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ANALYTICAL APPROACH TO THE BOND BEHAVIOUR OF FRP BARS

Dr. Zenon Achillides
(N.T.U. of Athens)

Dr. Kypros Pilakoutas
(Centre of Cement and Concrete, The University of Sheffield, UK)

Presented by:
Dr. Z. Achillides

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Outline

- FRP bar - Concrete interaction
- Suitability of Cube pullout tests for measuring bond strength
- Splitting bond behaviour of FRP bars - Importance of Young's Modulus
- A new approach to model bond splitting

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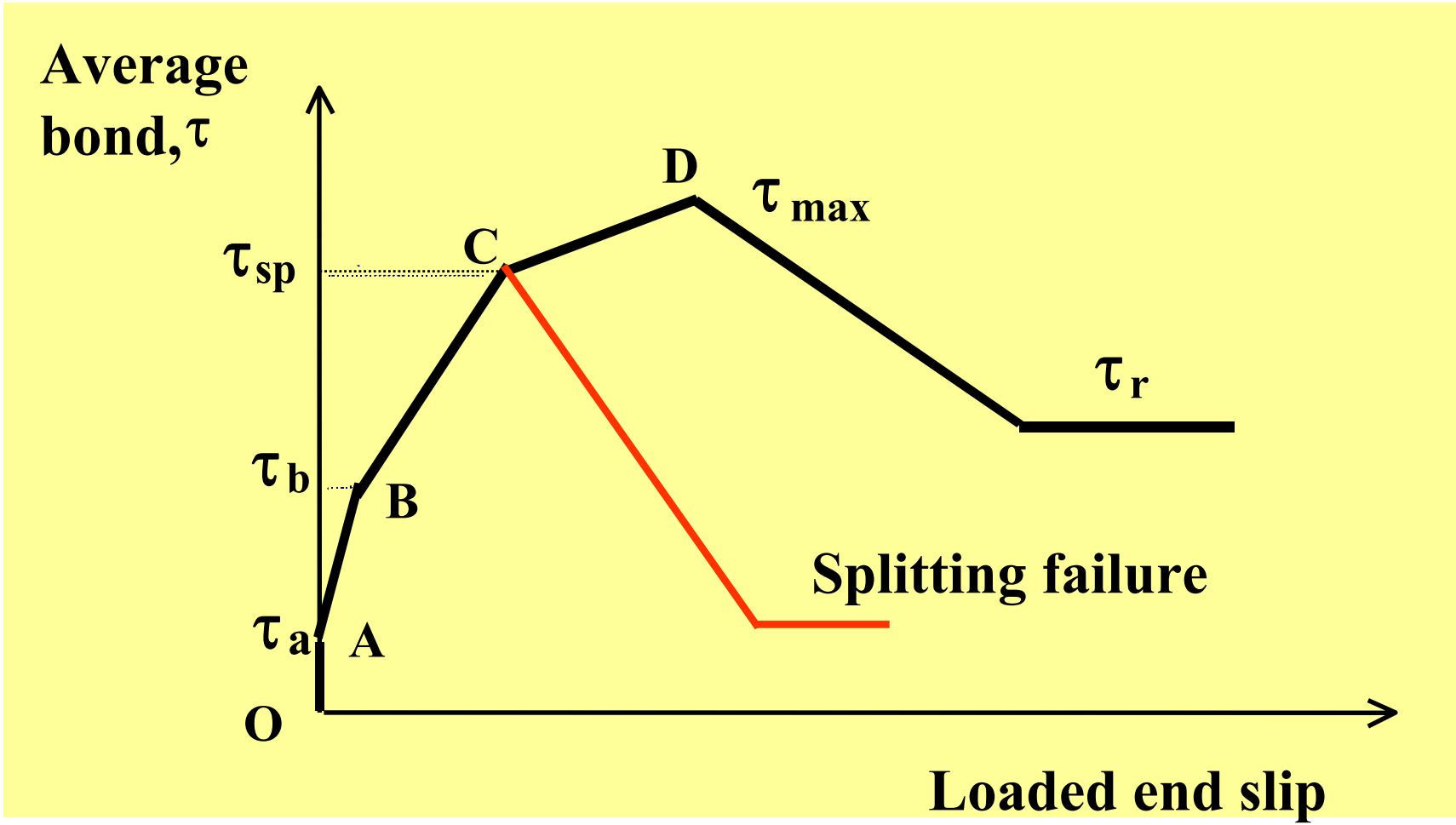
FRP bar - Concrete interaction



