MuRiCO3
Mechanics of masonry structures strengthened with composite materials
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Experimental study of the FRP-clay interface subject to normal stresses

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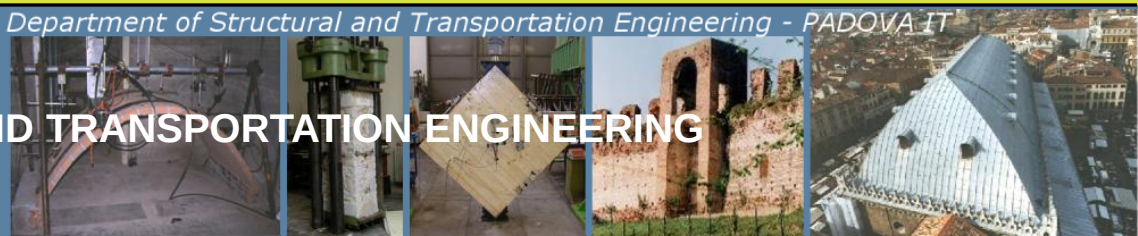
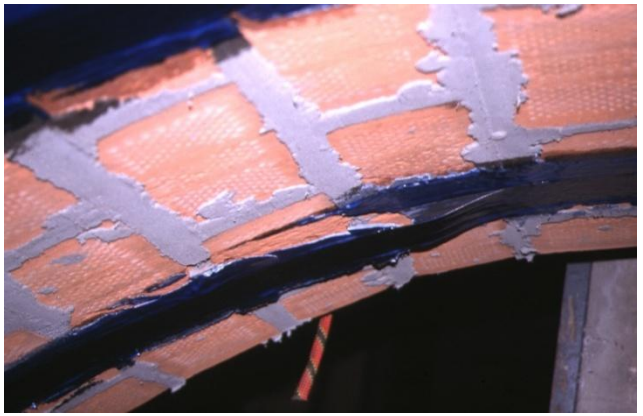


STARTING POINT

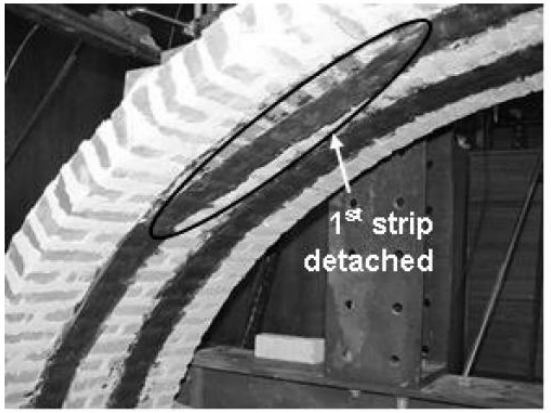
ARCHES AND VAULTS STRENGTHENED AT THEIR INTRADOS

EXPERIMENTAL EVIDENCE



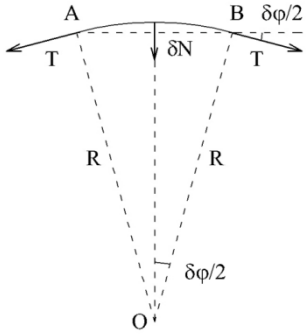
Valluzzi et al. (2001)

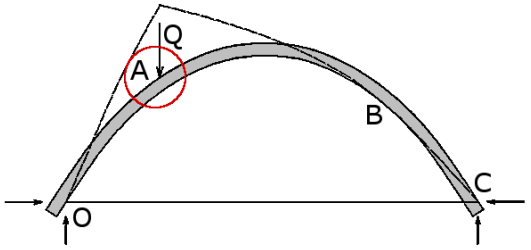
Basilio (2007)

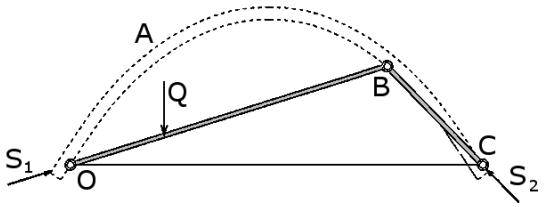


ANALYTICAL MODEL

$$P_{max} \Rightarrow \sigma_{max} \leftrightarrow \text{pull-off test}$$







BASIC MATERIALS

5 sets of bricks: 3 extruded elements; 2 facing ones

Bricks' data.

