Shear-bond behavior of Fiber Reinforced Polymer (FRP) rods and sheets

4th International Conference on Rehabilitation and Maintenance in Civil Engineering
July, 2018

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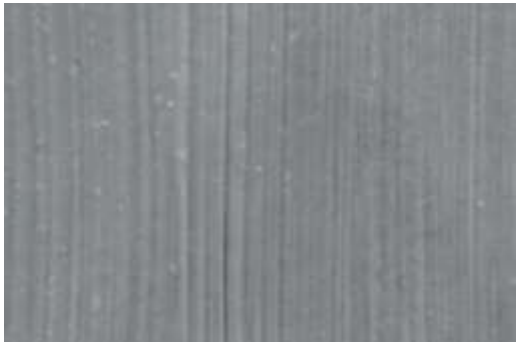
Background

- ***External reinforcing*** is a technology widely used to enhance the capacity of reinforced concrete members.
- ***Fiber Reinforced Plastics (FRP)*** offer a variety of products, including sheets and rods

FRP sheet



Attached FRP

FRP rod

The Main Problem

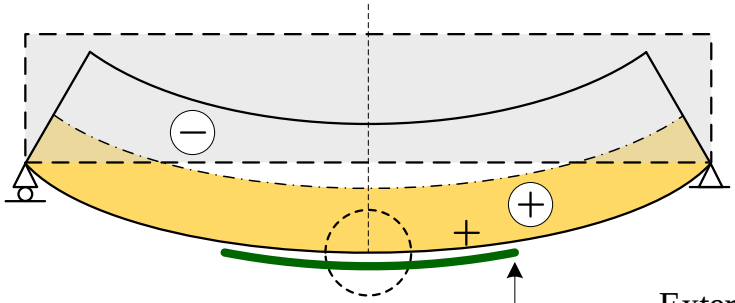
- ***The bond*** between the FRP and concrete is of major importance to the performance of the composite material.
- Which of the ***two materials provides the best solution?***
- How does their ***mode of failure differ*** from each other? The possible modes of failure are:

  1. **Failure of the FRP material**
  2. **Concrete rupture**
  3. **Bond failure in the ITZ;** in the ITZ between the FRP and epoxy, or between the concrete and the epoxy resin

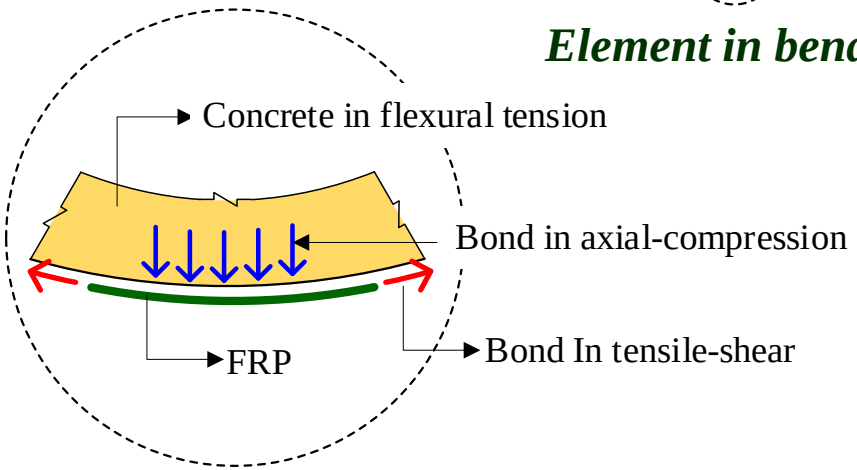
- The mode of failure is a ***function of concrete, FRP and epoxy resin material properties***, the application techniques, the surface roughness and the structural element's characteristics

Research Objective

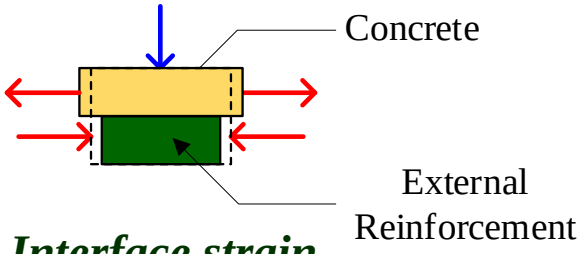
- When in bending, the ***bond*** response is distinguished into the ***shear*** and ***normal stress*** behavior