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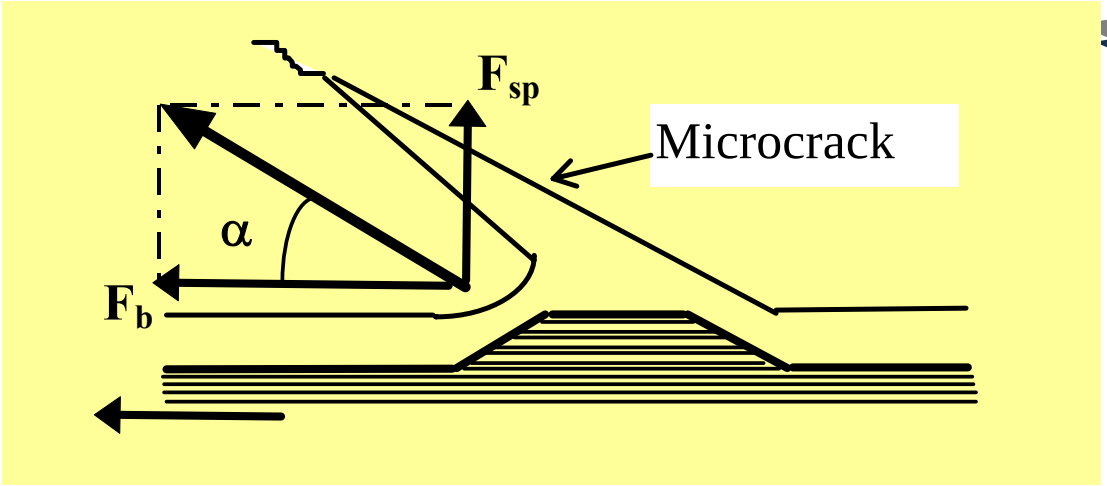
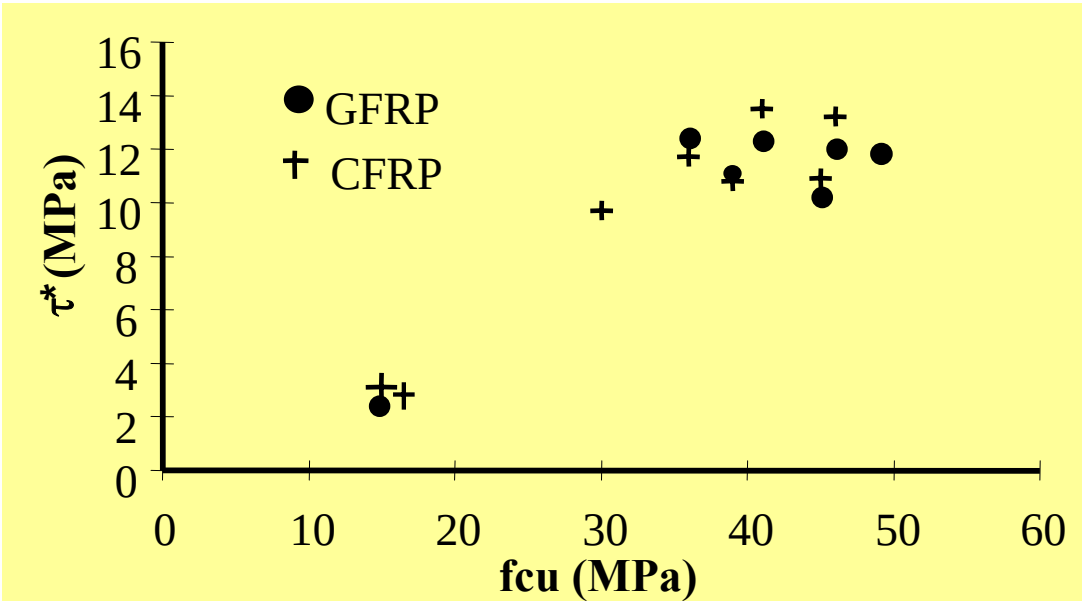
FRP bar - Concrete interaction (cont.)