Set	S1 ES, S3 ES, S5 ES	S2 FaV	S4 FaV
Product name	11010R	A001GL	F. a V. "Vivo", color rosa vivo
Manufacturer	Atesina/Zaf Furnace (VR)	Sant'Anselmo Furnace (VR)	San Marco Group (VE)
Type	extruded solid clay brick	fac. sol. clay br. w. sanded surf.	fac. sol. clay br. w. sanded surf.
Nom. dimensions	240x115x60 mm	250x120x55 mm	250x120x55 mm

E.B. FRP sheets: H.S. Carbon C1-30; A.R. Glass G60-AR

Reinforcement components properties.

MBrace© system component	Saturant	HS Carbon C1-30	Glass G60-AR
Equivalent thickness [mm]	–	0.165	0.230
Characteristic direct tensile strength [MPa]	>50	3430	1700
Maximum tensile strain [%]	2.5	1.5	2.8
Tensile elastic modulus [MPa]	>3000	230000	65000

INVESTIGATION'S FEATURES

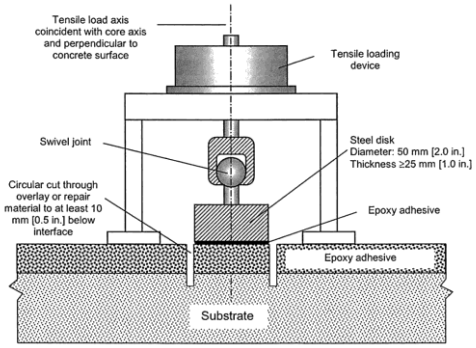
- **BASIC IDEA: performing 3 types of test on the same brick (compression/splitting tensile test, 3-points flexure and pull-off tests) in order to obtain mechanical properties related to the same masonry unit;**

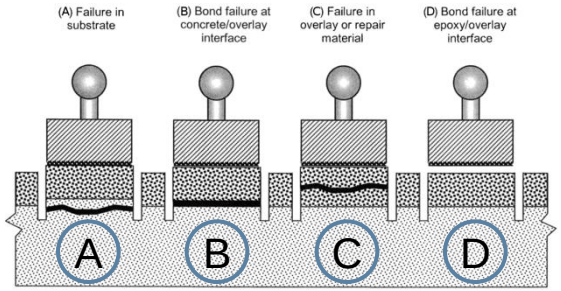
- **five sets of bricks have been used: three extruded elements (from the same manufacturer) and two facing ones (from different producers);**
- **two types of reinforcement have been adopted to cover the brick's surfaces before performing pull-off tests: high strength carbon (with or without primer) and glass;**
- **the flexural strength (f_{flex}) has been measured on every brick, while the splitting tensile strength (f_{splitt}) has been measured in some specimens instead of the compressive one (f_{compr});**

- **two pull-off tests for each clay unit have been carried out; failure type D (bond failure at epoxy/overlay interface) has never occurred;**
- **the results of 112 pull-off tests are available: 14 concerning specimens reinforced with CFRP without applying any primer, 80 normally reinforced with CFRP and 18 with GFRP.**

PULL-OFF TESTS ON SOLID CLAY BRICKS WITH EXTERNALLY BONDED FRP REINFORCEMENT

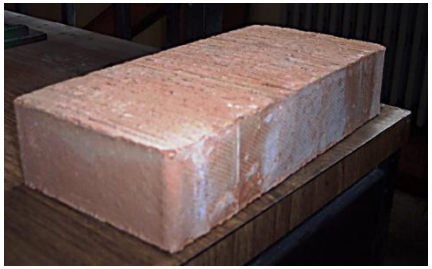
The pull-off test and its possible failures, following ASTM C1583-04



