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MODERN INTERVENTION METHODS FOR CONSOLIDATING THE MASONRY STRUCTURES

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Abstract* - *The paper presents an experimental program to determine the influence of reinforced of masonry made with the carbon fibres. In order to ensure the characteristics needed for reinforced masonry to be use in the Vrancea seismic zone, a program for reinforcing the masonry was developed. The main objective of the program presented in the paper is to reveal the contribution of the reinforcement with carbon fibre to the ductility performance, of the masonry. A part of program was develop to evaluate the influence of carbon fibre on the mechanical characteristic of masonry made with type 2S bricks with vertical gaps used in the current practice and with solid bricks.

Keywords – carbon fibres, consolidation masonry, design code, intervention

I. INTRODUCTION

I.1 General principles

The interventions upon the masonry structures, except the case in which are accepted the damaged state, can be categorised according to the obtained effects, the way of their realization, in the following categories:

- ***repairs*** – that are defined as the measures taken for a masonry structure by which we restore the initial state of the structure, the answer to a future earthquake being at the same level as the one of the initial structure or very close to that one;
- ***consolidation*** – the consolidation is the procedure by which to an affected/damaged masonry it is applied a certain type of intervention after which the structure has the capability to have a superior answer compared to the initial state of the structure.

The experience of the post-earthquake analysis for the masonry buildings have shown that for the structural consolidation of the buildings an individual approach is necessary without a support based upon specific standards. During the masonry buildings evaluation process in order to establish the insurance degree and the intervention measures was taken into account how they applied these procedures

In this paper there are presented a part of theoretical and experimental researches upon the intervention methods for the category of repairs and consolidations. In the research program was made an inventory of the most usual intervention methods adapted to the masonry structures. There have been evaluated the effects obtained by applying the consolidation procedures of the structural masonry upon the strength characteristics as well as upon their deformability. Further on it is presented the experimental program developed by the author and the obtained results only for the reinforced masonry, with Sika Carbodur S 1012 lamellas.

II. EXPERIMENTAL RESEARCH REGARDING THE USE OF CARBON LAMELLAS FOR CONSOLIDING THE MASONRY WORKS

The current study refers to the tests made on masonry panels (1.20 x 1.20 m) for studying the influence/ contribution of the Sika Carbodur S 1012 lamellas (applied in different configurations) on the strength and the failure manner of these elements [studies were made at INCERC Bucharest Branch].

II.1 Testing programme

To analyse how it behaves together the Sika Carbodur S 1012 lamellas and the masonry as well as for analysing the situations in which these elements can be used in this field, was suggested the following experimental research programme:

Stage I: The experiments made on masonry samples made of type 2S bricks with vertical gaps used in the current practice and with solid bricks, for studying the

failure mechanism and determining some data for the design phase. The models were masonry panels, 1.20 x 1.20 m that was tested for diagonal compression. The variable elements were the number and the position of the Carbodur lamellas mounted on the sides of the panels. Through experimental research wanted to highlight the following aspects:

a) the evolution of the deformation characteristics in relation with the applied force;

b) the failure manner and its particularity;

c) the values regarding the deformations and the strengths, compared to the ones obtained on the masonry panels without reinforcement with Carbodur lamellas.

Stage II: Experiments on masonry panels of 2.50 x 3.00 m, subjected to level relative deformations in their plane. The experiments were made on two masonry panels, as follows:
a) the testing of a panel until a certain degree of deterioration;
b) the testing of the same panel after the remediation and reinforcing with Sika Carbodur S 1012 lamellas;
c) the testing of the second panel initially reinforced with Sika Carbodur S 1012 lamellas.

By performing these experiments wanted to obtain information about:

(i) the evolution of the characteristics regarding the deformations and the strengths in these three situations;

(ii) the differences between the failure manners;

(iii) the designing (composition and calculation) of such reinforcing solutions.

II.2 Experimental results

In this first stage of the testing programme there were tested 10 masonry panels (5 panels made out of type 2S bricks with vertical gaps and 5 panels with solid bricks).