BC: Bearing forces in concrete



CD: Failure depend on concrete strength relatively to bar shear strength



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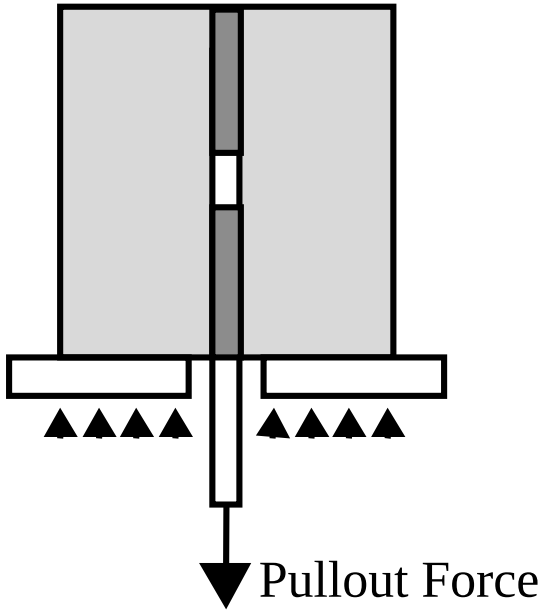
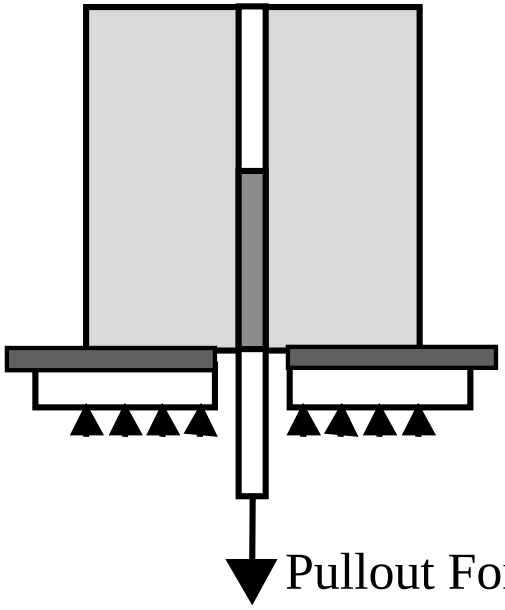
Suitability of Cube pullout tests for FRP bars

Two types of tests: Difference in the location of embedment length





Rehm (1961)

RILEM/CEB/fib (1970)

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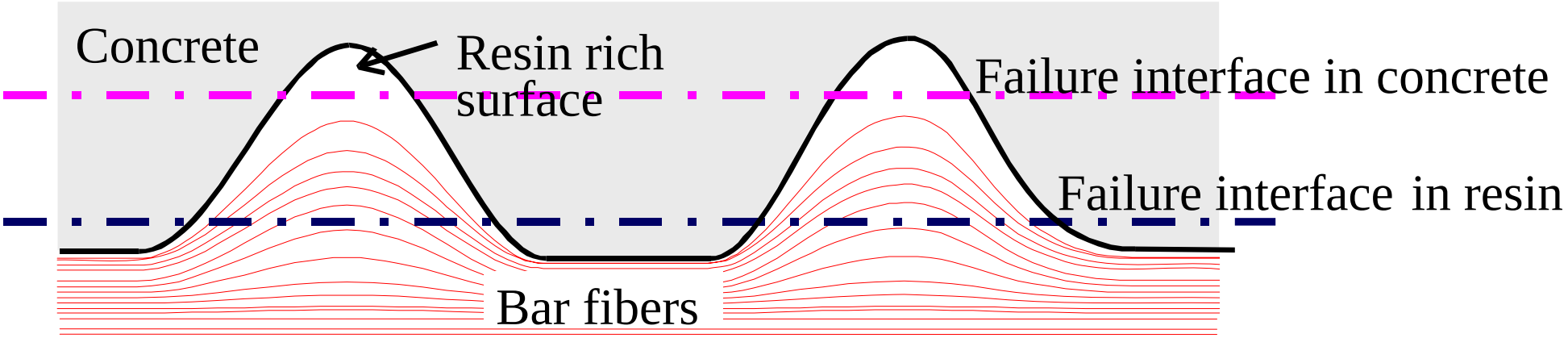
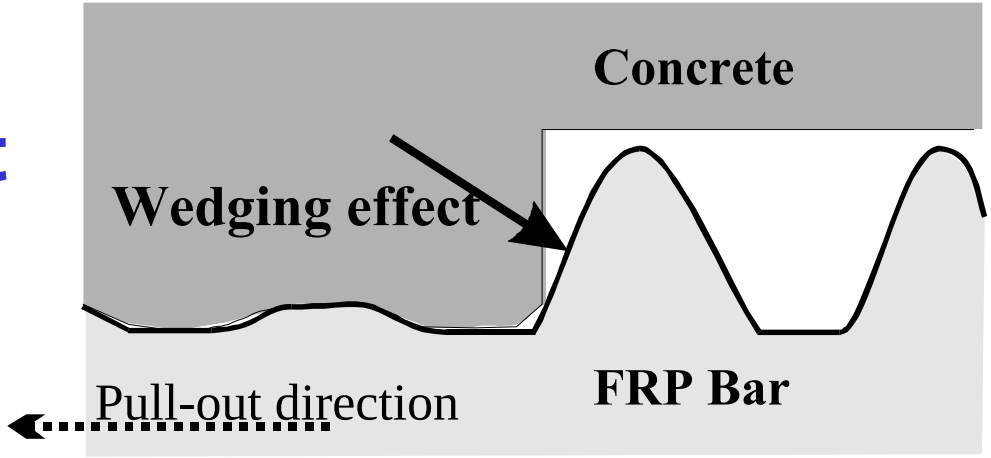
Bond Failure in pullout tests