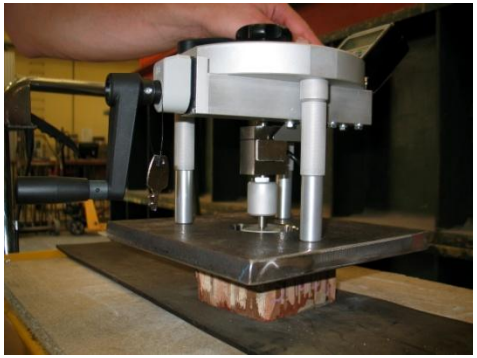


compression or splitting tension

BASIC IDEA: 3 TYPES OF MECHANICAL TEST ON THE SAME CLAY BRICK



flexure

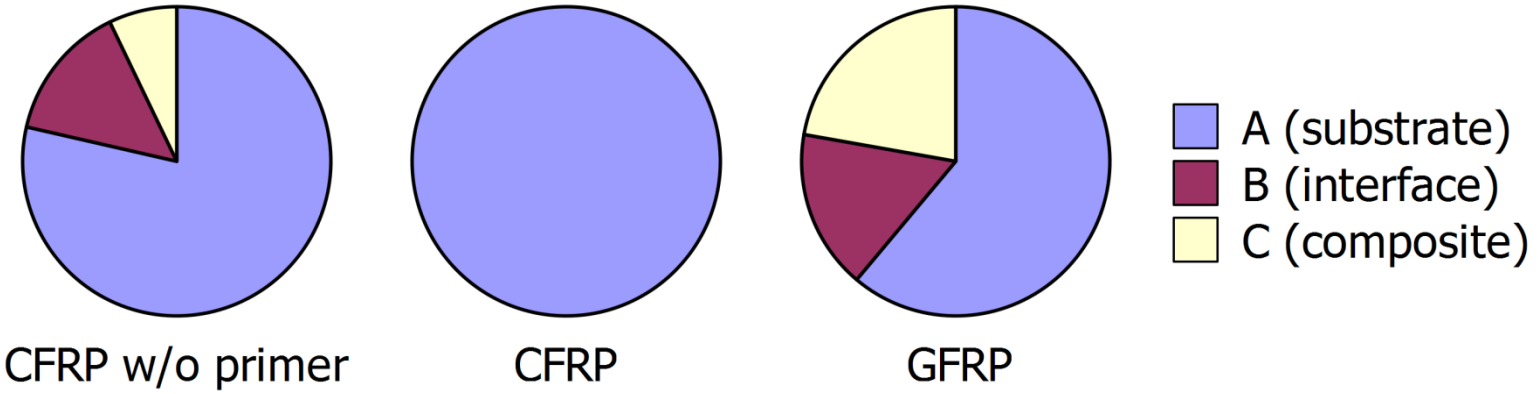


pull-off (after application of FRP)

