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CONSTRUCŢII. ARHITECTURĂ

OLD MASONRIES' REHABILITATION. DAMAGED AND COATED STRUCTURES MADE WITH WEAK MORTARS

BY

ADRIAN-CONSTANTIN DIACONU*, CRISTINEL-DUMITRU CIOANCĂ and LIVIA-INGRID DIACONU

"Gheorghe Asachi" Technical University of Iaşi,
Faculty of Civil Engineering and Building Services

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Abstract. The present paper realizes a synthesis of some experimental date regarding the vertical load behavior of wall elements made of pressed bricks and weak mortars (lime–sand, clay–sand and clay) tested for a damage degree at plastic limit and after retroffiting with different reinforced coating solutions (polymeris grids, welded soft steel nets having small grids).

Key words: masonry; weak mortars; experimental tests.

1. Introduction

Interventions made by rehabilitation/conservation were focused on restoring structural integrity and stability of old buildings or monuments according to the actual situation. The used models were not based on certain experimental data before and after intervention to quantify the intervention's quality and the structure's or adjacent structures behavior.

Most interventions are realized by coating or "corset" techniques without taking into account the behavior under exceptional or exploitation loads, function of the old masonries (hard brick and wake mortar). This paper aims to highlight, by experimental data, some of these behavior elements.

*Corresponding author: *e*-mail: acdiaconu@yahoo.com

2. Models and Materials

For the experimental program three types of weak mortars were selected namely

1. Lime + sand 1: 7 – Lime paste 12 – 0.1 m^3/m^3 – (f = 2) = 0.2 m^3/m^3; dry sand = 0.7 m^3/m^3.
2. Clay + lime 10:1 – dry clay 1,200 kg/m^3; lime paste 0.08 m^3/.
3. Clay + sand 10:1 – dry clay 1,200 kg/m^3; dry sand 100 kg/m^3.

These mortars have been used with simple normal brick recovered from demolition to obtain 1.0 × 1.0 m walls having a thickness of 24 cm, on a concrete foundation needed for handling, necessary for a set of nine models which were degraded and consolidated in different solutions (see Table 1).

Table 1
Realized Samples

Sample	Mortar
1	Clay sand 10:1
1	Clay lime 10:1
1	Lime sand 1:7
2	Clay sand 10:1
2	Clay lime 10:1
2	Lime sand 1:7
3	Clay sand 10:1
3	Clay lime 10:1
3	Lime sand 1:7

3. Testing and Measurement Equipment

To gather the necessary information during the experiments IAUC type inductive traductors of ±10 cm were used on vertical position (load's direction) and on the model's diagonal.

For motion parameters recording, a data acquisition system having embedded 12 channels and a laptop and 400 tf Amsler testing machine were used.

4. Initial Models Testing – Experimental Data

The models presented were tested to the limit of plastic deformation (approx. 50 tf) to bring them to a similar stage of demage (considering the same intensity and location of the demage factors).

From the performed tests were obtained the values, presented in Table 2.

Table 2
Initial Models Data

Sample	Mortar	F, yielding load tf	D_{max} of the plate mm
1	Lime sand 10:1	51.2	31.0
1	Clay lime 10:1	51.9	23.5
1	Lime sand 1:7	52.0	30.5
2	Clay sand 10:1	51.9	30.1
2	Clay lime 10:1	52.0	30.0
2	Lime sand 1:7	51.4	31.0
3	Clay sand 10:1	52.0	40.0
3	Clay lime 10:1	50.6	29.0
3	Lime sand 1:7	51.0	28.5

The analysis of acquired data performed using MATLAB, an average of the three main types of models using identical mortars, was realized, and results in the domain load/values number are presented in Figs. 1,…,3.

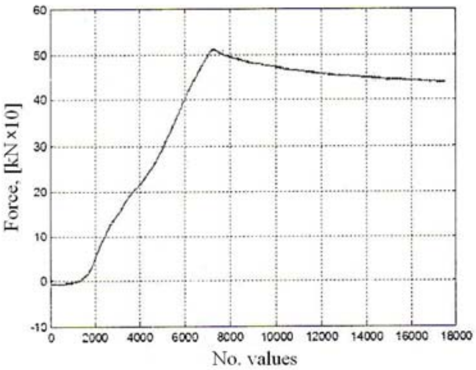

Fig. 1 – Load; average values – 10:1 sand clay initial stage.