Element in bending



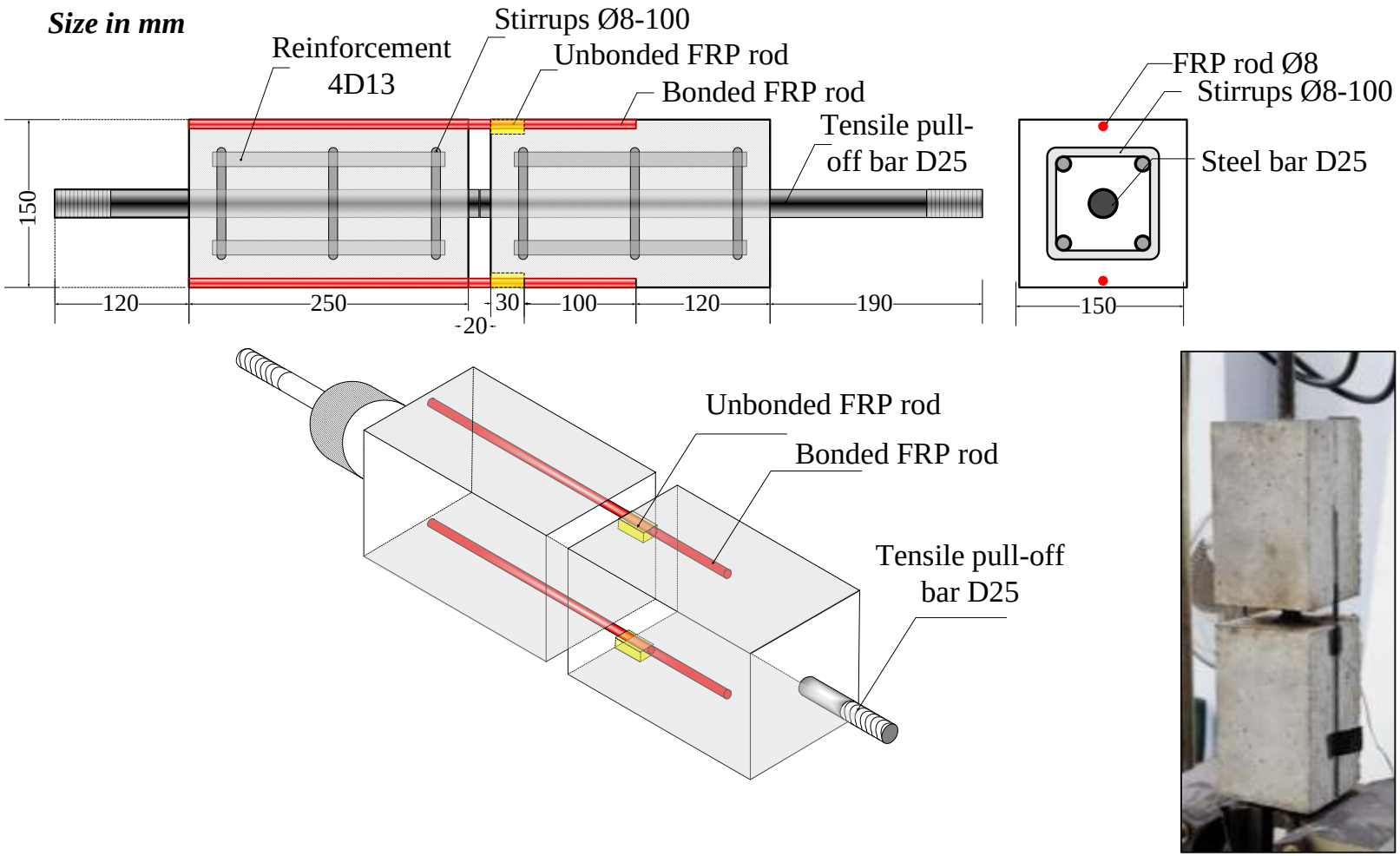
Shar and normal stresses



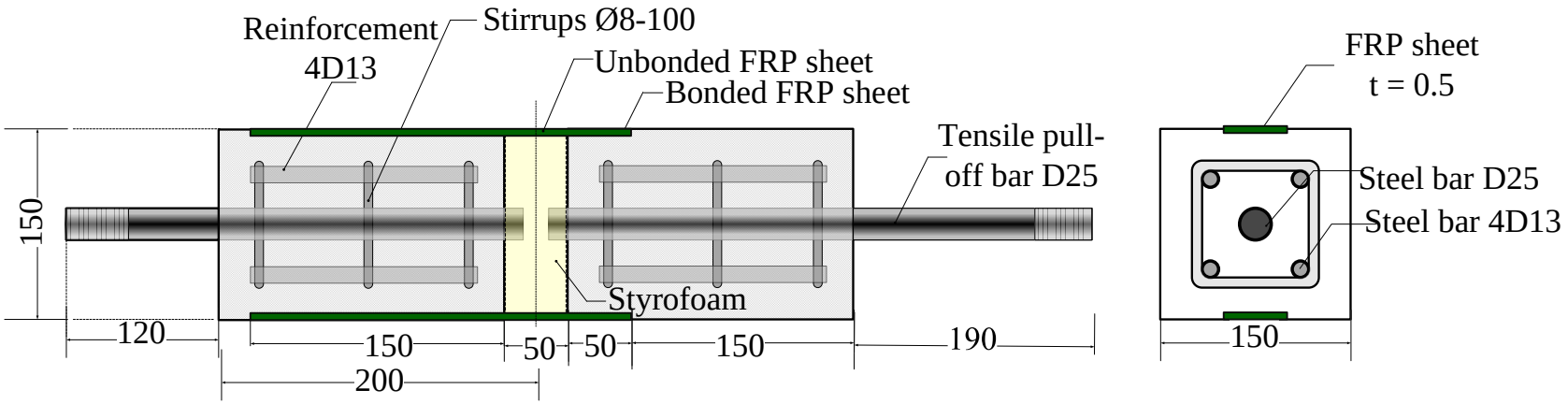
Interface strain responses