- **Bond failure in cube tests**



- **Wedging effect**



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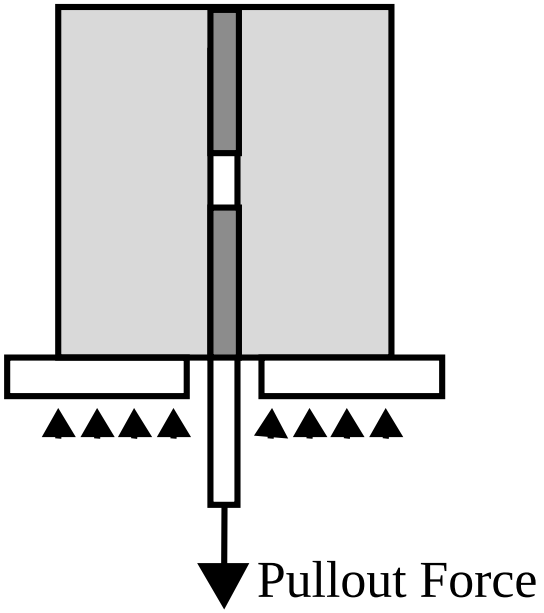
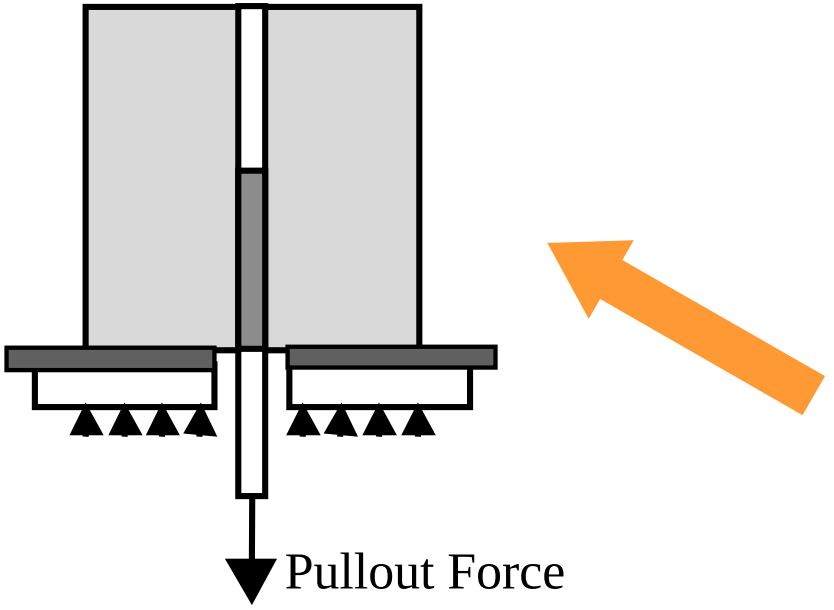
Which test is more suitable for FRP bars ?





Rehm (1961)

RILEM/CEB/fib (1970)

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Bond Splitting strength of FRP bars

Experimental evidence:

GFRP bars develop around 70% of bond strength CFRP bars

Possible reason:

Difference in Young's Modulus
(GFRP E=45GPa, CFRP E= 110GPa)

