AFTER EARTHQUAKE 23 NOV. 1980
TESTS "IN SITU" OF MASONRY WALL STRUCTURES

Dipartimento di Costruzioni Università di Firenze. Italy
Soprintendenza per i Beni Ambientali Architettonici
Artistici e Storici di Salerno e Avellino. Italy
Presenting Author: A. Pezzullo

SUMMARY

This paper presents the experimental in situ analysis performed on old masonry buildings with the aim of obtaining information about their behaviour under horizontal loads. The tests have been made in two phases: on the actual masonry and on the consolidated one. The importance of such tests is in improving the classical experimental methods on models or on structural elements, by directly testing full size buildings and frames, whose material and structural characteristics cannot be adequately reproduced in laboratories, for scale and degradation problems.

INTRODUCTION

The illustrated experience is included in experimental research programme on old buildings damaged by the earthquake of 23 November 1980 accordance with "Soprintendenza per i Beni Ambientali Architettonici Artistici e Storici di Salerno e Avellino-Ministero per i Beni Culturali and " Dipartimento di Costruzioni Università di Firenze". Here one of the tests executed on buildings of Salvitelle-an old village of southern Italy- is described as follows.

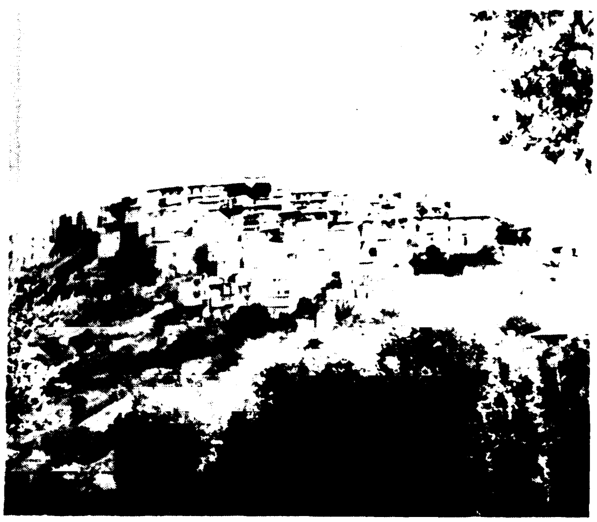


fig.no.1 THE VILLAGE OF SALVITELLE(I)

fig.no.2 THE BUILDING

Preparation of the test wall

The wall shown in fig. 3 is made of stone rather degraded masonry; it is subject to:

1) Self load;
2) Loads acted by floors;
3) Horizontal loads.

The horizontal loads have been applied by 6 DEFRIES jack-available diameter 60mm. (Ist test) and T 20 available diam.85mm. (second test) acted by ENERPAC BPM 6442 AL 7B pump and located between two couples of I 160. These were placed within the cut made along the whole height of the wall, 65cm. wide. One the external surface of the wall a fracturing white plaster has been put, in order to make evident the appearing of fractures and their developement recorded by EUROGARD TT1 fracturometers. Furthermore, on the plaster a triangular mesh has been designed, with the same base of the deformemeter HUGGENBERGER S 4229,.0001 used for strain measurements. The horizontal and vertical displacements of the several wall points have been recorded by centesimal dial gauge RAMBOLD.

