BEHAVIOUR OF MASONRY WITH FIBRE REINFORCED MORTAR
(Comportamento della muratura realizzata con malta fibrorinforzata)

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ABSTRACT : The paper concerns a new series of experimental studies intended to broaden pratical experience on the possibility of using in masonry mortars with steel fibres reinforcement.
To this aim two series of 6+6 panels were subjected to uniform compression test and diagonal compression test, according A.S.T.M. E 519/74. Results are described and commented upon.

SOMMARIO : Viene illustrata una nuova serie di studi di carattere sperimentale volti ad ampliare esperienze pratiche sulle potenzialità di impiego di malte rinforzate con fibre di acciaio nella muratura.
A tal fine due serie di 6+6 pannelli sono stati sottoposti a prova di compressione uniforme ed a prova di compressione diagonale, secondo le norme A.S.T.M. E 519/74. I risultati delle prove sono esposti e commentati.

1. INTRODUCTION

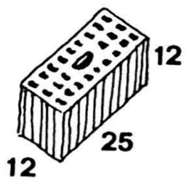
In a previous paper on the same subject presented by authors at 6th IBMaC a serie of experimental studies on masonry panels bonded with fibre reinforced mortar was described and commented (3). It was then underlined the interest of broadening the experimentation field carrying on tests on bigger size panels, built with bricks of different size and bonded with plain mortar or mortar reinforced with a new kind of fibre.
More specifically, specimens tested in this case were panels cm. 77x78x12 built with bricks cm 12x12x25 (against panels cm 39x51x11,5, built with bricks cm 11,5x7x24).
Two series of tests have been carried out: simple compression and diagonal compression according A.S.T.M. E519/74, in either case on elements bonded with plain mortar and elements bonded with mortar reinforced by steel fibres type Duoform instead of smooth ones.
It is worth to recall that, in previous experimentation, fibres length was chosen according mortar workability and possibility of filling bricks holes.
In the present case the employ of DOPPIO UNI Bricks -different from the previous ones in size and holing- allowed for using longer and deformed fibres.

2. MATERIALS CHARACTERISTICS

Specimens were prepared using following materials:

<u>Bricks</u> : DOUBLE UNI type (production by firm RDB Nord)

nominal dimensions	mm 120x120x250
density	Kg/mc 970
holing percentage	45,5%
characteristic compressive strenght (‖ holes- gross area)	fbk=MPa 29



Mortar : Cement mortar M1 class, proportion 1.0.3 (cement- lime-sand) by volume, silico calcareous aggregate Ø max 2 mm.
Optimal workability conditions by a water/cement ratio = 0,6.

Fibres : Steel fibres Wirand Duoform (deformed), aspect ratio L/D = 63 (L = 25 mm; D = 0,40 mm), standard production.
According found out workability, we deem it possible, in future experimentations to use fibres with an higher aspect ratio L/D to improve the efficacy of fibres reinforcement.

3. EXPERIENCES DESCRIPTION

3.1 Tests on mortars

Bending tests and compression tests have been performed on 9 specimens in plain mortar (mortar A) and on 9 specimens in fibre reinforced mortar (mortar B) dimensions mm 40x40x160. According the results of previous tests (3), a blending ratio of 40 Kg fibres for cubic metre of mortar (corrisponding to 0,5% in volume) has been chosen.
Values of flexure and compressive strenght are listed in Table 1 (tests carried out according RILEM).

	Bending		Compression	
Kind of mortar	A	B	A	B
Mean strenght (MPa)	3,99	4,11	22,37	22,61
Standard deviation	0,72	0,52	1,38	1,17
Characteristic strenght (MPa)			19,64	20,28

Table 1 - Mechanical properties of mortars

3.2 Compressions tests on masonry panels bonded with the two types of mortar

6 panels were assembled, dimensions as in fig. 1 (3 for each kind of mortar). Their slenderness ratio l/t = 6,4 is somewhat higher than the limit value suggested in "Recommendations for calculation and design of constructions with masonry bearing walls" (published by ANDIL °) to point out the effect -if any- of the fibres in mortar. Loading measurements were obtained by means of pressure transducers: strain measurements by means of 4 potentiometric transducers (2 on each side of the panel) placed (510 mm base) on the first and 5th bricks layer.
A couple of dial gauges was set near the bordes of the panels, to the aim of following deformations till collapse.