Higher splitting tendency of GFRP Bars

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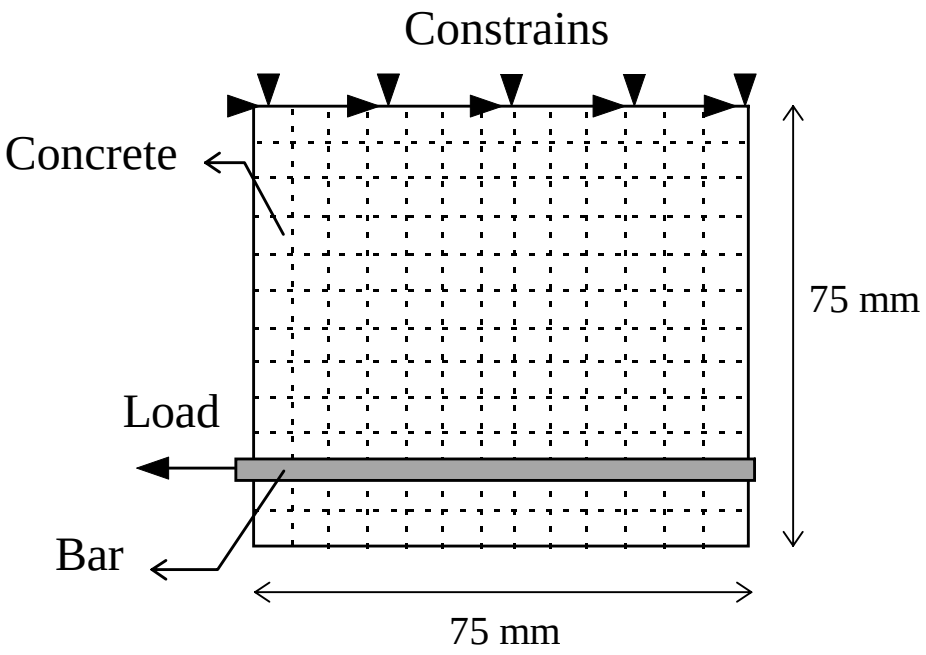
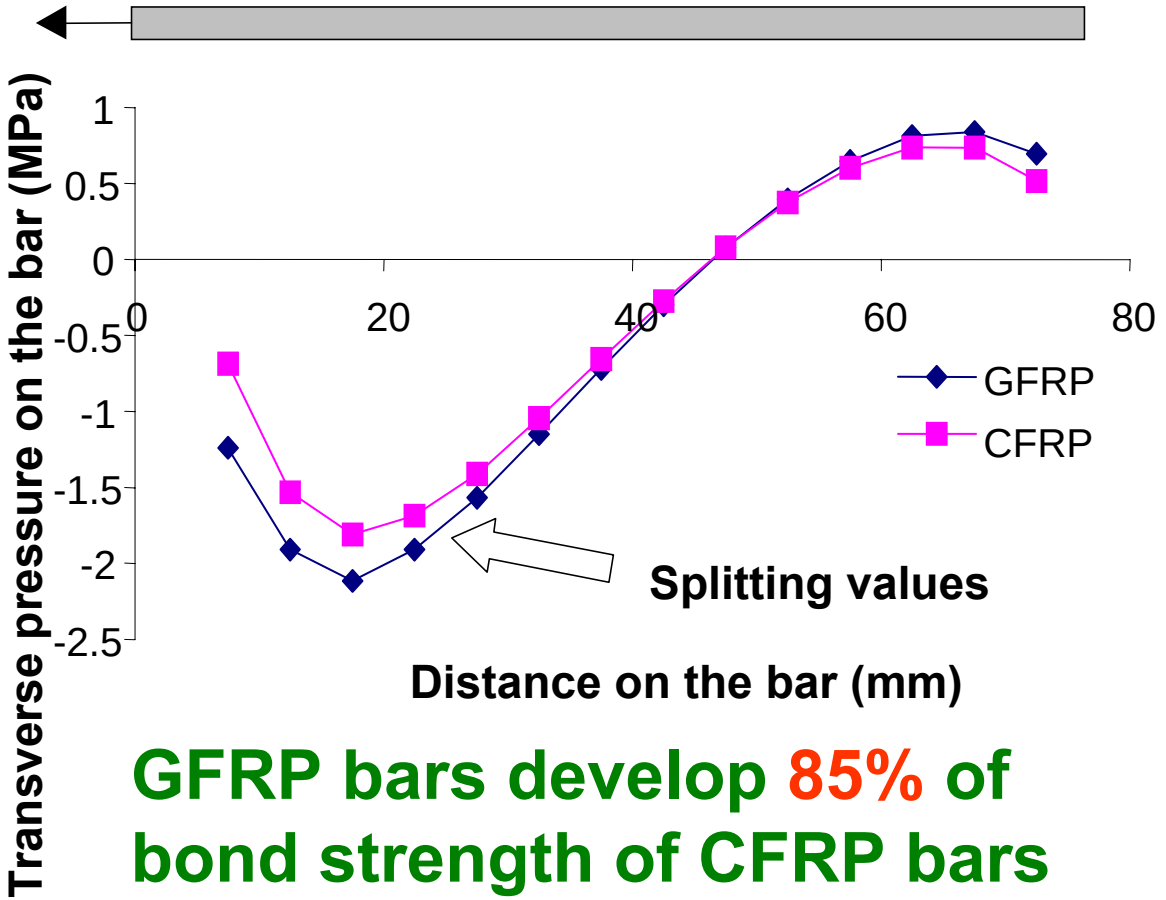
Analytical evidence