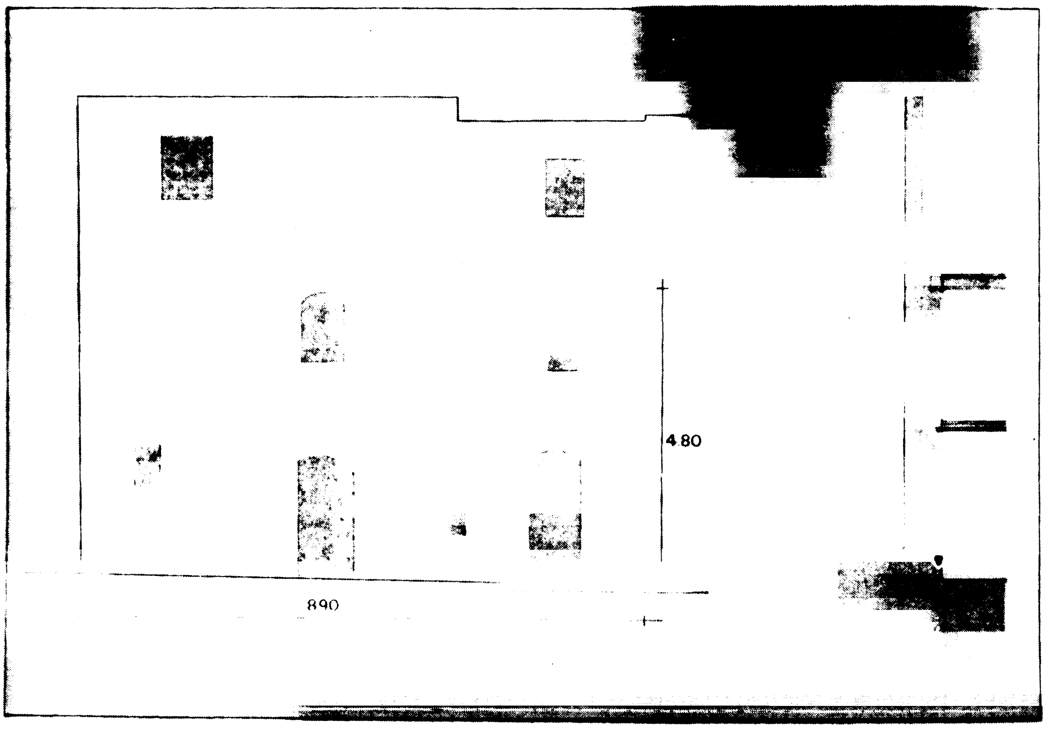


fig.no.3 DESIGN OF TESTING WALL

First load test

The test has been executed by loading cycles with constant increments of the maximum load achieved. Special attention has been payed following the phenomenum development, because the masonry structers have an elastic-fragile behaviour, with the aim to size with the best accuracy the maximum point of the load-displacement curves. The curve in fig.5 (comparator n.4) shows one of the typical curves obtained during the test phases. For the first load values we have a typical elastic behaviour. Until a total load of 0.15 MN: here, at the same time, together with the first fractures we can note a first appreciable variation of the curve scope, until the load of 0,5 MN, corresponding to the appearance of a large fracture pattern. Beyond this load value the tangent of the envelope curve of the path tops drops tending towards a horizontal position: this is a clear sign of the whole slackening of the structure.

PROVA DI CARICO			
STEPS	CARICO TOTALE (MN)	STEPS	CARICO TOTALE (MN)
1	0	14	.204
2	.0255	15	0
3	.051	16	.255
4	.085	17	.306
5	.102	18	.408
6	.085	19	.459
7	0	20	0
8	.051	21	0
9	.102	22	.17
10	.1275	23	.306
11	.153	24	.4675
12	.1785	25	0
13	.204		

