Earthquake Engineering, Tenth World Conference © 1992 Balkema, Rotterdam. ISBN 90 5410 060 5

Seismic protection of monumental buildings in Italy

R. Ballardini & C.Gavarini
University of Venice and Rome & National Committee for the Seismic Protection of Monumental Buildings and Italian Cultural Heritage, Italy

ABSTRACT: The National Committee for the Seismic Protection of Monumental Buildings and Italian Cultural Heritage was created in 1984, by the two Ministers of Cultural and Environmental Heritage and of Civil Defence, as a scientific body on a multidisciplinary basis: seismology, architecture, seismic engineering, geotechnics, history. The Committee has produced a series of activities and documents which should be of some interest precisely due to the global approach they propose for problems having many very different aspects to deal with.

The present paper will introduce and illustrate the main topics treated by the Committe; two of them (Guidelines for seismic retrofitting of monumental buildings and Seismic vulnerability survey of monumental buildings) will be illustrated with more details in two companion papers submitted to the same Conference.

Here the attention will be focused on the General Research Program proposed by the Committee in 1988, a program which is also a definition and a classification of the relevant problems. The program considers four disciplinary research lines and an inter-disciplinary field of case studies.

INTRODUCTION

The recent seismic events in Italy, mainly the 1980 Irpinia earthquake, have produced significant damages on historical buildings, on a very large geographical basis. In some cases the level of damage has been really serious, related to deficiencies in the structural strength; but in other cases, probably the most of them, the problems arise due to the influence of decay rather than to the intensity of the earthquake. In both cases the consequent provisions for repairing have been characterized by a heavy use of "modern" techniques and materials: cement grouting, introduction of steel bars (nailing), micropiling, substitution of wood floors with reinforced concrete ones, and so on. In some cases the structural behaviour has been completely changed, as in the case of the Paestum greek temple of Ceres: from a series of isostatic cantilevers to a unique hyperstatic frame. The modern culture of Engineers, deeply involved with the tecniques of reinforced concrete and steel construction, has been unable to deal properly with problems which should concern also history and conservation; and the prescriptions of the regulations have been generally in the same direction, based as they are on the problems connected with new and modern constructions. So many mistakes have been made, and in many cases a monument, lightly damaged by an earthquake and essentially in need of restoration rather than strengthening has been turned into something totally different from the original construction.

Due to such a situation, the two Ministers of Cultural and Environmental Heritage and of Civil Defence created in 1984 the National Committee for the Seismic Protection of Monumental Buildings and Italian Cultural Heritage, as a scientific body on a multidisciplinary basis: seismology, architecture, seismic engineering, geotechnics, history. The Committee has produced activities and documents which should be of some interest precisely due to the global approach they propose for problems having many very different aspects to deal with.

The actual paper will present some topics treated by the Committee; two of them will be furtherly illustrated in two companion papers submitted to the same Conference.

THE RESEARCH PROGRAM

The 1988 Research Program proposed by the Committee considers five sectors: four Research Lines (RL) and an inter-disciplinary field of Case Studies. The RL are the following:

1) Characters and typology of existing built-up areas.
2) (Seismic) Vulnerability (of monuments).
3) Seismic behaviour (of monuments) and the relative numerical analysis.
4) Retrofitting technologies.

The scientific program has devoted $ 8 millions to 55 Research Groups formed by the Universities, and the activity is starting now. More than one half of the funds are assigned to experimental activities on materials, structural elements and retrofitting technologies.

CHARACTERS AND TYPOLOGY OF EXISTING BUILT-UP AREAS

This research line deals with problems of architectural and historical nature, problems which are very important for buildings with a cultural value.

The line is divided in 4 objectives:

1.1 Typology of buildings and morphology of urban areas

1.2 Characters of constructive typologies

1.3 Development of characterization techniques and methods

1.4 Study of the structural organization and technology.

VULNERABILITY

The scheme of this research line is built up with three objectives applied to three categories of objects.

The objects are:

a) built-up areas with an historical value (fig. 01)