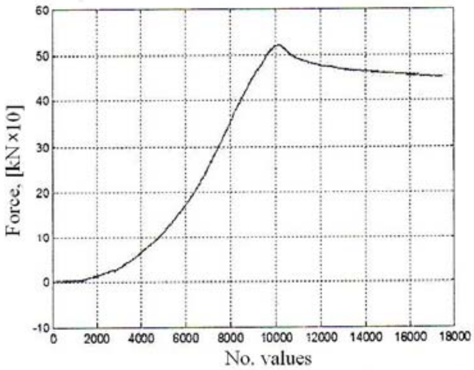

Fig. 2 – Load; average values – lime sand 1:7 initial stage

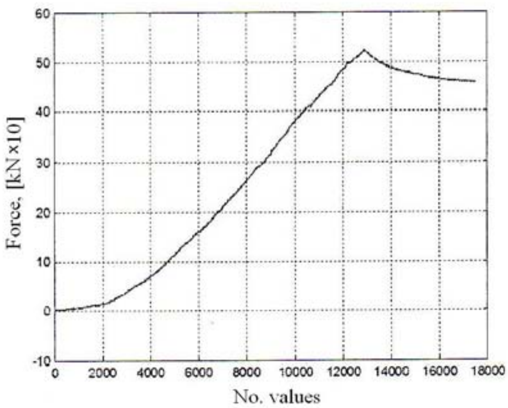

Fig. 3 – Load; average values clay – lime 10:1 initial stage.

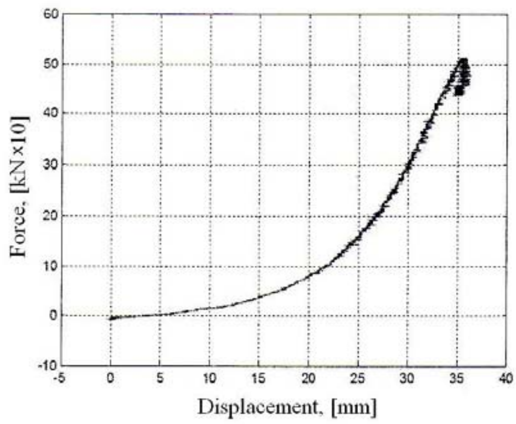

Fig. 4 – *F vs*. *D* averages values – 10:1 sand clay initial stage.

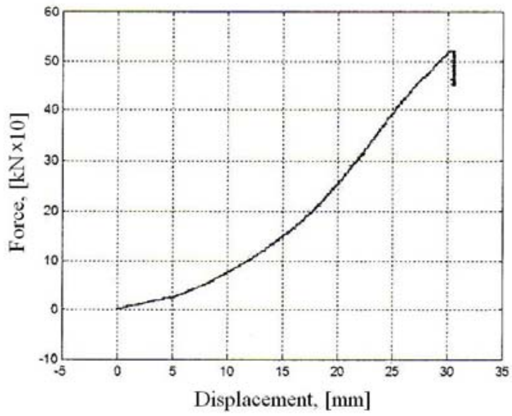

Fig. 5 – *F vs*. *D* averages values – lime sand 1:7 initial stage.

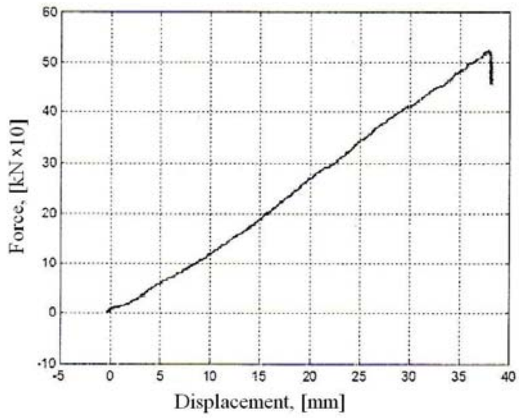

Fig. 6 – *F vs*. *D* averages values – clay - lime 10:1 initial stage.

As can be noticed, the load's value increasing mode is different, depending on the deformation capacity, implicitly on the energy absorption, of each type of mortar, determining a different behavior of the retrofitting solutions chosen for rehabilitation.

Significant for the energy dissipation capacity of these models is the behavior shown in the force (*F*) *vs*. displacement (*D*) diagrams (Figs. 4,…,6).