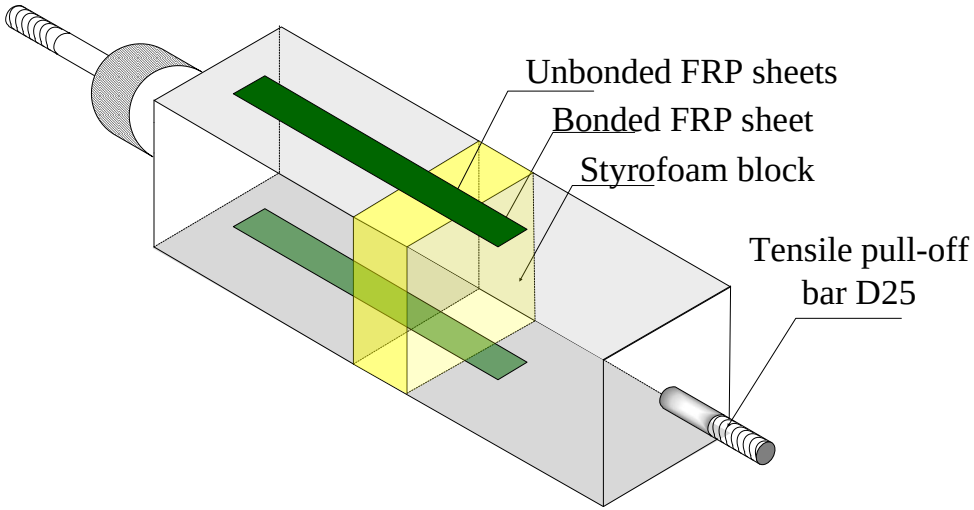
Research Work

- The experimental test evaluated the ***bond response of FRP sheets and rods*** in pure shear