The positioning of the Sika Carbodur S 1012 lamellas is shown in the image 1, for the samples made of type 2S bricks with vertical gaps and in the image 2, for the samples made with solid bricks.

Two control samples (masonry samples on which no Sika Carbodur S 1012 lamellas were applied) have been tested for each type of masonry.

The results obtained on the samples made out of type 2S bricks with vertical gaps are shown in the table 1:

Table 1 The results obtained during the tests of the samples consolidated with carbon fibres

Sample	A mm^2	P_{rup} kN	τ_{rup} N/mm^2	γ_{rup} 10^{-3} %	$0.5\tau_{rup}$	$0,5\gamma_{rup}$ %	G N/mm^2
1	365348	110	0.213	45	0.106	22.5	473
2	364156	170	0,333	27	0,165	13,5	1222
3	367800	80	-	-	-	-	-
4	372993	300	0,569	145	0,284	72,5	392
5	372638	200	0,379	77	0,190	38,5	493

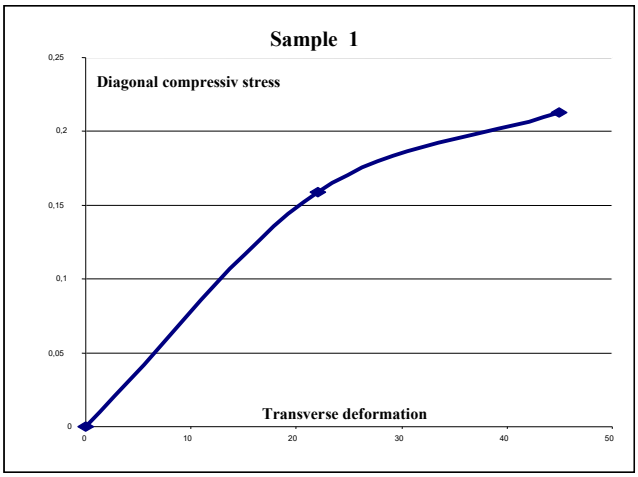
The samples 1 and 2 were control samples. The samples 3, 4 and 5 were consolidated on both sides, according to the image 2, with Carbodur S 1012 lamellas.
During the testing of the 3 consolidated samples the same phenomenon was manifested, that is, the samples failed in the loading area by the breaking of the exterior walls of the bricks.

Was notice the fact that the surface of the lamellas has represented 1.4% (sample 3), 3.33% (sample 4) and 2% (sample 5) from the total surface of the samples.
The failure was produced early in the case of sample 3 at a value of the load representing about 70% from the value of the force that the non-reinforced samples have failed. The result was not considered conclusive.

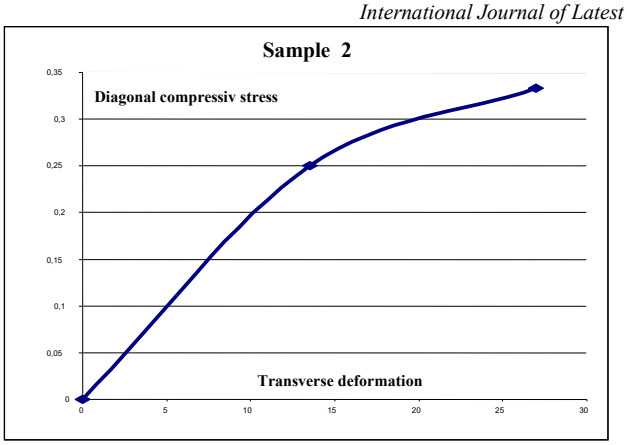
In the case of the samples 4 and 5, was notice an increase of the capacity to resist stresses (with at least 75% more compared to the non-reinforced samples in the case of using the consolidation method on both sides of the sample, with three lamellas positioned parallel with the diagonal and at least 20% in the case of using the consolidation method on both sides of the sample, with two lamellas positioned parallel with the joints) as well as a considerable increase of the deformation (almost double in the case of sample 5 and more than three times in the case of sample 4).

The areas where the lamellas were positioned did not show any deterioration.