5. Tests on Reinforced Models – Experimental Data

The models were retrofitted in the three ways for the weak mortars presented above; the solutions were achieved by 3.5 cm thick coating, in three versions namely

1. Reinforced coating with Ø3 mm black wire mesh independent bar 5 × 5 cm.
2. Reinforced with Ø6 mm welded mesh with hard steel (10 × 10 cm).
3. TENSAR reinforced coating with polymeric grille.

The testing was realized to fracture and several experimental data categories were obtained (s. Table 3), presenting

1. Numerical data on the applied load evolution.
2. Pictures regarding the yielding mode of the coated models' structure, which characterize the fracture mechanism.

As regards the loading force in time evolution, several experimental data are presented in Figs. 7,…,11.

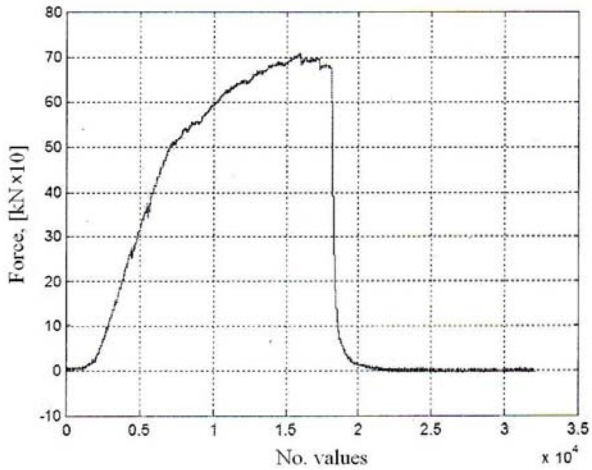

Fig. 7 – Force values – 10:1 sand clay consolidated net.

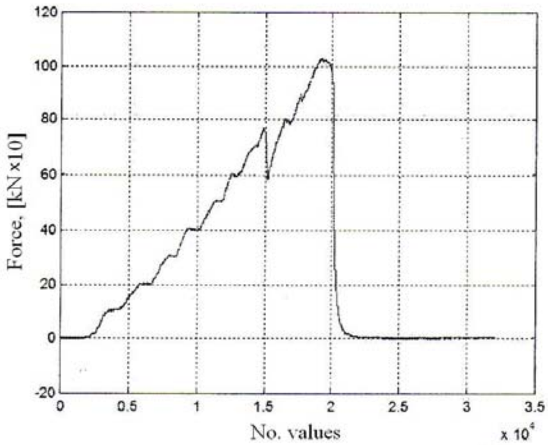

Fig. 8 – Force values – 10:1 lime clay consolidated net.

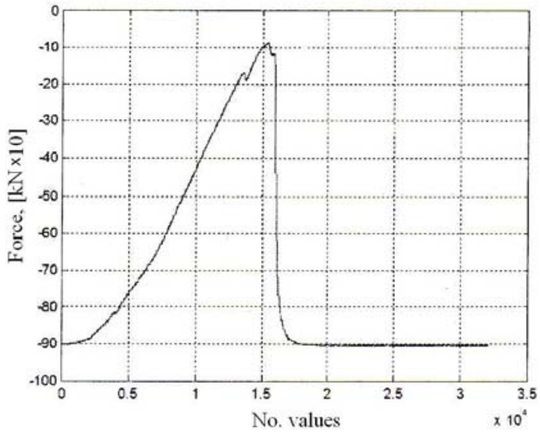

Fig. 9 – Force values – lime sand 1:7 consolidated.

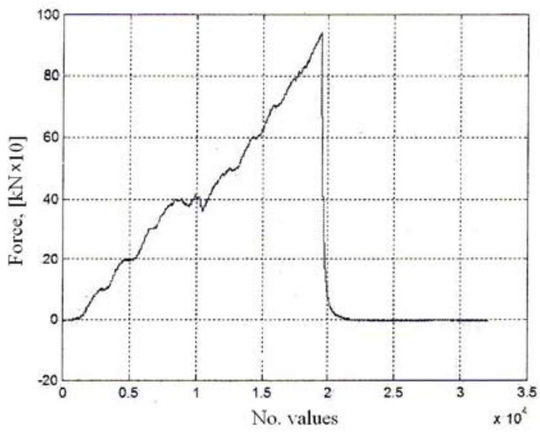

Fig. 10 – Force values – 10:1 sand clay reinforced.