FAILURES

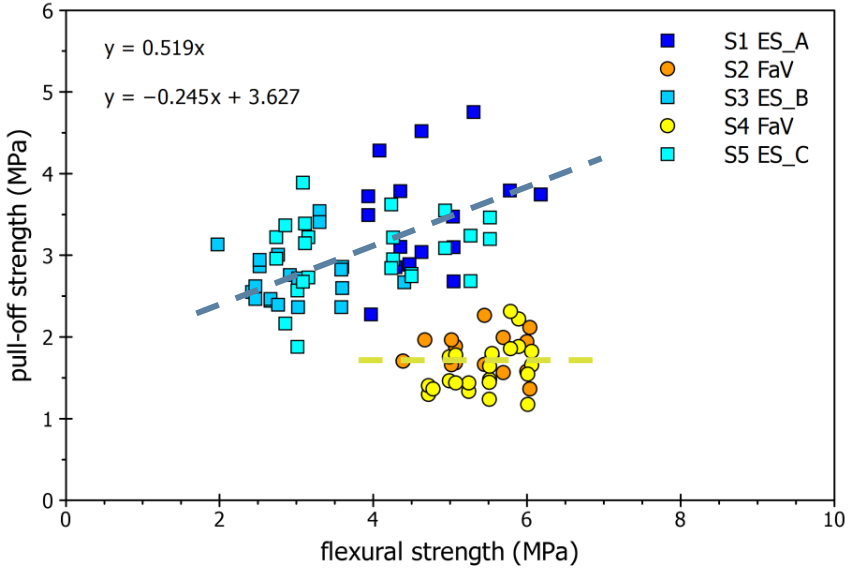
Failure type A

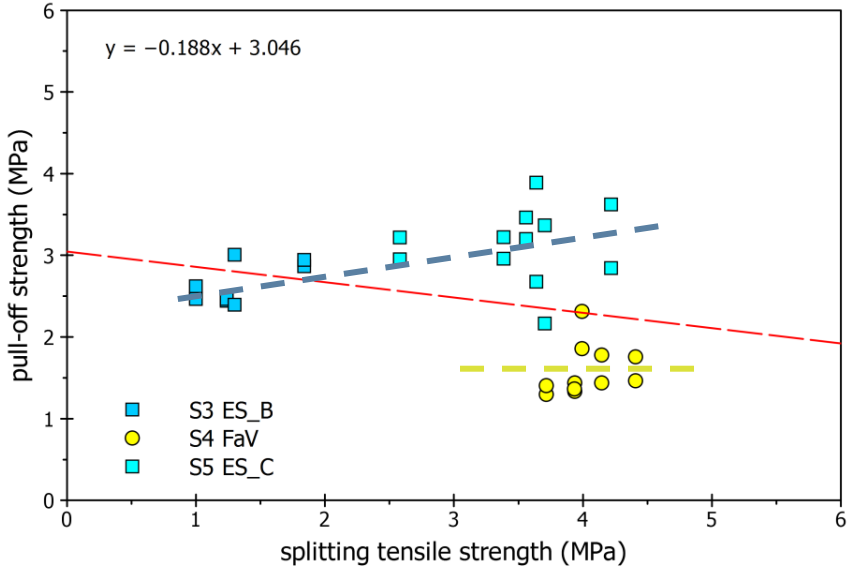
Failure type B

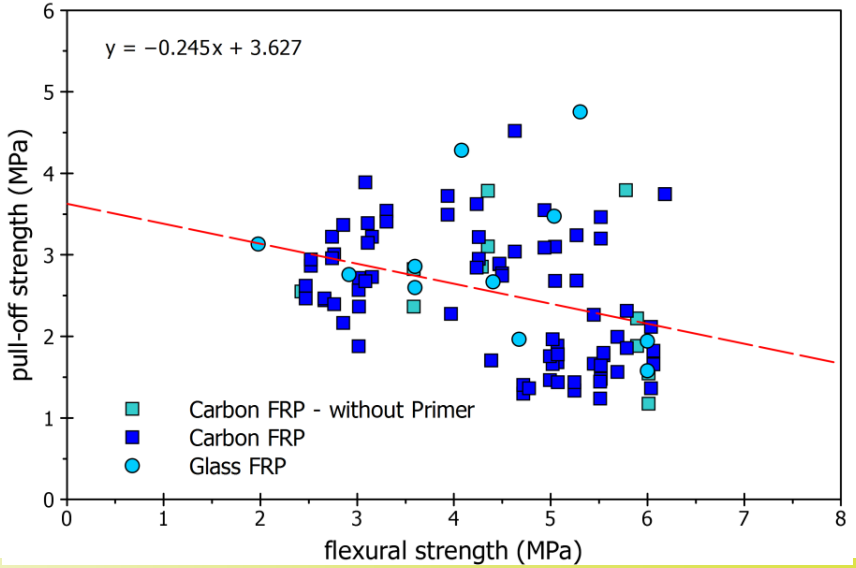


ANALYSIS OF THE RESULTS (1)

