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RETROFITTING OF OLD BUILDINGS CASE STUDY OF BARREA (MIDDLE ITALY)

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SUMMARY

This paper describes the experience of applied research carried out in the historic centre of Barrea (Central Italy), which had been damaged by the seismic events of May 1984. From the surveys made, an estimate of the damage, vulnerability and stability of the entire old residential area was arrived at, in addition to making it possible to define the type of action required for the structural, functional and architectural restoration of the damaged buildings. The latter operation involved the coordinated efforts of both public and research bodies.

INTRODUCTION

Within the framework of the events following the May 1984 earthquake in the Abruzzo Region of Central Italy, that pertaining to the historic centre of Barrea, certainly one of the worst hit, has assumed particular significance.

Situated in the central zone of Apennine chain of mountains at the eastern edge of the National Park of Abruzzo, the Commune of Barrea found itself in the very centre of the area of maximum macroseismic intensity, calculated around the Seventh grade MCS.

Apart from its high natural and scenic value, a characteristic of this territory is the high number of medioeval centres (XI-XIII C) of modest dimensions but of considerable historic, architectural and environmental importance. Amongst these, one of the most significant is precisely Barrea, situated at 1000 metres above sea level, in a highly strategic position vis-à-vis the surrounding territory, at one time controlling the low valley routes which during the winter period led the flocks to the southern Italian pastures.

From an urban point of view the town is notable for the presence of an old nucleus, a well and truly fortified borough, consisting of a series of walled buildings crowded one against the other, arrayed mainly in lines and blocks at the summit of a rocky ridge overlooking a gorge where the waters of the Sangro river flow from the dam which has formed the lake of Barrea.

As a result of the damages provoked by the seismic shocks in May 1984 to the historic centre, accessible only through two original arched gateways and traversed by very narrow, solely pedestrian, streets, the Mayor emanated a decree on 12 May 1984 ordering total evacuation pending a technical assessment of the potential danger to both public and private safety. A commission made up of the Fire Brigade technicians subsequently ascertained and reconfirmed the total unfitness of the entire historic centre within the two above-mentioned gates, which were therefore barred.

The adoption of these drastic measures, understandably cautious in a state of emergency, later unreasonably hindered the safety checks as well as the survey of the damage and vulnerability which in the meantime were being carried out in the other neighbouring communes hit by the earthquake.

A serious delay therefore ensued in carrying out the various phases foreseen by the decrees emanated in support of the task of reparation.

More than two years after the seismic events, nothing at all had been done about the historic centre of Barrea, and the citizens who used to reside there continued to be forcibly debarred from their homes. As a result of the particularity of this situation, in September 1986 the UCCR (Ref. 1) of the Abruzzo Region, took the initiative, in agreement with the local Administration and the GNDT (Ref. 2) and proceeded to verify the true situation of the buildings in the historic centre. The extent of the damage and vulnerability were ascertained on the spot, using index cards (Ref. 3) elaborated by GNDT and already experimented and refined on several occasions following the various seismic events which had taken place in Italy during the last ten years.

The GNDT in particular welcomed the proposal, also as an opportunity of considerable interest at the applied scientific research level, in view of the possibility of being able to carry out proper experiments under real conditions.

These were particularly favourable, given the freedom of action allowed and the full availability of a historic centre still in the damaged condition caused by an earthquake.

Investigation procedures The initiative was programmed to obtain an analytical, objective and quantifiable picture as regards the degree of damage and vulnerability of the buildings complex, so as to activate operations aimed at restoring access to and the functionality of entire historic centre. The various types of intervention were objectively divided in such a way as to achieve the most equitable and rational use of the financial resources available.

