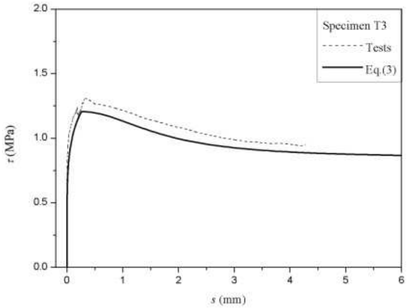
$$\beta = -0.15 + 0.14\frac{p}{f_t}, \quad \text{for} \quad 0 \le \frac{p}{f_t} \le 0.8$$

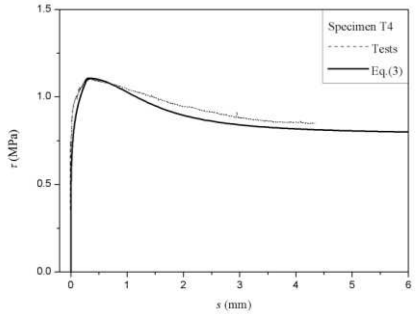
Bond stress-slip relationship

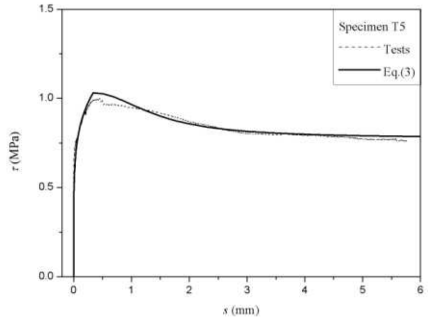
- The comparison between the proposed model and test results

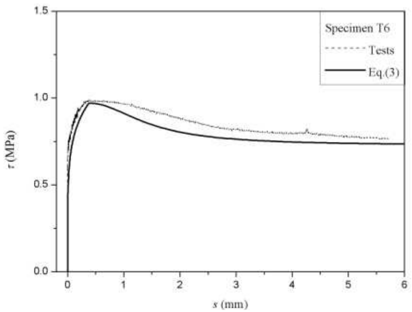


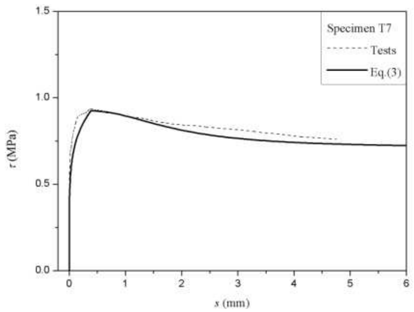


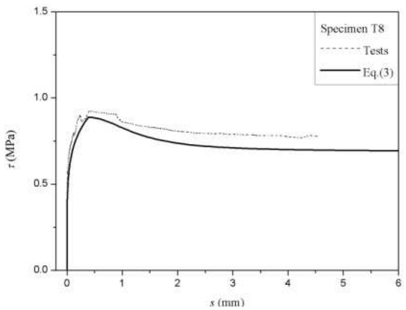


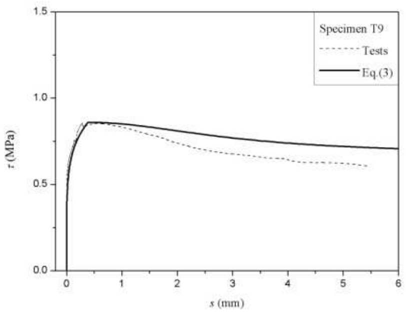






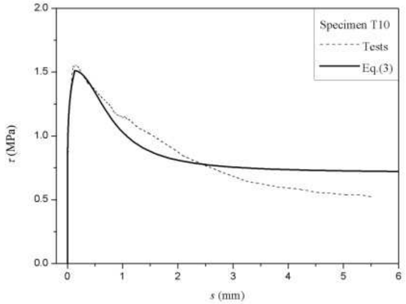


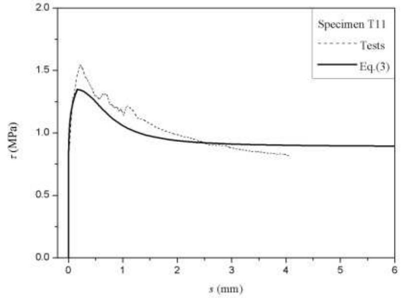


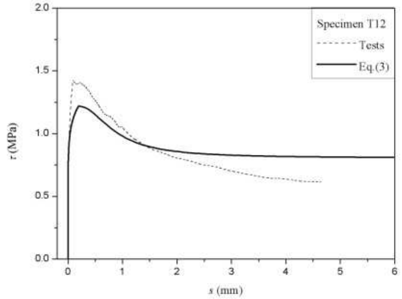


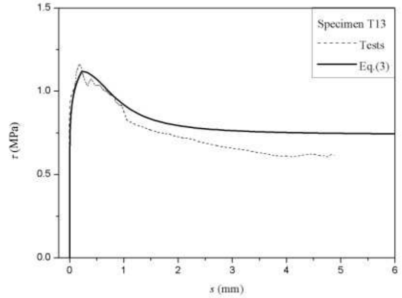
Bond stress-slip relationship

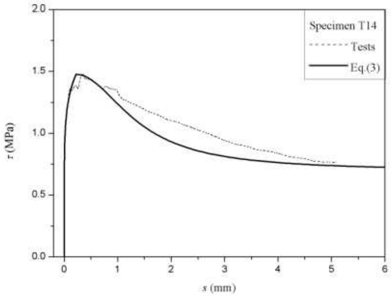
- The comparison between the proposed model and test results

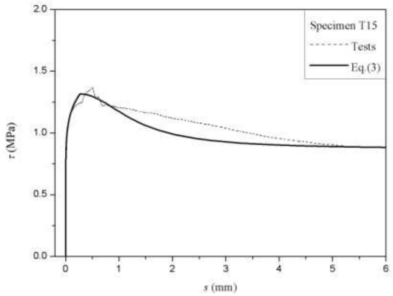


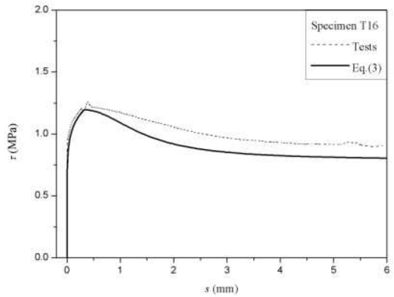


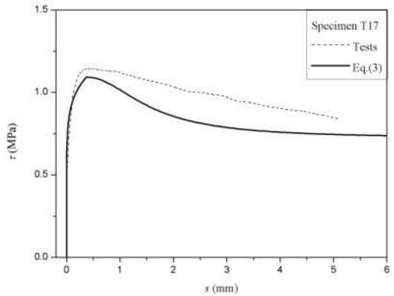












Conclusions

- When the lateral tension is applied, the bond stress-slip curve shows that in the ascending branch, bond stress increases gradually with the increase of slip before it reaches the peak point. In the descending branch the bond stress drops slowly and then decrease to a constant residual value.
- The ultimate and residual bond strengths are significantly influenced by the lateral tension, but the ratio remains constant when the lateral tension is applied. With the increase of uniaxial lateral tension, ultimate bond strength decreases exponentially.

Conclusions

- The lateral tension and the bar's diameter can influence the slip corresponding to the peak bond stress. When the uniaxial lateral tension increases, s_0 firstly increases and then remains constant.
- An empirical constitutive model of bond stress-slip relationship with the effect of uniaxial lateral tension is proposed. The model shows a good agreement with the experimental data for all the lateral tension's levels.

Thanks for Your Attention!