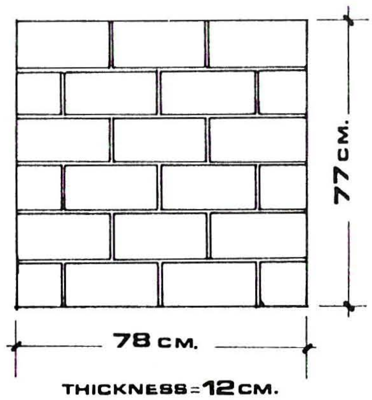


Fig. 1

(°) ANDIL = Associazione Nazionale degli Industriali dei Laterizi.

Load was imposed so as to attain loops with increasing peaks.
Table 2 shows the collapse compressive strenght attained by the two kinds of panels.

	Panels with mortar A			Panels with mortar B		
N° panels	1	2	3	1	2	3
(MPa)	7,59	9,96	11,18	11,65	11,78	12,62

Table 2. Compressive strength (collapse values) in specimens with mortars A and B.

As in previous experimentation, a significant increase in resistance has been recorded in panels bonded with fibrous mortar: furthermore -and this aspect appears to be a most significant one - fibres presence prevented the "explo - sive mode" of collapsing which - on the contrary- was typical of plain mortar bonded panels (see figg.2 and 3).

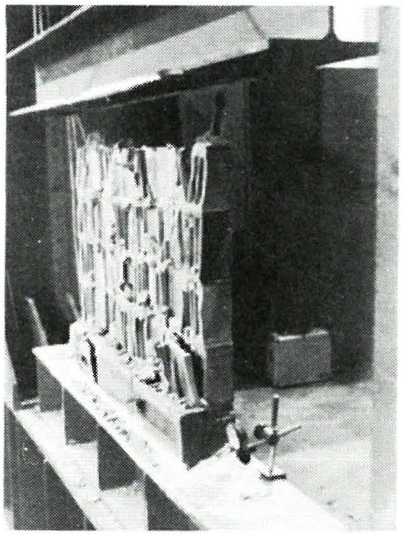
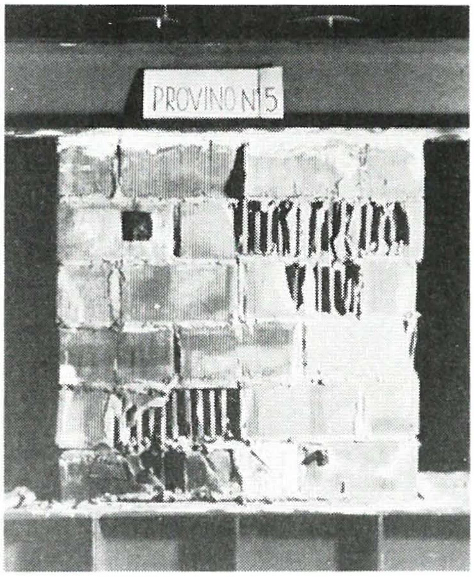


Fig. 2 Mode of collapse in panels bonded by mortar A.



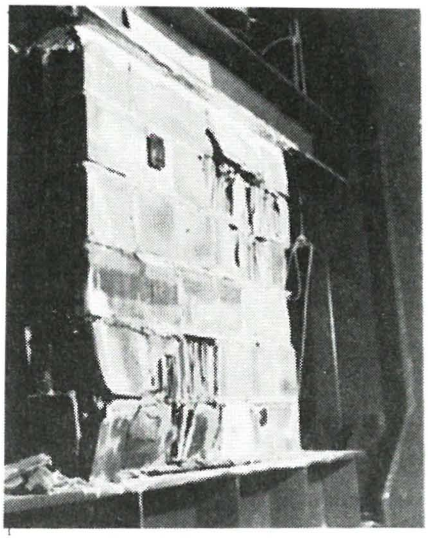


Fig. 3 Mode of collapse in panels bonded by mortar B.