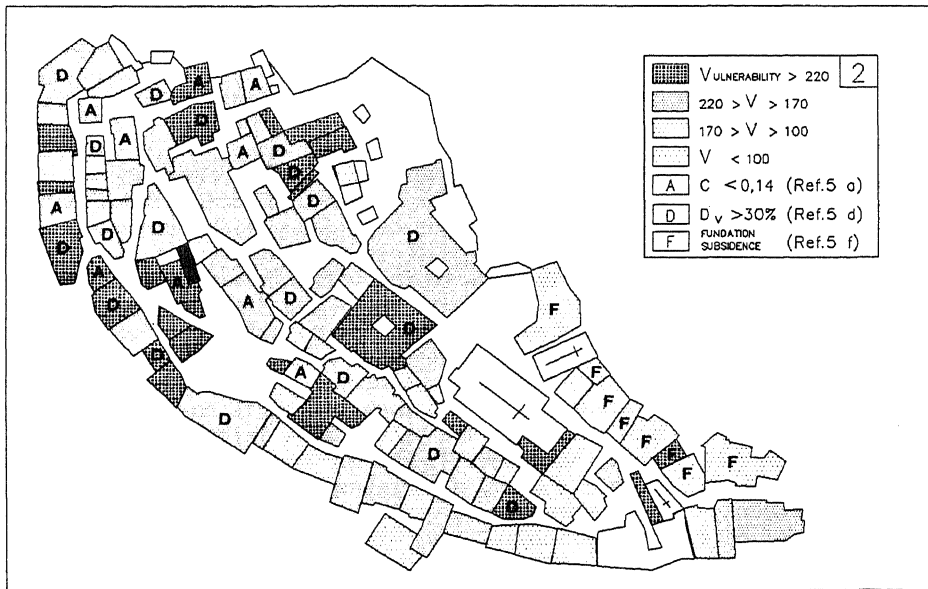
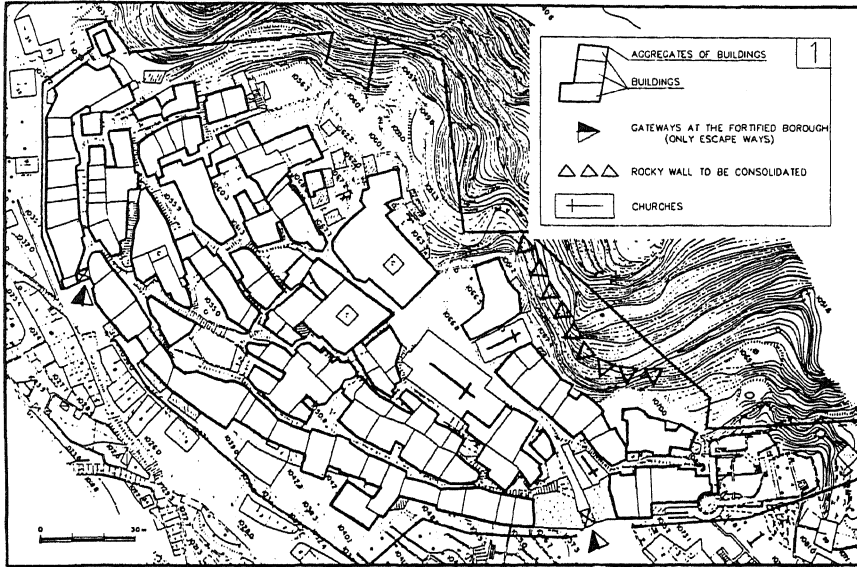
The cataloguing of the buildings was organized by the UCCR with the scientific coordination of the GNDT which, in order to carry out the survey of the position, damage and vulnerability, decided to adopt 6/86 version of the index cards, at the moment considered the most up-to-date available. The operation involved two teams of three surveyors each for a period of five weeks (Ref. 4). The different stages of the survey can be summarized as follows:

- the singling out of aggregates of buildings distinguishing one from the other in the absence of adjoining structural elements (or at the least, insignificant), so that they are generally considered blocks (Table 1);
- the singling out of the buildings which make up structural aggregates with partial discontinuity (discontinuity of elevation, adjoining supporting walls...); the building therefore represents a minimum aggregation of real estate, such to guarantee the unity of the intervention under the structural profile ("minimal structural threshold"), even if in reality some connections between adjacent buildings, within the same structural block, are always present; such an operation of subdivision, sometimes forced, is nonetheless indispensable for a correct use of the damage and vulnerability card applicable to a building but not to a complex structural aggregation (Table 1);
- survey of all the data on the card for each of the 118 buildings identified.