fig. no. 4
PROGRAMME OF LOADS 1ST. TEST

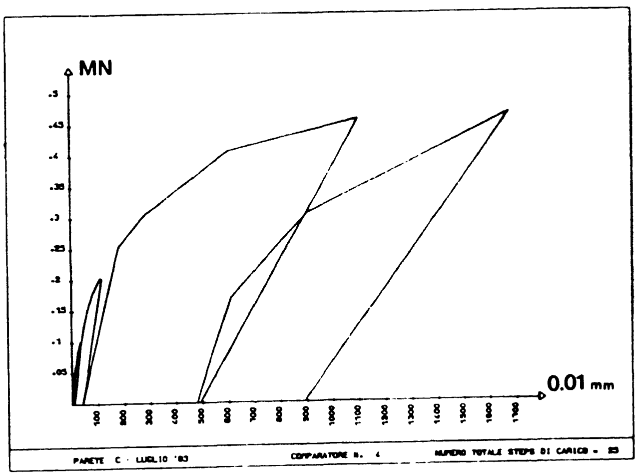


fig. no.5
COMPARATOR no.4
LOAD/DISPLACEMENT

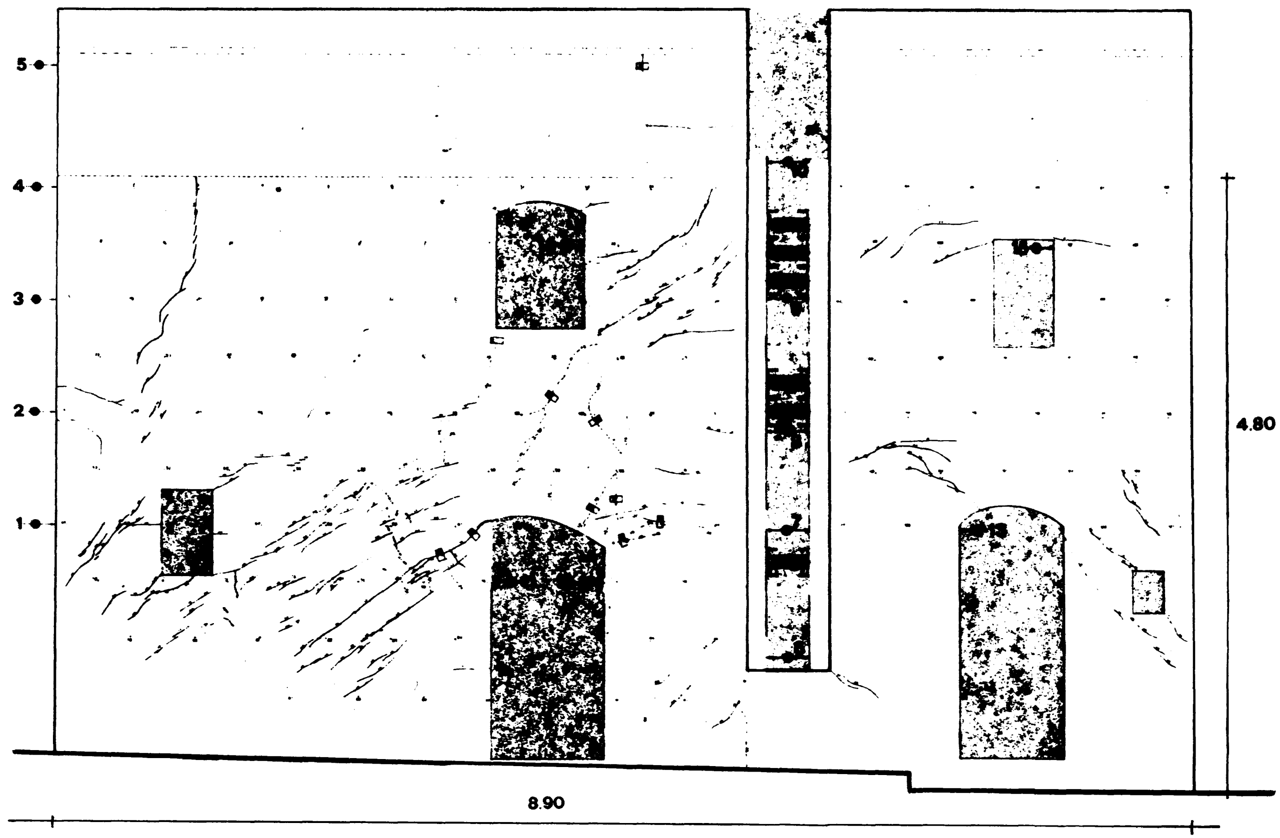
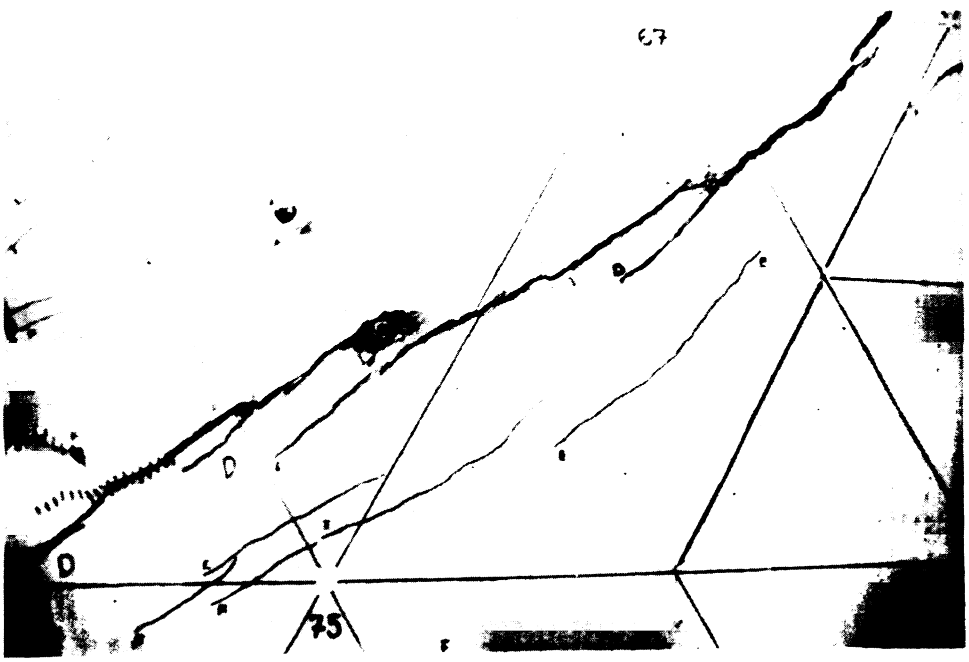


fig.no.6 FRACTURE PATTERN AFTER IST. TEST JULY 1983

Considerations

The test has been stopped at the load value of 0,5 MN; at this point the wall parted in rigid-elastic blocks, in spite of one another, were moveble through the large fractures of the same wall.