PULL-OFF STRENGTH VS FLEXURAL AND SPLITTING TENSILE STRENGTH





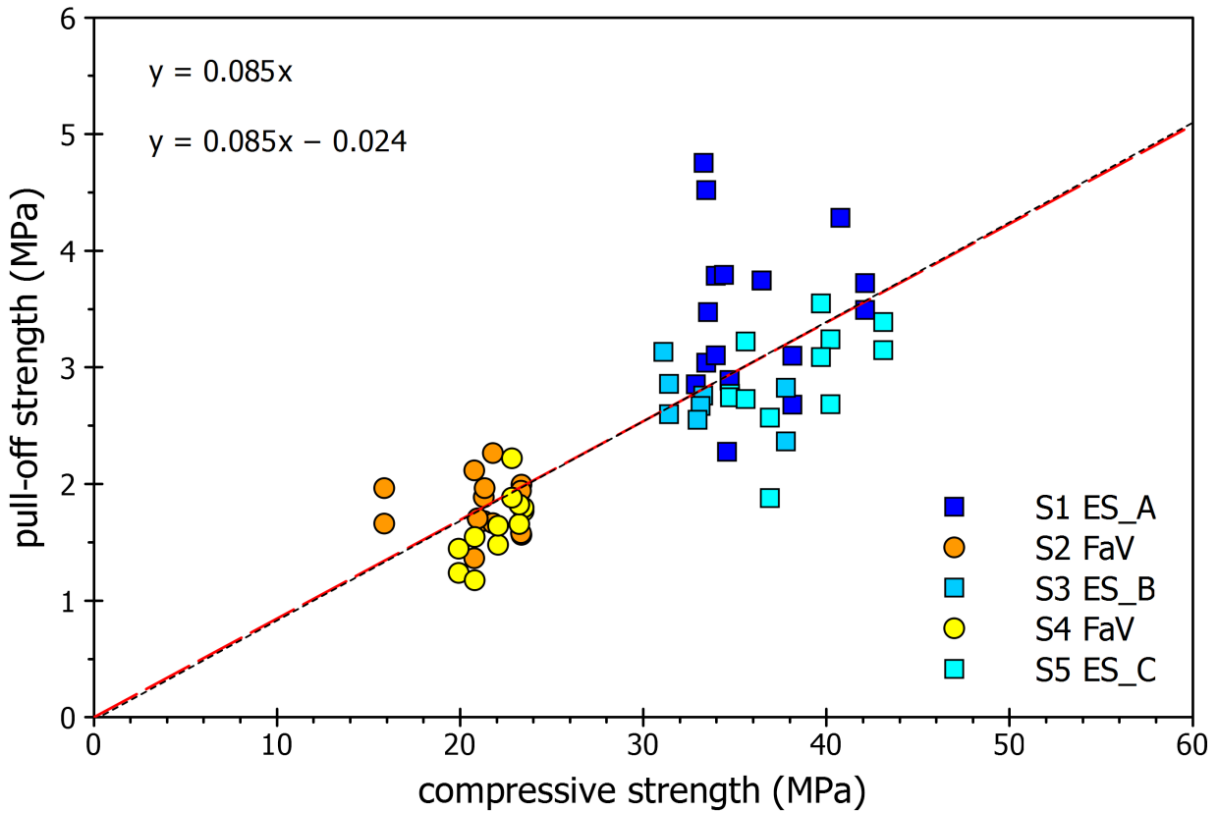


$$\sigma_{pull-off} = -0.186\, f_{splitt} + 3.045 \quad [\mathrm{MPa}]$$

$$\sigma_{pull-off} = -0.245\, f_{flex} + 3.627 \quad [\mathrm{MPa}]$$

ANALYSIS OF THE RESULTS (2)