• Effect of Young's Modulus





End bar - concrete "system" between successive microcracks

GFRP bars develop 85% of bond strength of CFRP bars

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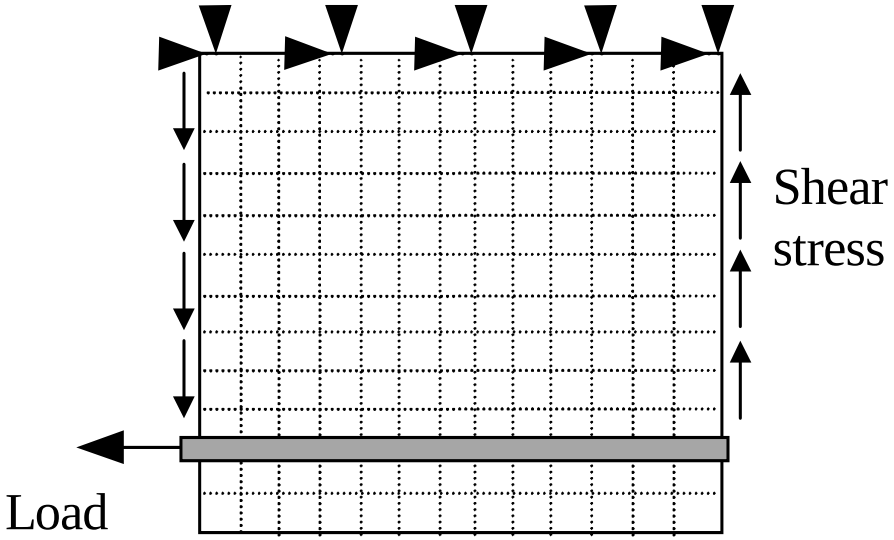
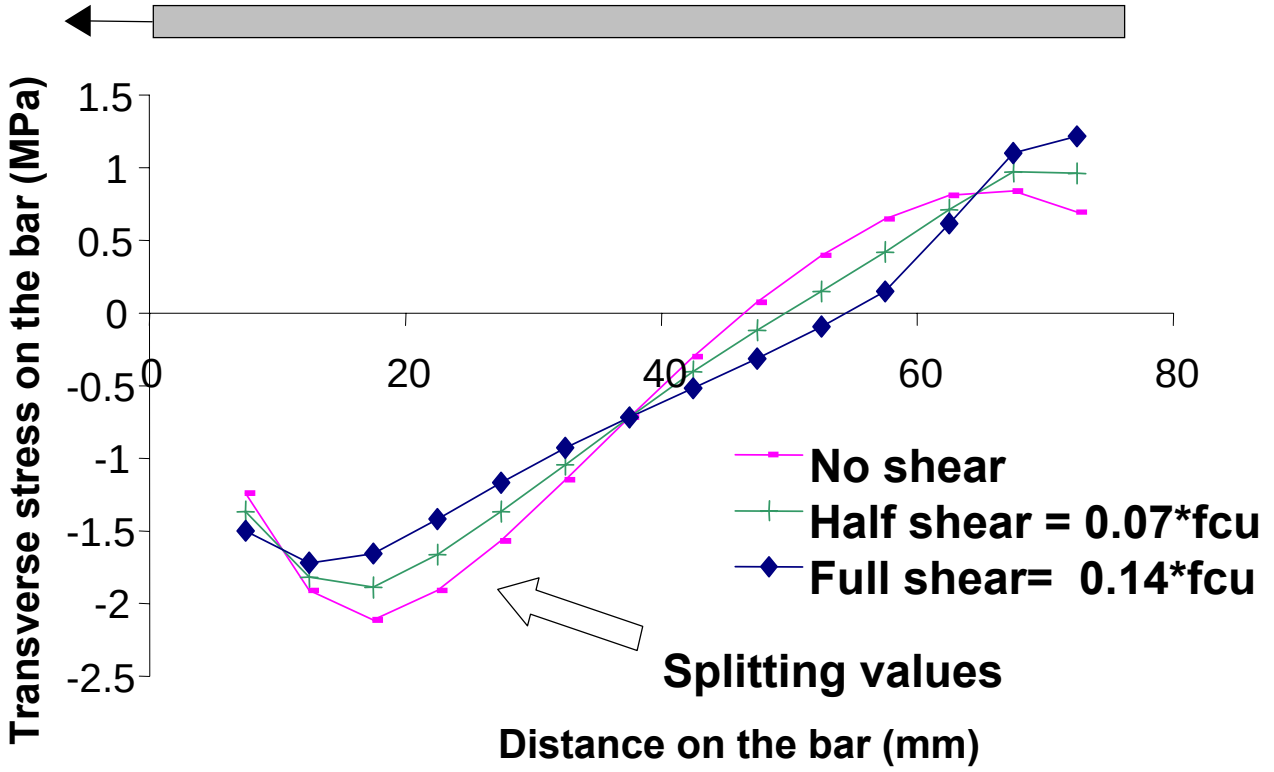
Analytical evidence