Although positive aspects were noticed in the case of using the Sika Carbodur S 1012 lamellas, the reduced number of tested samples, the high spread of the results obtained on non-reinforced samples and especially the failure manner of the samples do not allow a clear formulation of the advantages brought by this consolidation system for the brick masonries.



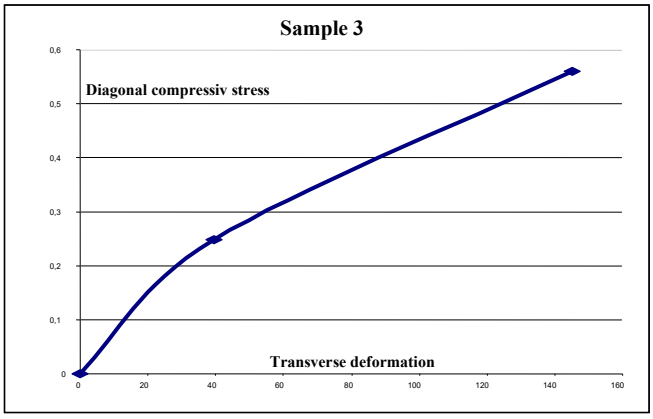
a)



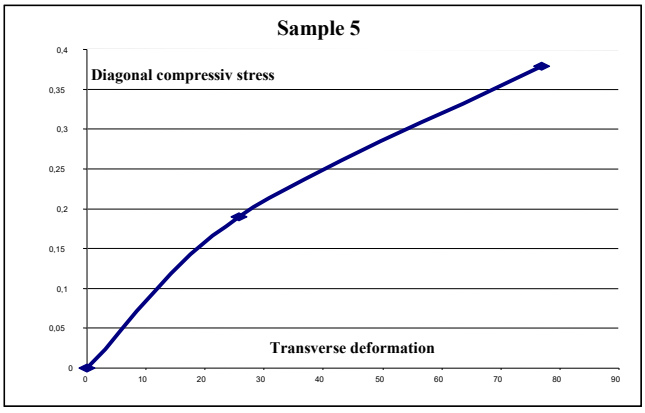
b)

Figure 1 Stress-deformation diagrams for the control samples (according to the table 1):

a) sample 1; b) sample 2



a)



b)

Figure 2. Reinforced sample diagram: a) sample 4; b) sample 5 (according to the table 1)

Out of the six samples made out of solid bricks, the results were validated only for four samples. The results taken into account for analysis are presented in the table 2.

Table 2 The results of the diagonal compression test for samples made out of solid masonry

Sample	A mm^2	P_{rup} kN	τ_{rup} N/mm^2	$\gamma_{rup} \cdot 10^{-3}$ %	$0.5\tau_{ru_p}$	$0,5\gamma_{ru_p}$ %	G N/mm^2
1	302500	120	0,28	29.75	0.14	14.875	943
3	300480	84	0,19	-	-	-	-
5	291102	130	0.316	59	0.158	29.5	535
6	300348	130	0.306	373	0.153	186.5	82

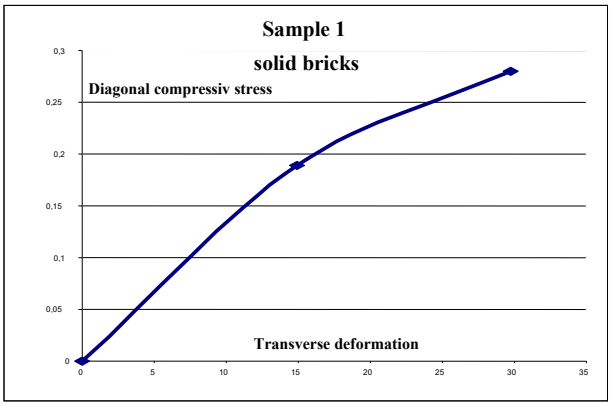
Sample 1 was a control sample. The samples 3, 5, 6 were reinforced according to the image 2.