Results of the investigation The processing of results has permitted a detailed picture of the situation to be traced, providing all the information required to define accurate management procedures at the intervention stage. In particular it has been possible to decide the type of work to be effected to the buildings based on:

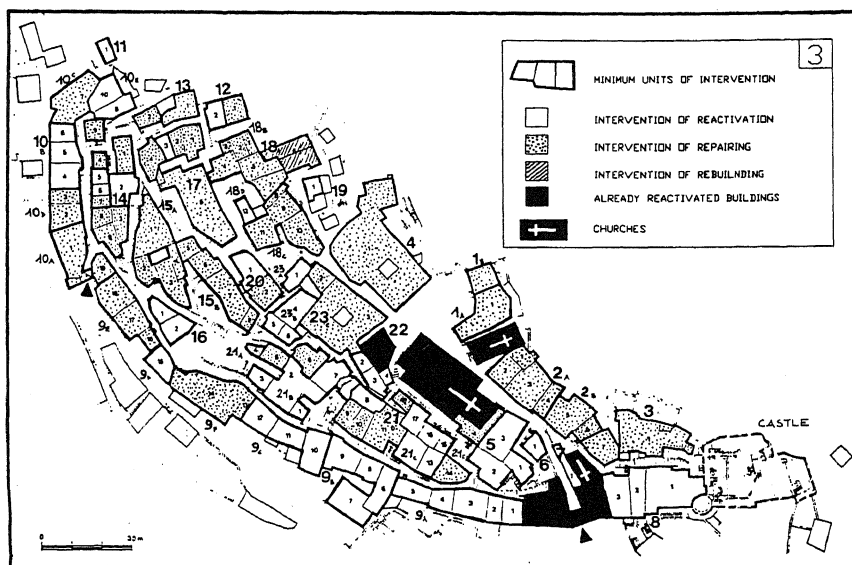
- the technical conditions laid down by the ministerial decree which determines the buildings to which it is not possible to apply the method of "reactivation", a light intervention to little damaged buildings with good basic characteristics of resistance (Ref. 5) (Table 2);
- the degree of vulnerability of the buildings through an analysis of valuation

parameters contained on the card (organization of the resistant system, quality of the resistant system, conventional resistance, position and foundations of the buildings, bearings, planimetrical conformation, elevation conformation, maximum damage to the walling, roofing, no-structural elements, actual state) (Table 2);



- the general conditions of stability of the residential area for which a specific investigation was carried out from which it emerged that "the conditions of stability of the greater part of the historic centre are excellent;...conditions of precarious stability are found only at the north-east end, in a restricted strip developed along the brow of deep gorge of the Sangro" and for which therefore specific works of consolidation will be foreseen (Ref. 6).

From a combination of all these elements, bearing in mind also the frequency of real estate units belonging to more than one building, "units of minimum intervention" and relative typologies (reactivation, reparation, rebuilding) have been determined (Table 3).

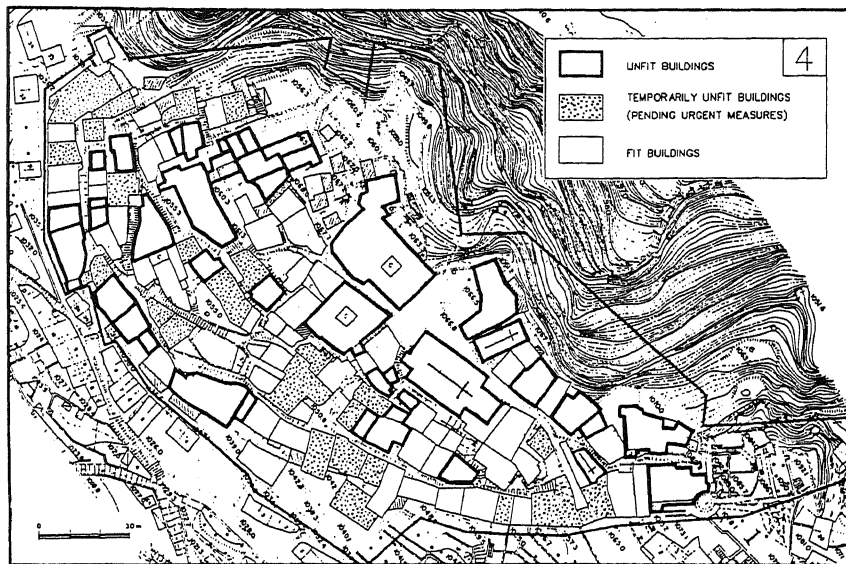


Survey of habitation safety Taking advantage of the opportunity of great scientific interest offered by the state of the historic centre of Barrea, frozen so to speak at May 1984, another survey, covering the safety of the buildings, was carried out. This was done applying for the first time a procedure recently perfected by Prof. Carlo Gavarini, who personally supervised the operation (Ref. 7).