- **Effect of concrete shear stress at microcracks**





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Analytical evidence

Results of analytical study

- **Young's Modulus influences**
  - **Deformability** of the bar
  - **Crack geometry** ⟷ Concrete shear strength at the location of the crack
- **The combine effect of the above factors result to a higher splitting tendency of GFRP bars (~75% of bond strength of CFRP bars) similar to experimental results**

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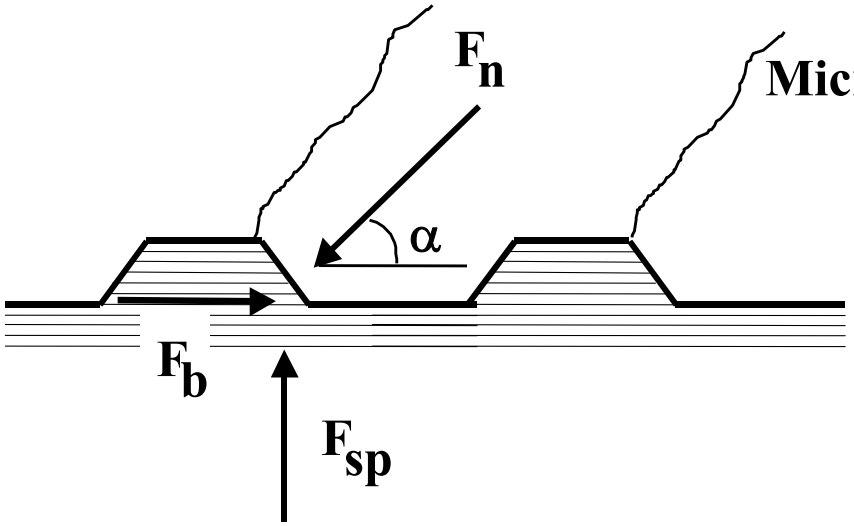
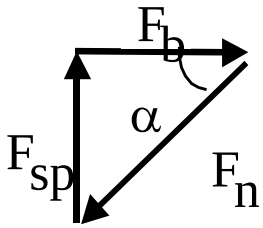
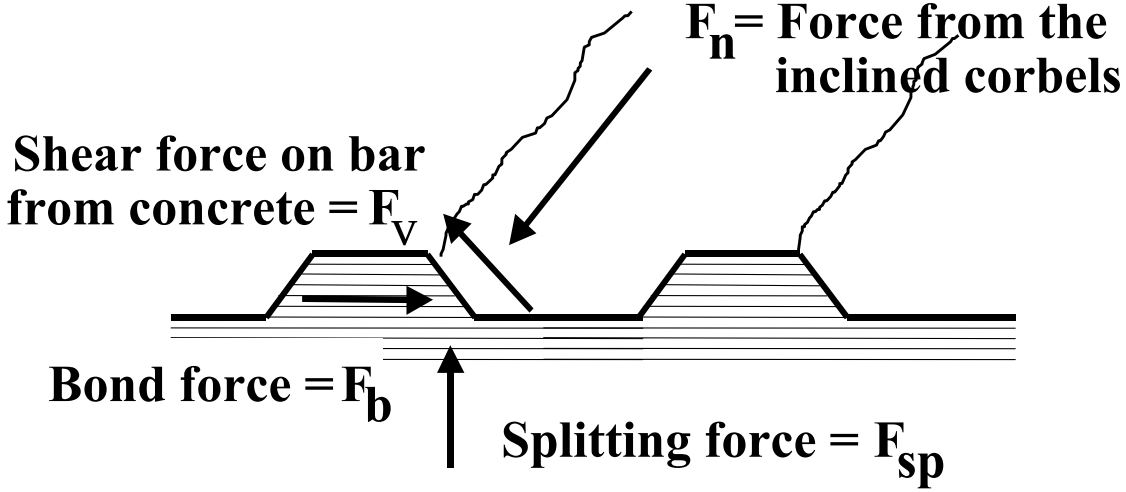
Existing approaches to examine bond splitting



Tepfers (1973)