Sample 3, reinforced on a single side, with two lamellas positioned perpendicular to the direction of the stress has failed by bending at a value of 70% of the force recorded in the case of the non-reinforced sample, registering an arrow in the horizontal plane, perpendicular on the path of the lamella, of 18 mm. No deteriorations of the reinforced area were noticed.

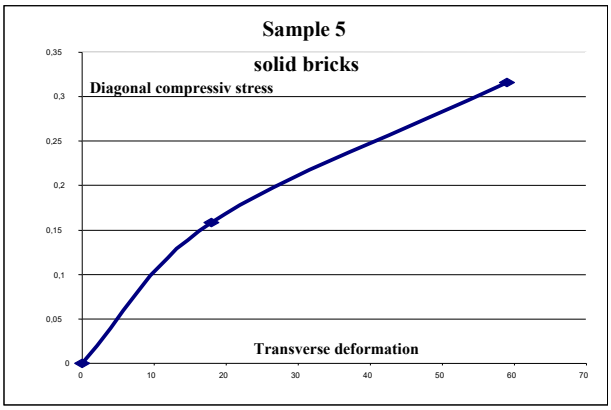
The samples 5 and 6 with the positioning of the lamellas on a single side, respectively on both sides, parallel with two sides of the masonry panel have shown an important increase of the deformation capability (double for the reinforcement on one side – sample 5 and ten times larger for the reinforcement on both sides – sample 6). Both samples have failed by the detachment of the lamellas: in the central area in the case of sample 5 and at the ends in the case of sample 6.

There were not recorded increases in the bearing capacity.

The stress-deformation diagrams are presented in the figures 3.



a)



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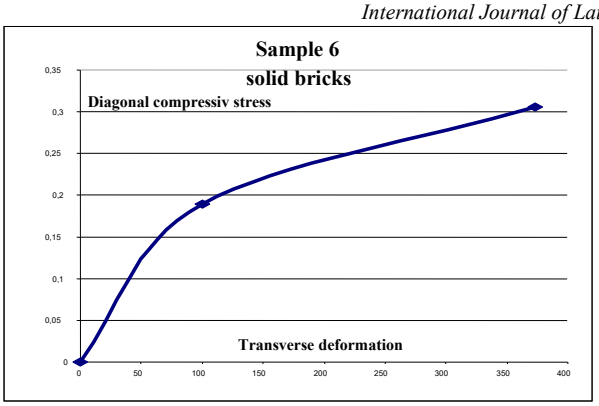


c)

Figure 3 The stress-deformation diagram for solid bricks a) control sample; b) sample reinforced on one side; c) sample reinforced on both sides (according to table 2).

Aspects from the construction and testing phase of the samples are presented in the images 1 and 2. (tests made by the author at INCERC Bucharest Branch)

Image 1 Marking the position of the lamellas

Samples made out of solid bricks

Image 2 Sample made out of solid bricks prepared for reinforcement

III. CONCLUSION

The tests made in this stage have supplied information referring to the behaviour of small sized masonry panels (1.20 x 1.20 m) made out of bricks with gaps and solid bricks reinforced with Sika Carbodur S 1012 lamellas.

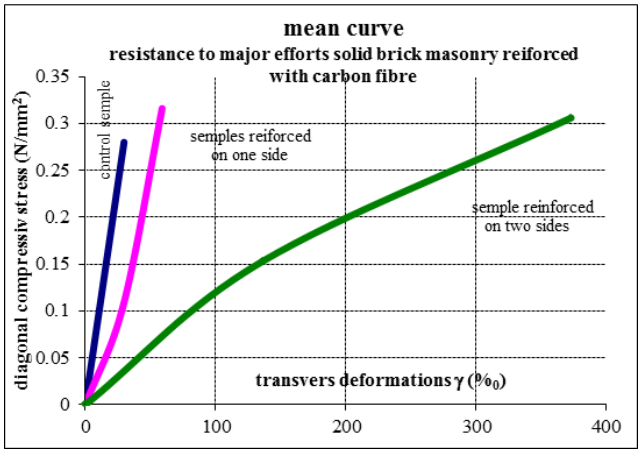
Although the dispersion of the results obtained on the tested samples, as well as the small sizes of the

panels do not allow us to formulate general principles for using these products for the consolidation of the masonry elements, the experimental programme made in this first step has shown some common characteristics of the behaviour of these elements.