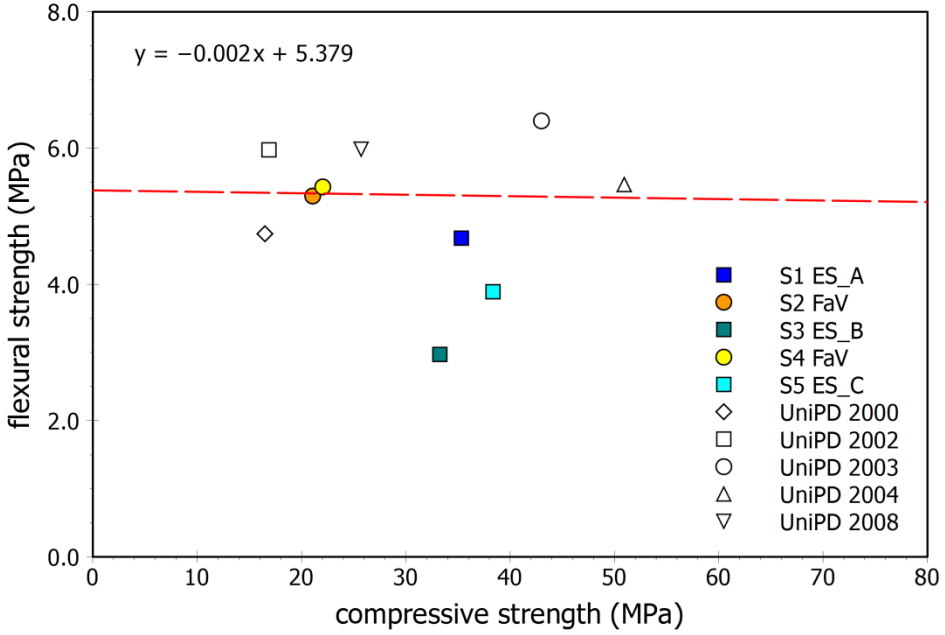
PULL-OFF STRENGTH VS COMPRESSIVE STRENGTH



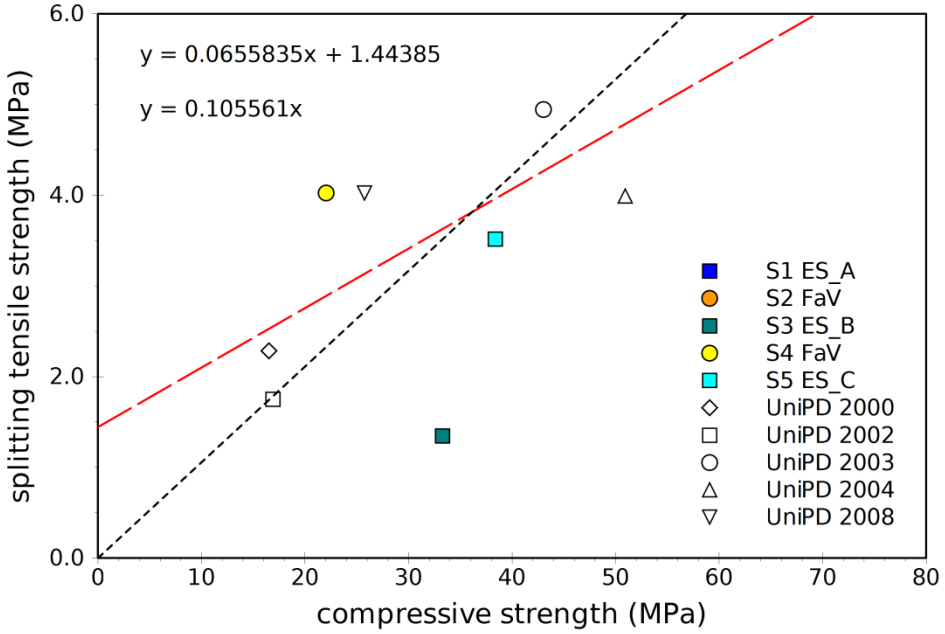
$$\sigma_{pull-off} = 0.085\, f_{compr} \quad [\mathrm{MPa}]$$

BRICKS' AVERAGE MECHANICAL PROPERTIES

FLEXURAL STRENGTH VS COMPRESSIVE STRENGTH



SPLITTITTING TENSILE STRENGTH VS COMPR. STRENGTH



$$f_{flex} = 0.002\, f_{compr} + 5.379 \quad [\mathrm{MPa}]$$

$$f_{splitt} = 0.065\, f_{compr} + 1.444 \quad [\mathrm{MPa}]$$

CONCLUSIONS

- **The type of fibers, as expected, does not seem to affect the measured pull-off strength of the bricks, but some differences occurred on the failure modes. In particular, GFRP has shown more ruptures within the reinforcement layers than CFRP; however, this problem could be related to the available fabric applied;**
- **the absence of a layer of primer affects the failure mode, causing more inappropriate failures;**
- **no clear correlation between the pull-off strength and the flexural strength of the bricks has come out, even if a slightly different behaviour of extruded and facing bricks has been observed;**
- **in the case of the relationship between pull-off strength and splitting tensile strength, even if a smaller set of values is available, the observed behaviour seem to be similar;**
- **on the other hand, a quite significant relationship between the bricks' pull-off strength and their compressive strength has emerged, and a linear fitting function seem to be sufficiently appropriate to describe it;**
- **finally, the possible relations among the average properties of the bricks, flexural, compressive and splitting tensile strength, tested during the present activity and during other previous experimental campaigns performed at the University of Padova, were investigated. The flexural strength is not influenced by the compressive and the splitting tensile strength variations, while the splitting tensile strength reveals a slightly increasing correlation with the compressive strength.**

THANKS

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