FRP rod test set-up





FRP sheet test set-up

Results

Failure Modes

- ***FRP sheets.*** Two failure modes were observed:

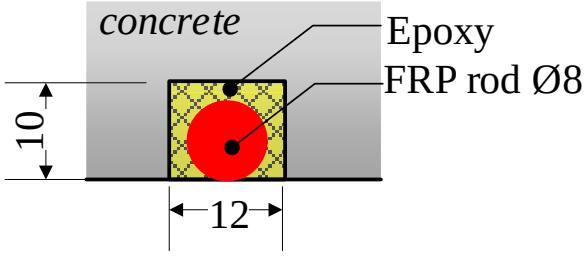
    1. Concrete shear-tension
    2. Debonding in the interface between the epoxy and the concrete, only detected in the ***"untreated concrete surfaces"***

Concrete shear failure

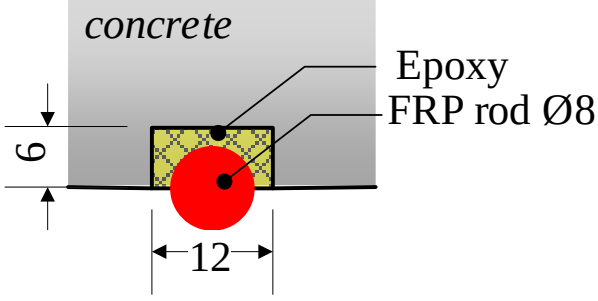
Debonding

- ***FRP rods.*** Two failure modes were observed:

  1. Concrete shear-tension
  2. Debonding in the interface between the epoxy and the rod, only detected in the rods with an embedment ***less than the ACI 440-08 required depth***

