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Seismic retrofit of historical buildings

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ABSTRACT: The poster shows the results of experiences made in the repair and seismic retrofit of historical buildings damaged by South Italy 1980 earthquake
The development reached by some original techniques used in many of those retrofits is also shown. All of these retrofits were made to order of Governative Office of Italian "Ministero per i beni culturali".

All repair projects were realized utilizing the original results reached on two research fronts:
a. Stress analysis of masonry buildings performed by use of F.E.M. code named "NINFEA". This code performs a step-by-step stress analysis of two-dimentional walls taking into consideration the non-linear behaviour of materials.
b. In-site tests on mechanical properties of materials before and after introduction of strengthenings descripted below.
Here is a set of the most original techniques used in retrofit of masonry buildings.

1. Bindings with pre-stressed steel cables

This strengthening technique was introduced to reach a noteworthy solidarity of masonry masses, reducing any offence to the architectural value.
It is realized through the use of pre-tensioned steel cables, with the aid of small drilling equipments which can operate almost everywhere in the buildings, even on the roofs.
Perforations have diameters varying from 60mm. to 100mm. After insertion and tensioning of cables, grouting mixture injections are performed into the holes. Anchors, cables and plates are the same in use for the pre-stressed concrete, but here stresses are quite lower.

2. New masonry composition

When the structural damage is at a level such as to impose the partial re-building of walls, it is recommendable to utilize the same techniques and the same stones of destroyed panels. Moreover this is done improving the structural and hygroscopic performances using lightweight concrete with inerts of artificially expanded clay and inserting steel reinforcements to improve the ductility.

3. Recuper and strengthenings of domes.

The following technique is succesfully in use to repair damaged domes which need ties. The existing filling is substituted with clean and light material (i.e. "argilla espansa"). Over this layer, a thin r.c. slab is casted. Inside this slab, pre-stressed steel cables are embedded.

4. Truss-work binding superior edges of wall-box

An evident example of structural weakness is that concerning the churchs, whose walls behave as plates with three constrained edges and the fourth free. The substitution of the roof with new structures allows us to realize a steel truss-work binding the four top edges of walls so as the horinzontal actions can be transferred to the couple of them parallel to the forces; the set of walls is transformed in to a closed-box structure, much more stiff than the original one. Of course the truss-works must be placed carefully without interference with the paintings on the ceiling.

Pictures

Figure 1: "Palazzo Orsini" (XVII cent.), Solofra, Avellino, Italy. The partially destroyed building as it appears after the retrofit.

Figure 2 and 3 : Exterior and interior of the "Collegiata"(Church, XVII cent.). The strongly damaged constraction as it appaers after the retrofit.

Figure 4: Small drilling equipment working on the roof of "Palazzo Orsini" to realize steel cables holes.

Figure 5 and 6: Differents kinds of cables adopted in the retrofit of historic buildings.

Figure 7: Anchor plate, with steel cable heads after the tension.

Figure 8: The steel-cables-frame-work constructed into masonry masses of "Collegiata".

Figure 9 and 10: Destroyed walls re-constructed using old stones along the surfaces, steel reinforcements inside and light concrete to fill up the whole.

Figure 11, 12 and 13: Recuper and strengthening of domes; Castle in S. Angelo dei Lombardi. Avellino.

Figure 14 and 15: Truss-work binding superior edges of wall-box in S. Francesco's church in Montoro.