This is one of the most interesting aspects of the test because it stood out a phenomenum we always have found during all the tests: i.e. immediately before the collapse, the fracture pattern concentrates on preferetial lines which part the wall in spite of the movability of the blocks to define the last kinematic motion with a good accuracy; it is also very interesting to verify that the values of the ultimate stresses correspond to the same evaluted by The Italian Recommedations issued after the November 1980 earthquake and, for the most part, due to the experiences performed in Yugoslavia on masonry buildings.



THE FRACTURE PATTERN AFTER 1ST. TEST

Consolidation of the wall

The wall has been consolidated by injecting a cement mixture which was composed of 100 litres of water,100 kilogramme of cement and a fluid additive of Thoro and has been chosen on the basis of experimental results performed on consolidated samples, by differently composed mixtures. The injection drillings have made on a nodal square mesh of 30cm.; the adopted injection pressure was 20 Pa.

Second load test

After consolidation the second test has been executed with the same procedure as the first one, with the purpose to verify the difference of the structure behaviour.

The first important remark concerns the maximum load value that has been possible to achieve, 0.72 MN, when, on the wall, the collapse mechanism was of less importance. This second test, the sixth following the order of the performances, has been improved by the previous experiences; in fact,much more complex loading programme has been performed, made by 103 steps of loading/unloading. The diagram shown in fig.8 is typical of those we obtained and shows a strong increasing of the asyntotical point tends towards the envelope curve.

STEPS	CARICO TOTALE (MN)	STEPS	CARICO TOTALE (MN)
1	0	53	.272
2	.102	54	.357
3	.034	55	.408
4	.136	56	.306
5	.17	57	.204
6	.102	58	.102
7	.051	59	.034
8	.102	60	.102
9	.136	61	.204
10	.17	62	.306
11	.204	63	.408
12	.136	64	.442
13	.068	65	.476
14	.136	66	.51
15	.17	67	.408
16	.204	68	.306
17	.238	69	.204
18	.187	70	.102
19	.119	71	.204
20	.051	72	.306
21	.102	73	.408
22	.136	74	.51
23	.17	75	.544
24	.204	76	.578
25	.238	77	.612
26	.272	78	.476
27	.204	79	.408
28	.136	80	.306
29	.068	81	.204
30	.102	82	.102
31	.136	83	.204
32	.17	84	.306
33	.204	85	.408
34	.238	86	.51
35	.272	87	.612
36	.306	88	.646
37	.238	89	.68
38	.17	90	.714
39	.102	91	.646
40	.136	92	.51
41	.17	93	.408
42	.204	94	.306
43	.238	95	.204
44	.272	96	.102
45	.306	97	.204
46	.34	98	.306
47	.272	99	.408
48	.204	100	.51
49	.136	101	.612
50	.068	102	.714
51	.136	103	0
52	.204		