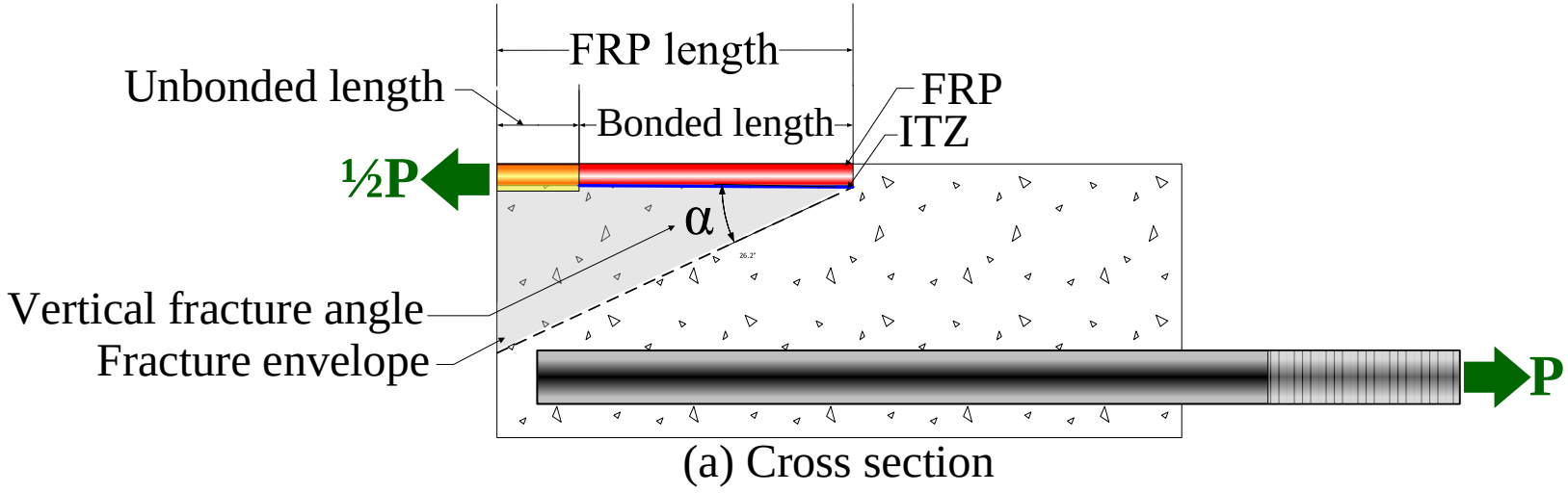


Concrete shear failure

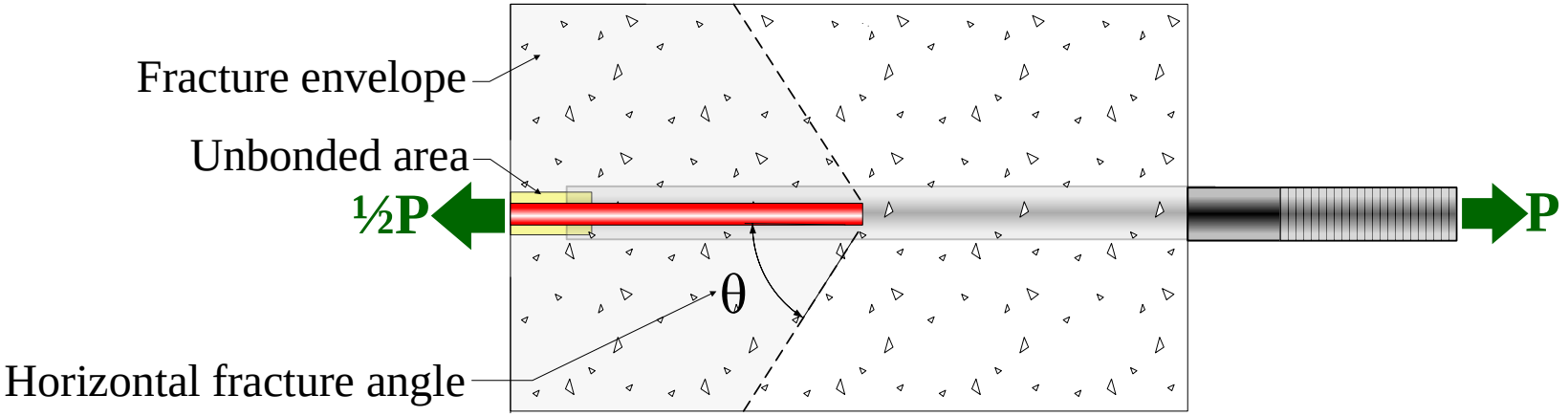


Debonding

Evaluation of Concrete Fracture Plane



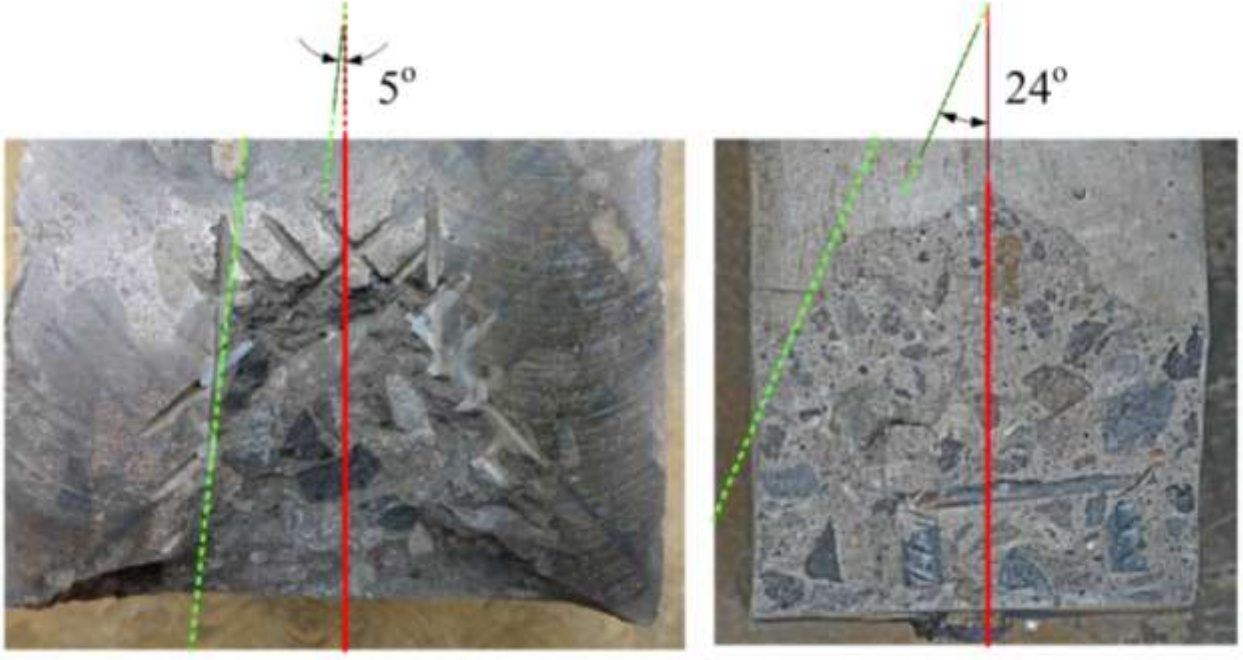
(a) Cross section



(b) Plan view

	Fracture Angle	
	Vertical α	Horizontal θ
Sheet	5^0	2^0
Rod	24^0	60^0

Evaluation of Concrete Fracture Plane

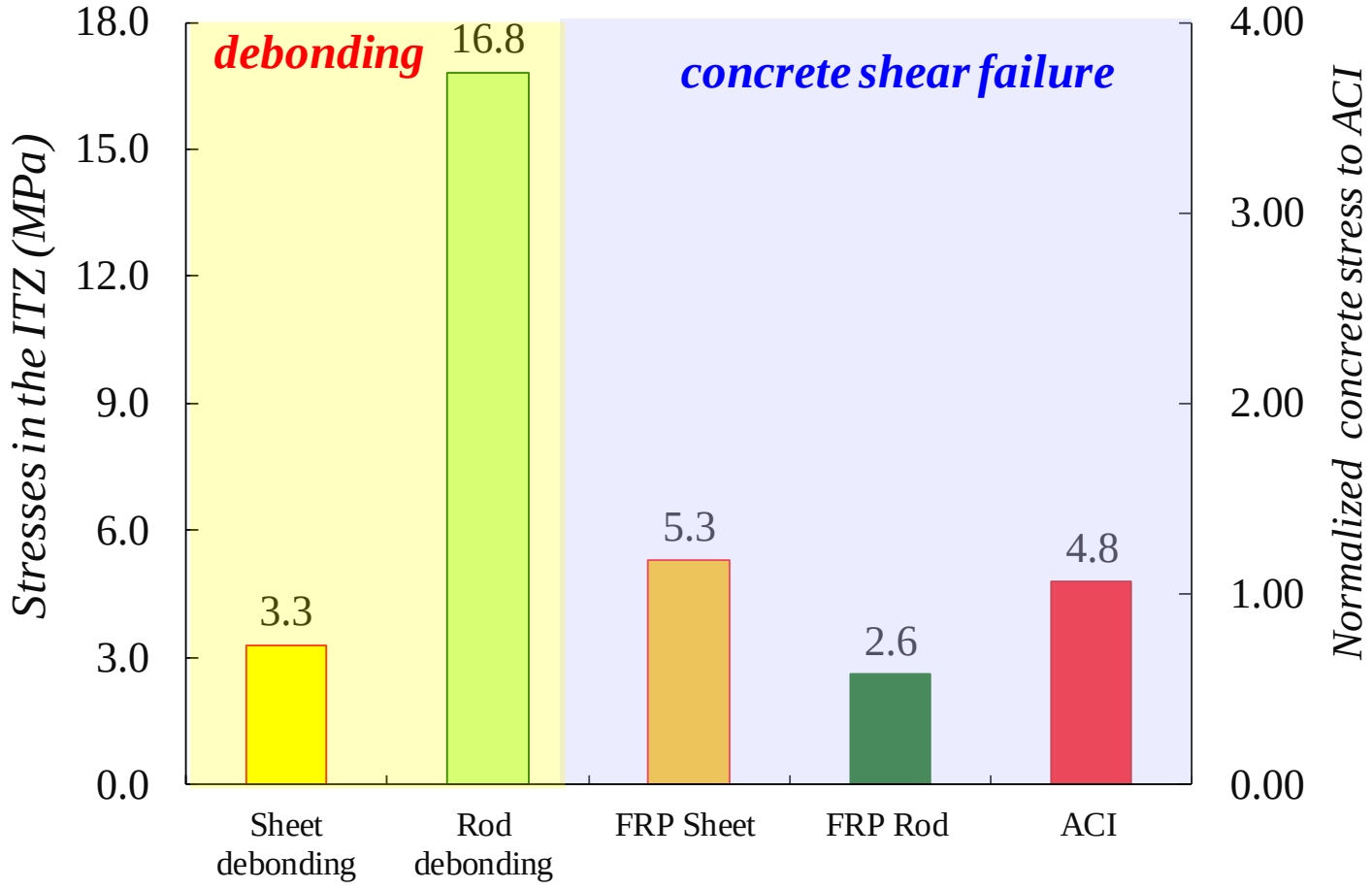


(a) FRP sheet (b) FRP rod

Concrete shear failure, plan view

	Fracture Angle	
	Vertical α	Horizontal θ
Sheet	**5^0**	**2^0**
Rod	**24^0**	**60^0**

In Retrospect



	Ultimate load (kN)	
	Concrete failure	Debonding
Sheet	**40.0**	**33.0**
Rod	**26.5**	**21.5**

Conclusions

- The ***FRP sheets*** require additional treatment, beyond the advise of the FRP producer
- The quality of the ***FRP sheets bond*** is very dependent on the application technique
- The ***FRP rods*** need to be embedded in accordance to the ACI guidelines and ***half embedded rods*** should be avoided
- In practice, the ***rods are more easily applicable***, since they require less preparation area, and reduce the use of resin
- The application of ***sheets***, due to their large area, ***produces dust and noise pollution***