The experiment proved to be valid in verifying the efficacy of the method which, although susceptible to improvement, constitutes an extremely important instrument for the rationalization of controls in post-earthquake emergency situations: the capacity, that is, on the part of the technicians to recognize the so-called safety of the buildings "in other man's activities, without the conditions of security obtaining before the event being substantially muted" (Ref. 7). This, in order to avoid situations of unfitness requiring the temporary relocation to thousands of persons, especially in the case of non-destructive earthquakes such as that of May 1984 in Central Italy.

In particular the "card of seismic fitness of buildings" analyses among others the following aspects: type of building and position, seismic setting, geotechnic setting, geotechnic risk, non-structural damages, risks brought on by the building, external risk. The indexing arrives at the following definitions: unfit building, temporarily unfit building (to be rechecked either for

geotechnic reasons or because of doubts on the elevation structure), temporarily unfit building (pending urgent measures), fit building. The results of the application of the indexing of the historic centre of Barrea are set out in Table 4, which refers to a seismic setting which considers the seismic crisis over.



Operative phase of the intervention At the end of all the investigations and relative data processing, including the economic aspects, a successive operative phase was coordinated by the UCCR and the GNDT with the full collaboration of the local Administration and with the cooperation of all the local planners.

These were furnished with a series of instructions for carrying out detailed surveys (geometric survey, physical survey -on materials-, mechanical survey -on damages-, housing and functional hygiene survey, photographic survey). Indications were also provided on project aspects according to the type of intervention to be carried out as previously identified (reactivation, reparation or rebuilding).

Finally, considering the noteworthy historico-environmental value of Barrea, the planners were also provided with indications of the architectonic, environmental, decorative and formal aspects of the historic centre. The work on the historic centre should not only be considered an experimental and applied research intervention. In addition to aiming at the repair of the damage caused by the 1984 earthquake and to the improvement of the structural characteristics of the buildings, it should be directed to the greater safety of the citizenry and of the physical heritage vis-a'-vis future seismic shocks. It should also include a check of the original architectonic features, reducing to a minimum possible formal damage caused by structural interventions, as well as correcting alterations, particularly those carried out in the last few years.

REFERENCES

1. UCCR: Consulting and Control Office on the Reactivation of the Abruzzo Region, set up especially by the National Department for Civil Defence.
2. GNDT: National Group for Defense from Earthquakes of National Research Council (CNR).
3. Benedetti D., Petrini V., "On the seismic vulnerability of walled buildings: an evaluation method" in L'industria Italiana delle Costruzioni, n.149, 1984.

4. Survey participants: Antonio Martinelli and Altero Leone (UCCR-Abruzzo engineers), Alessandro Atami, Lorenzo Nardis, Galliano Di Marco and Paolo Cristoforo (engineers).
5. The ministerial decree 230/FPC/ZA defines the buildings on which it is not possible to carry out reactivation interventions:
 - a) buildings whose conventional resistance to horizontal forces is $< 14\%$ of the total weight of the building ($C < 0,14$) for second class zones ($S=9$), or 20% ($C < 0,20$) for first class zones ($S=12$)...
 - b) buildings with uneven walls to a width of more than 5 cm. over the height of one floor, or anyway which affect a height of over $2/3$ of the wall itself;
 - c) buildings which have suffered partial falls of the vertical load-bearing structures affecting an area over 3% of the total area of the load-bearing walls;
 - d) buildings which in correspondence of at least one level present diagonal lesions of more than 30% of the total area of the vertical structures at the same level;
 - e) buildings with crushing lesions covering more than 30% of the walls;
 - f) buildings affected by foundation subsidence.Summarizing, "reactivation" is an intervention feasible on little damaged buildings, especially in their vertical structures, and is to all intents and purposes one of improvement at contained costs, whereas a "reparation" is effected on badly damaged buildings, also in their vertical structures, and implies a true and proper seismic adaptation.
6. C.Bosi and P.Messina (CNR), "Geologico-technical observations on the stability of the historic centre of Barrea".
7. C.Gavarini, "Safety of buildings after an earthquake: a methodological proposal" in L'Industria Italiana del Cemento, n.6, 1985.