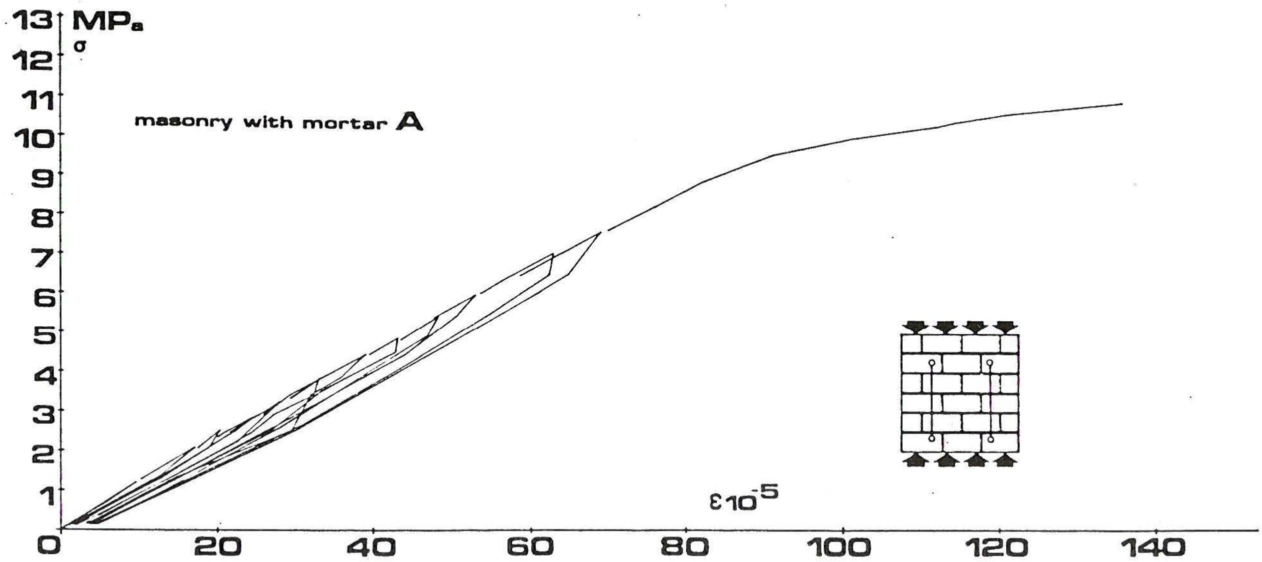


Fig. 4

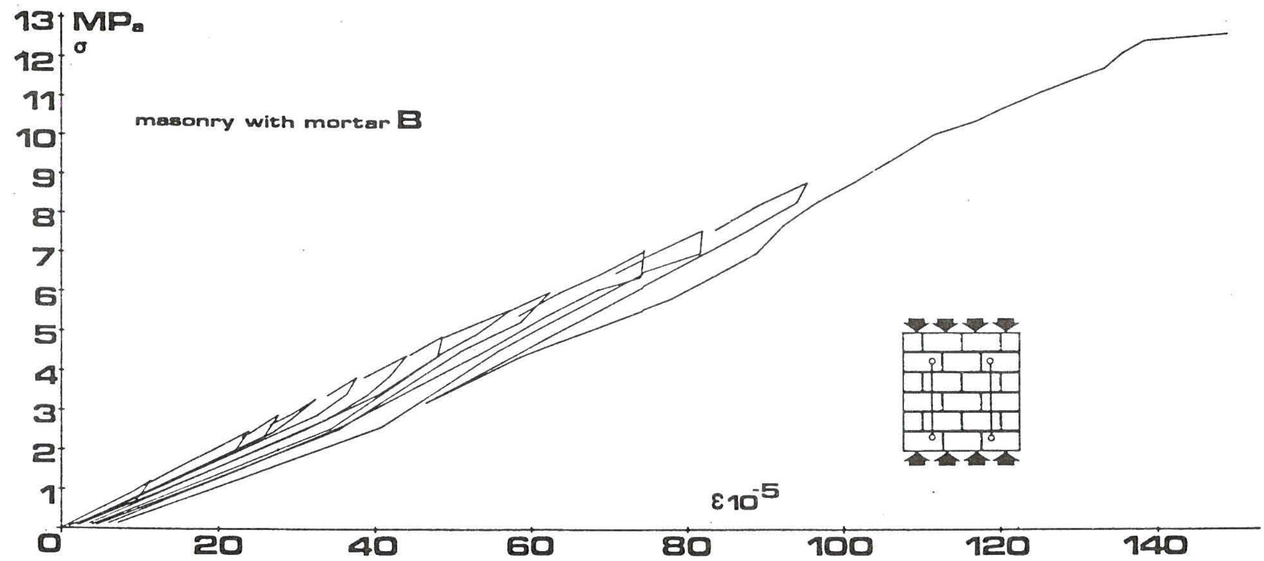


Fig. 5

Examination of diagrams drawn in Figg. 4 and 5 underlines an homogeneity of behaviour in both sets of tests.

Loops concerning B panels involve an higher enclosed area in comparison to the corresponding A panels loops and - as previously stated - the collapse load reached is higher (about 18%) if we use fibrous mortar.

3.3 Diagonal compressions tests