- The ACI code on bond shear ***overestimates*** the ultimate stress for ***rods,*** but ***underestimates*** the values for ***sheets***

With special thanks to:

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Ir. Hioe Hartono	**PT. SIKA Indonesia**
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Bugi Mahendra	**Bachelor student**
Wibowo	**Technician**
Sutio	**Technician**

MEMORANDUM OF UNDERSTANDING (MoU)

ON

JOINT RESEARCH

FOR

EXTERNAL REINFORCEMENT USING FIBER RODS, BEHAVIOR AND CONFIGURATION

AUTHORIZED SIGNATURES :

Each party represents that the individuals signing this MOU have the authority to sign on its behalf in the capacity indicated.

Semarang, 24 January 2018

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Prof. Hsuan-Teh Hu NCKU – Taiwan	
Dr. Techn. Sholihin As'ad UNS	
Ir. Hioe Hartono PT. SIKA Indonesia	

Journal of
Advanced Civil and Environmental Engineering
Vol.1, No.1, 2018, pp 9-17
ISSN: 2599-3356

Bond-shear Behavior of FRP Rods as a Function of Attachment Configuration

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(**Received:** March 4th, 2018 ; **Accepted:** March 13th, 2018)

ABSTRACT: The use of external reinforcement to improve or enhances the flexural capacity of a member depends on the transfer capacity, and the failure behavior of the composite between the reinforcement, the epoxy resin and the concrete. The most influencing factor is the bond-shear capacity between the rod and the epoxy, and the epoxy to the concrete. Fiber Reinforced Polymer (FRP) rods are the latest alternate for fulfilling the external reinforcement scheme. In the field, the mandated embedment depth as outlined by the ACI 440 code, could customary not be achieved since factors such as the depth of the concrete cover, and presence of stirrups limits the space. This study is aimed to evaluate the effect of FRP rod configurations with respect to the concrete surface, to the effectiveness of external reinforcement. The study looked into the bond-shear capacity as well as the mode of failure, influence by the rod attachment depth. It was shown that the embedment depth significantly influenced the failure mode, and therefore the strain transfer capacity from the concrete to the rods.

Keywords: *bond-shear, FRP rods, embedment depth, mode of failure*