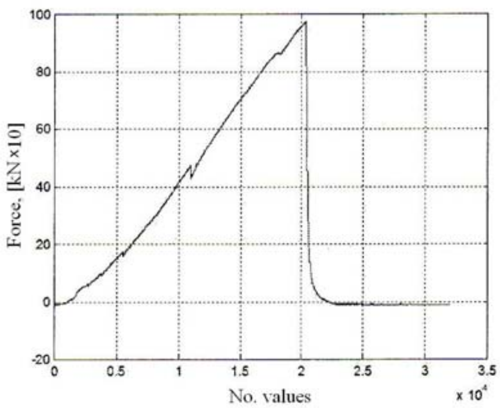

Fig. 11 – Force values – lime sand 1:7
reinforced polymeric grille.

Table 3
Several Data on Retrofitted Models

Nr. crt.	Sample	Mortar	*F*, yielding load tf	Retrofitting coatings – 3,5 cm
4	2	Clay sand 10:1	72.0	net
5	2	Clay lime 10:1	103.0	net
6	2	Lime sand 1:7	81.8	net
7	3	Clay sand 10:1	94.0	Polymeric grids
9	3	Lime sand 1:7	97.0	polymeric grids

Fractures in steel grid reinforced coating and in polymer grid reinforced coating are represented, respectively, in Figs. 12 and 13.

Fig. 12 – Fracture in steel grid reinforced coating.

Fig. 13 – Fracture in polymer grid reinforced coating.

6. Conclusions

From the data presented above the following conclusions may be draw:

a) The initial tested models behavior strongly depends on the used mortar in energy absorption and from deformability point of view.

b) Force *vs*. displacement relation shown in Figs. 4,…,6, highlights that the week mortars curing under load have the same loading rate.

c) As shown in Figs. 7,…,9, the retrofitted models with steel nets with 10 × 10 cm meshes have a totally different behavior depending on the used mortar. Thus, the model realized with lime–sand 1:7 mortar has a quasi-linear behavior together with the coating concrete, the mortar realized with clay–lime 10:1 is weaker due to the anchorage (it has to be mention that the anchorage elements are identical for all the models), while the clay sand mortar of 10:1 initially has a retrofitted behavior and then the yielding is accentuated.

d) It has to be noticed that the masonry made of clay mortar may have reduced strength qualities up to 60% due to the moisture.

e) The use of polymeric grids in coatings' reinforcing tend to uniform the masonry models as can be observed from Figs. 7,…,11. It is to be noticed that the used and tested polymeric grids in this program bring a substantial increase in capacity to take over the horizontal force both for their use in new buildings, in the form of reinforcement in horizontal joints and confinement, or for damaged and polymeric grids coating retrofitted masonry buildings.

f) The obtained data relieve clearly the failure mode of masonry structures and the difference between grid reinforcement polymer (which have a great deformation capacity of masonry and is totally leading it) and the one which uses welded meshes that work together only limited with the masonry.

REFERENCES

Diaconu A.-C., Cazacu M., Groll L.-I., *Strengthening Emergency Postseism Severely Damaged Structures Using New Materials for Injection, Produced in Romania.* Contract 31-079/2007, Program PN II, 2007–2010.

Diaconu A.-C., Radu C., Hariga F., *Solutions to Enhance Economically Efficient for Traditional Structures Made of Masonry of Various Types and Qualities, Using Conventional and Unconventional Materials*. Contract no. N 11 / 2003 - Item 6 - 06-11.04.07 PN code; client: MEC, 2007–2010.

Diaconu D., Diaconu A.-C., Popa T., *Structural Rehabilitation and Hygrotermica Residential Buildings Completed in the Industrial System*. RELANSIN Program, Contract 181/1999 (1999–2003).

REABILITAREA ZIDĂRIILOR VECHI. STRUCTURI REALIZATE CU MORTARE SLABE DEGRADATE ŞI CAMĂŞUITE

(Rezumat)

Se prezintă o sinteză a unor date experimentale legate de comportarea la sarcini verticale a unor elemente de pereți (1,0 × 1,0 m) realizate din cărămidă plină presată şi mortare slabe (var–nisip, argilă–nisip şi argilă) testate pentru un grad de degradare la limita plastică şi după consolidare cu diverse sisteme de cămăşuire armată (grile polimerice, plasă sudată şi plasă din sârme moi independente, cu ochiuri mici).