Specimens prepared were 6, 3 for each kind of mortar. Panels dimensions and positions of strain bases are shown in fig. 6.
As in previous set of tests, imposed loads have been surveyed thanks pressure transducer : strains along diagonals, through potentiometric transducers- two on each side of panels - on a base of 550 mm.
A significant difference between collapse strenght of panel type A versus type B has not been recorded, or a different way of behaviour at collapse, either (Fig. 7).

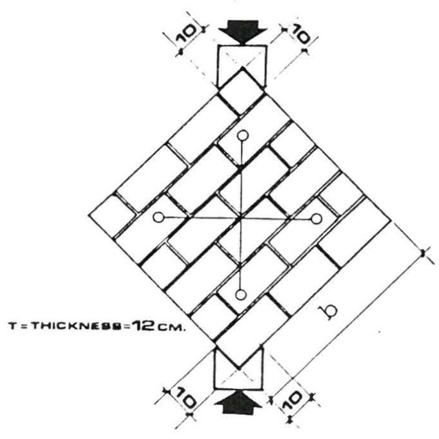
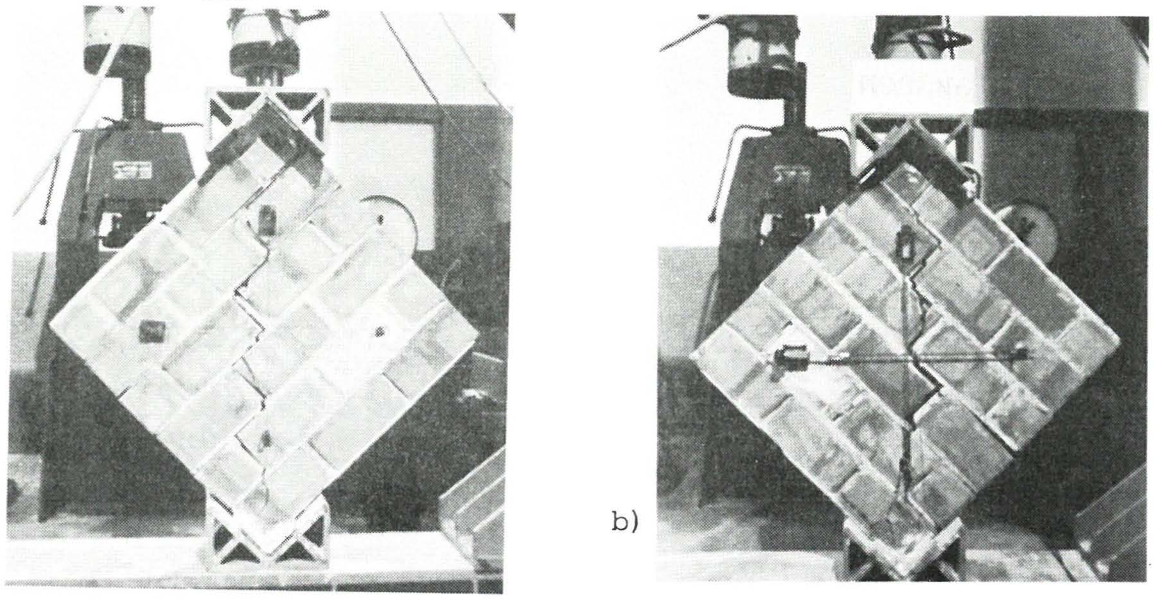