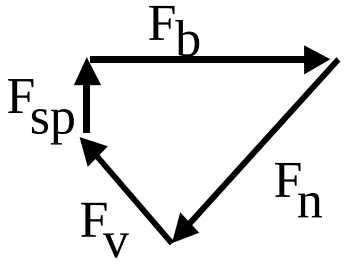
$$\tau = f_{sp} * \cot\alpha$$





Cairns and Jones (1995)

$$\tau = f_{sp} * \cot\alpha_1 + f_{nsp}$$



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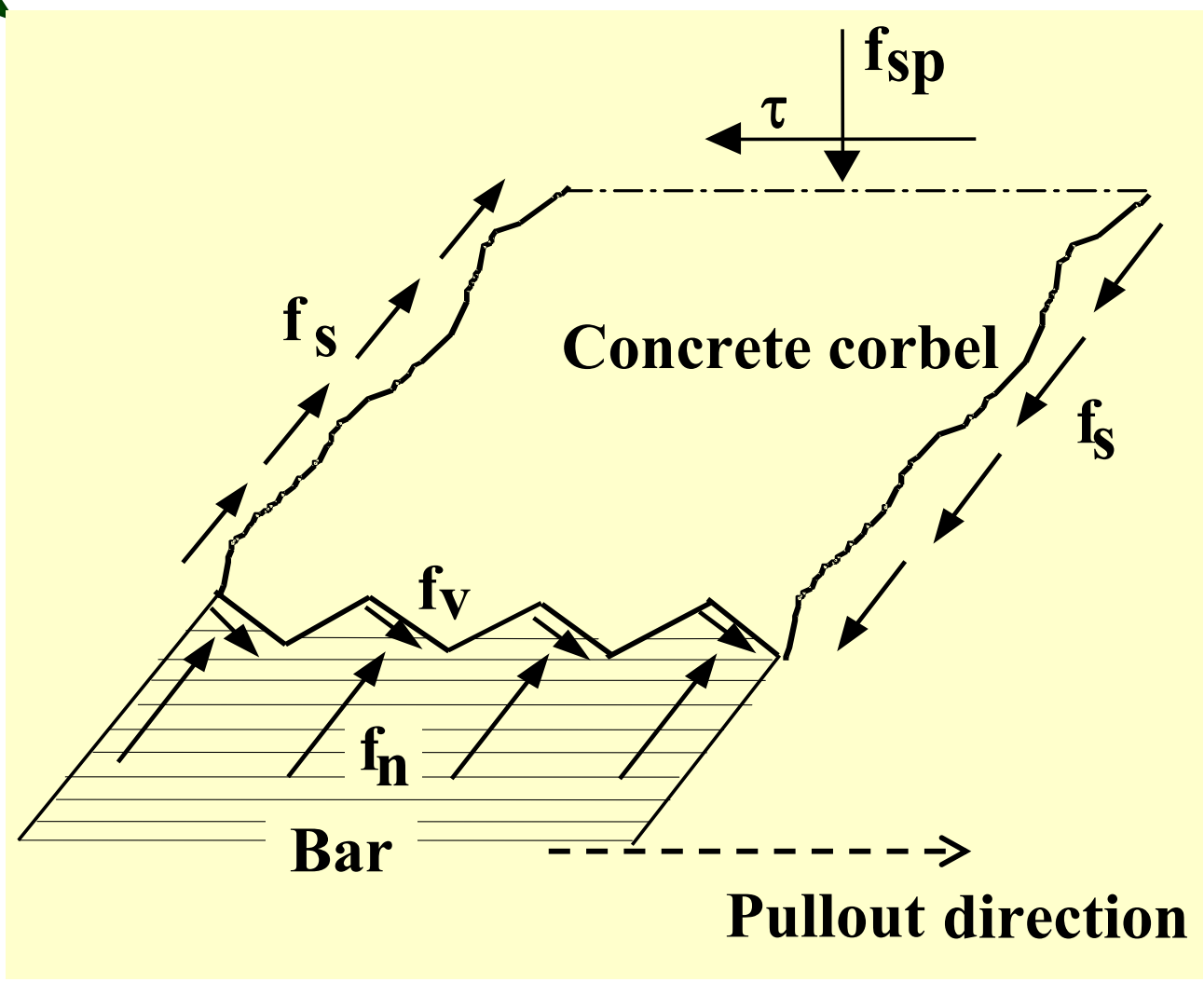
A New approach to examine bond splitting



f_n : stress induced in the concrete

f_v : frictional stress

f_s : concrete shear stress

f_{sp}: splitting stress

τ : bond stress

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Outcomes of the suggested approach to bond splitting

- The values of τ and f_{sp} can be calculated by solving the *corbel stress system* at each stage during pullout

- Any change in τ due to change in f_s or f_v is *not necessarily* accompanied with a change in f_{sp}