fig.no.7
PROGRAMME OF LOADS

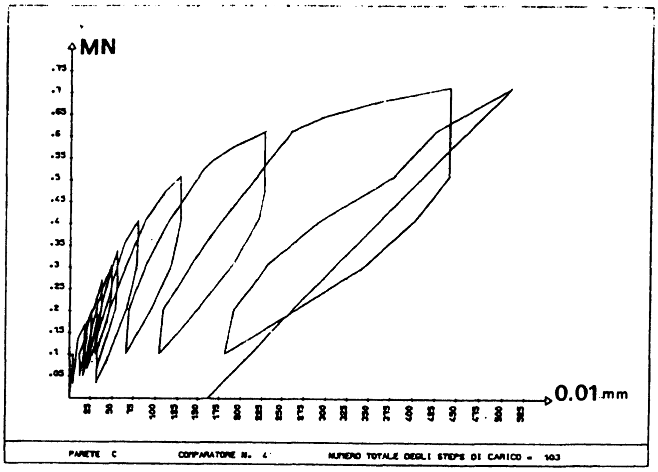


fig. no.8
COMPARATOR no.4 LOAD/DISPLACEMENT

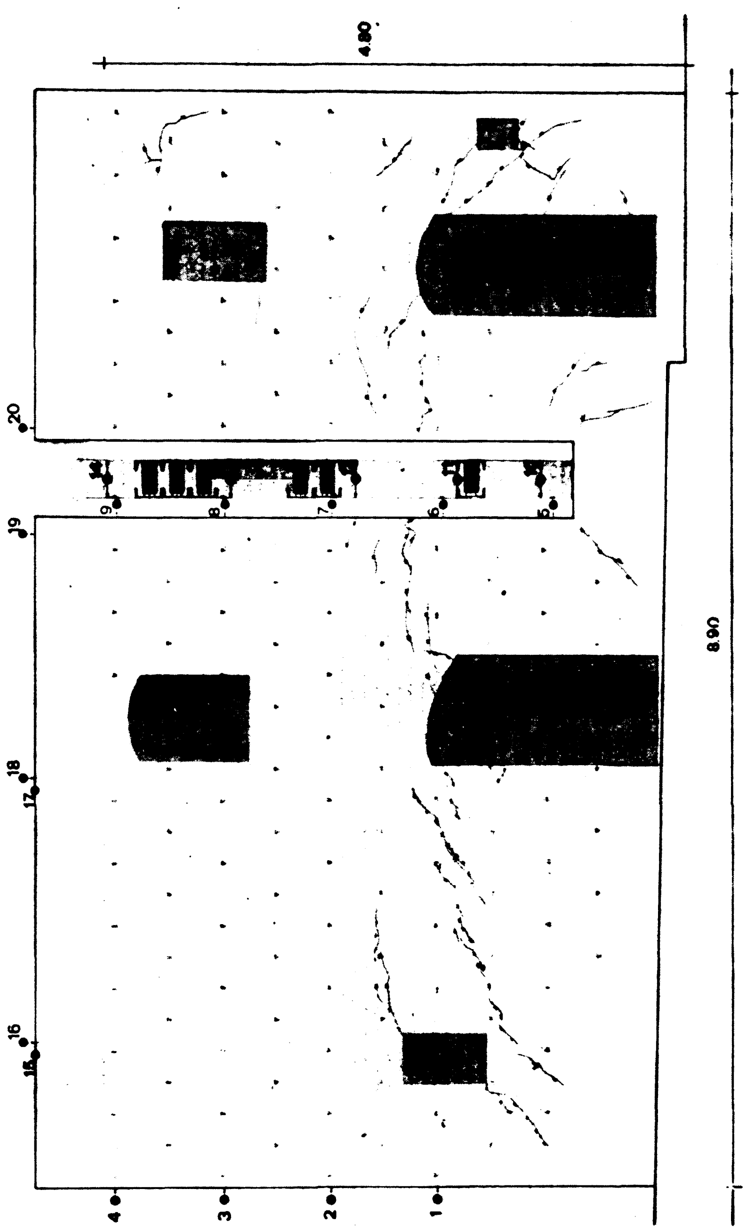


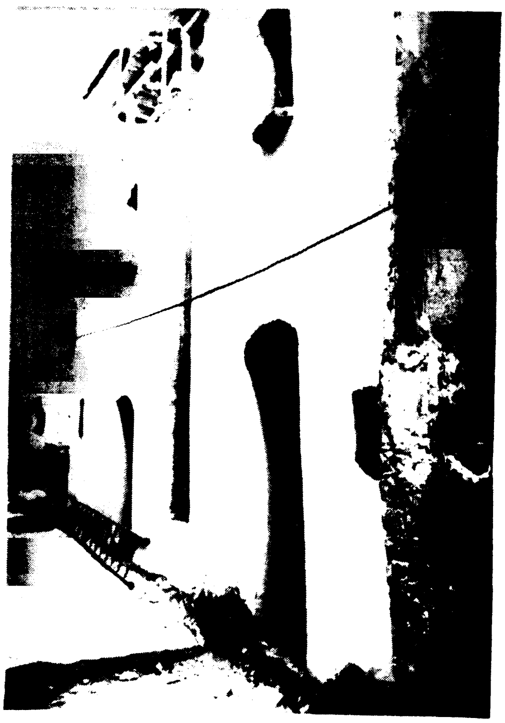
fig. no.9 FRACTURE PATTERN AFTER 2ND. TEST SEPTEMBER 1983

Conclusion

The complexity of tests made does not consent to draw general conclusions; it should be remarked that according to our knowledge, a test as well as the one we made in Salvitelle; has never been made. So during this research, we modified the test procedure continually to take into account the information obtained. In this way the last test, here explained, has been both more complex and more complete than the first one. The research programme is still in progress.

The material, forming the tested structure is poor, irregular, heterogeneous and an-isotropic, in spite of this, gave very regular answers.

It is possible to suppose that with some well-chosen consolidation a large part of historical buildings can be saved.



THE BUILDING AFTER 2ND. TEST