Fig. 6

	Panels with mortar A			Panels with mortar B		
N° panels	1	2	3	1	2	3
f_V (MPa)	0,46	0,66	0,55	0,61	0,56	0,43

Table 3. Diagonal collapsing strenght specimens A and B (according formula $f_v = \frac{F}{2bt}$)



a) b)

Fig. 7 a) =specimen with mortar A , b) = specimen with mortar B

However, a difference is apparent if we observe the diagrams plotted in Figg 8 and 9, which represent the behaviour of panels in the whole process and show a strain effect we consider peculiar (Figg. 8a and 9a put in better evidence the loading phase till collapse).
It is worth to observe, infact, that panels bonded with plain mortar don't show any strain follow up by reolading after collapse, while panels with fibrous mortar show a peculiar and extended capability of strain recovery by reloading.

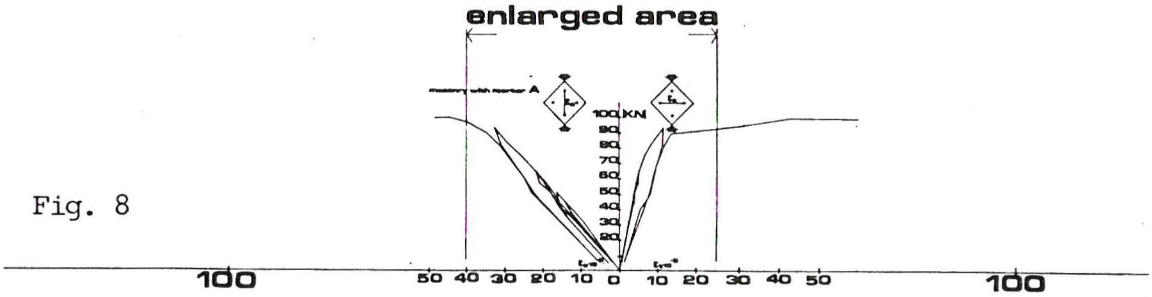


Fig. 8

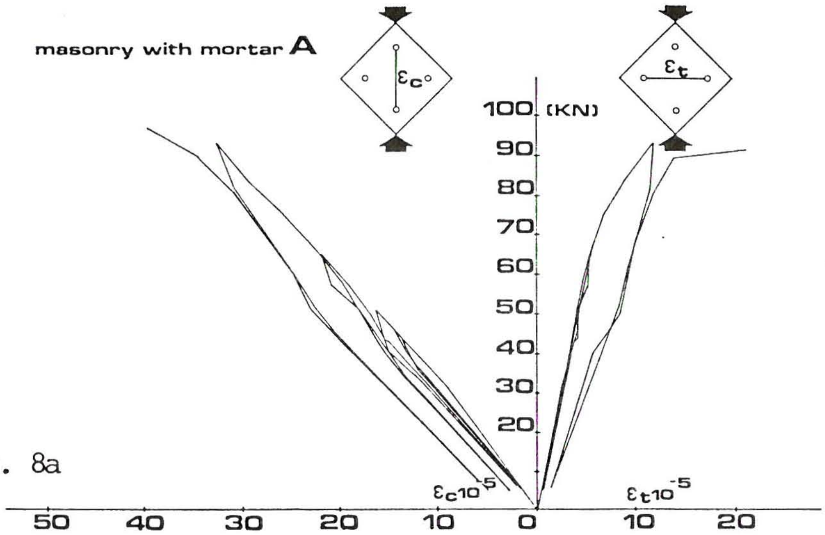


Fig. 8a

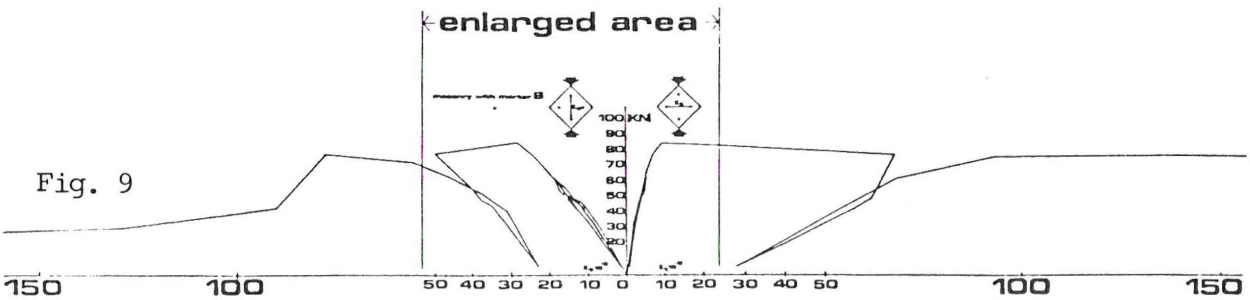


Fig. 9

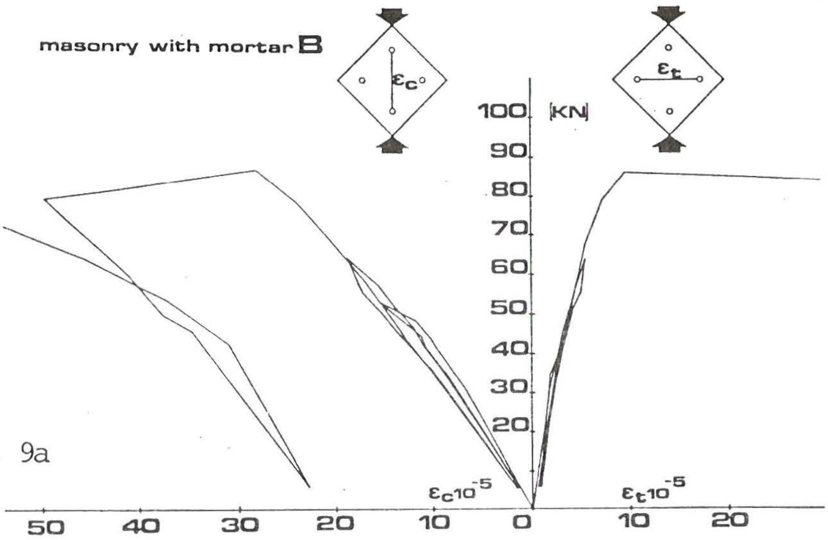


Fig. 9a

4. CONCLUSIONS

The increase in the value of compressive strength, already recorded in previous experimentation, has been confirmed and -we can say- enhanced.
The bonding effect provided by fibrous mortar is more apparent in the present set of tests since the size of bricks employed in panels reduce almost to the half the number of mortar joints in comparison to a fabric with bricks 7x11,5x24.
The difference in behaviour at collapse between the two kind of panels(plain or fibrous mortar) has been clearly confirmed. Plain mortar panels "explode" liberally at collapse load and pratically disintegrate while fibrous mortar panels keep form and consistence after collapse.
In diagonal compressions tests a difference between panels A and panels B has not been recorded as far collapse strength is concerned.
This effect appears consistent with the fact that fibrous mortar (at least by a blending ratio comparatively low as 0,5% by volume) doesn't present, as far tensile stress is concerned, higher resistence than plain mortar. If we consider however the behaviour of a masonry wall as pure shear wall it is apparent the possibility offered by fibrous mortar bonding to the effect of energy dissipation after cracking. Deformation along compression diagonal members will be present in extended way in cracked wall elements thus providing a possibility of energy dissipation before the final collapse effect is reached. This point however is worth more experimentation which we intended to perform in the next future.

AKNOWLEDGEMENT We wish to express our thanks to the Firm RDB, who kindly provided for the bricks used in the experimentation.

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