The main aspects that results from the behaviour of the panels during the diagonal compression test, on samples of 1.20 x 1.20 m, are the following:

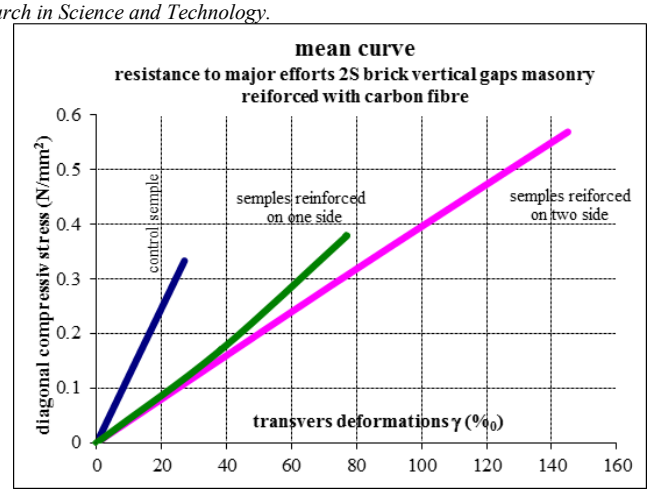
a) the consolidation of the small sized masonry panels with carbon fibre lamellas, Carbodur type, certainly increases the panel capacity of deformation when are breaking. This thing can be clearly noticed from the diagrams from figure 3 a) ,b), c) drawn for the samples made out of solid bricks (the double deformation for the application on one side of the panel and 10 times larger deformation for the application on both sides of the panel);

b) the symmetric application of the lamella, on both sides of the masonry panels is clearly the only viable and efficient solution for consolidating these elements;



c) ensuring the anchorage at the ends of the lamellas is an essential condition for the efficient consolidation of the masonry or concrete elements. This thing was highlighter also by the tests from this stage (see sample 6 made out of solid bricks, consolidated).

d) the application of the lamellas on the type 2S bricks with vertical gaps pose extra issues related to the transversal strength of these bricks, in the areas next to the consolidated areas.



IV. ACKNOWLEDGMENT

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REFERENCES

[1] Matei, C. L. (2012). Characteristics of masonry in Romania in correlation with the European codes. 15th World Conference on Earthquake Engineering 24-28 September 2012, Lisbon, Portugal. Electronic volume.

[2] Matei, C. L., Mironescu, M., Braghina, A. N. (1999). Data on the characteristics of masonry in Romania: Comparisation with other countries. Alberto Bernardini Seismic Damage to Masonry Buildings A.A. Balkema Publishers PO Box 1675 BR Rotterdam Netherlands, pag. 153-160, ISBN 90 5809 1 15 5.

[3] Dragomir, C.S., Matei, C.L, Dobre, D., Georgescu, E.S. (2012). New concept and solutions for post-seismic assessment and strengthening of buildings *Land Reclamation, Earth observation & Surveying, Enviromental Engineering*. University of Agronomic Sciences and Veterinary Medicine of Bucharest- 2012 - ISSN 2285-6072 (CD-ROM) / ISSN-L 2285 – 6064.

[4] Matei, C.L, Matei R.C.. (2013). Stady to evaluate the characteristics of masonry for "Stirbey family chapel" to retrofit the structure. *Structures and Arhitecture: Concepts, Applications and Challenges – CRC Press /Balkema* Cruz (ed) 2013 Taylor & Francis Group, London, pp 263-264 ISBN 978-0-415-66195-9.

[5] Matei C.L. (2014) Reinforcing AAC Masonry Using Polymeric fabric. *International Journal of Latest Research in Science and Technology. Volume 2, Issue 6, November- December 2013 :* Paper ID 25-18122013, pp 18-22 ISSN:2278-5299.