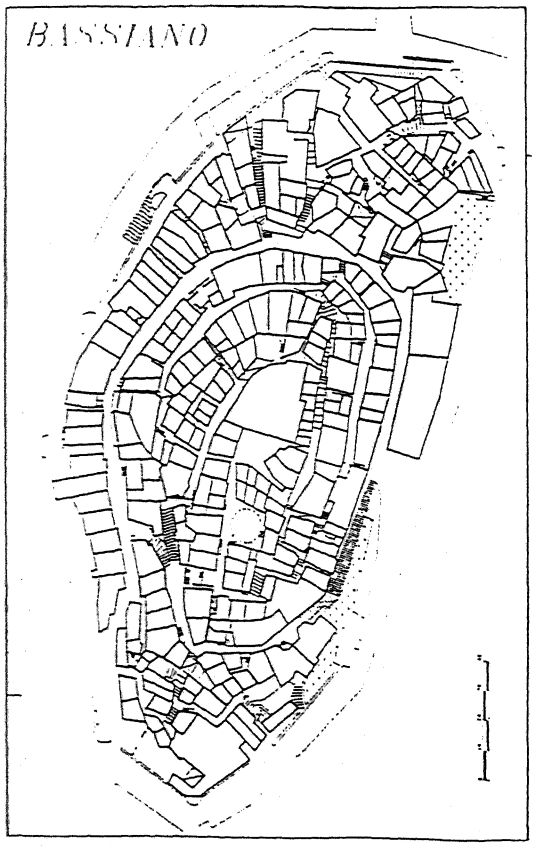

Fig. 01: The plan of a little historical village (Bassiano, near Rome)

b) single monumental buildings (fig. 02)

c) movable cultural properties, as books, paintings, statues, ...

Fig. 02: The Cathedral of Reggio Calabria before the 1908 earthquake

The objectives are:

1) Identification of the buildings or other objects in a vulnerability sense.

1.a) Built-up areas

Most of the results obtained for common buildings within the activity of another italian official body (the National Group for the Earthquake Loss Reduction) are and will be useful; here special attention must be paid to:

- specific problems in historical centers of old towns and villages;
- the opportunity of gathering more information, mainly on local seismic history and on decay;
- computer based organization of information.

1.b) Monumental buildings

The problem is specific, because of the fundamental difference in the structural nature of the monumental buildings compared to ordinary buildings; so the results obtained for the latter are only partially useful. Something has been done in the frame of the Committee, as illustrated in a companion paper in this Conference (Gavarini).

1.c) Movable properties

Nothing has been done: the problem is open.

2) Prevision of seismic damage starting from identification data.

2.a) Built-up areas

As for identification, many of the past and the future results on ordinary buildings may be useful; special attention must be devoted to:

- ordinary damages and decay and their temporal evolution
- role of decay
- vulnerability of building aggregates, very frequent in historical centers
- urban vulnerability in historical centers
- influence of local ground conditions.

Entirely new methodologies could be possibly proposed, and this could generate new problems in the evaluation of seismic risk.

2.b) Monumental buildings

It is an open problem, because of special typologies, different meaning of damage (think for example of painted walls), role of decay, imperfections in the definition of seismicity. So original methods are necessary, with a great research effort, and some complementary studies are needed, mainly:

- correlations between decay and vulnerability for old buildings
- historical studies on seismic damage that the ancient monumental buildings have suffered in the past and the correlation of the same with vulnerability.

2.c) Movable properties

Everything has to be done; among the problems a special attention should be given to the vulnerability of the containing buildings, mainly museums.

3) Mitigation of future damages.

It is necessary to give information and evaluation methods in order to give a support to the decisions concerning the protection policy through the knowledge of the consequences of the various possible strategies.

3.a) Built-up areas

The important sector of retrofitting is the main goal of the research line number 4. Here the research to be done concerns comparation studies on the effects of different strategies and technologies, including benefit-costs analyses.

3.b) Monumental buildings

Here the benefit-costs analyses which are usually performed for ordinary buildings must be completely revised: the provisions with few perturbation, distributed in time, become very important; the acceptable risk level must be discussed again; the occupancy becomes an important variable; the usual correlations between progressive damage and progressive consequences change. So new methodologies are required.

Another outstanding problem concerns the definition of "value" for the monumental buildings; it is a nearly impossible problem but it results from the necessity of making any-how decisions and of setting priorities in the frame of mitigation policy. Again there is the problem of studying the effects of different strategies.

In the whole this is a central part of the entire problem, with a very high level of specificity and with the necessity of insisting on the "philosophical" aspects of the problem.

3.c) Movable properties

Again everything has to be done. The whole problem concerning the seismic protection of movable properties will be the object of feasibility studies.

SEISMIC BEHAVIOUR AND RELATED NUMERICAL ANALYSIS

It is necessary to admit that very little is known about the seismic behaviour of monumental buildings. The main difficulty is related to the role of the non linear behaviour of materials, quite generally non resistant in tension. In fact there is much more information about reinforced concrete and steel buildings.

So the task must be undertaken nearly from the beginning, considering ordinately the following objectives:

1) Modeling of materials (costitutive laws and strength domains for single and composite materials).

2) Modeling of structural elements (walls, arches, vaults, columns, foundations).

3) Modeling of structural bodies (wall buildings, churches, buildings made of big stones, ground-structure interaction).

4) Safety evaluation.

Of course the attention will be focused on materials, elements and typologies which are of interest for monumental buildings and a straigth correlation with experimental activity is necessary. A particular regard is needed as to the influence of decay, the aspects concerning durability, the diagnostic problems, the modifications in the behaviour produced by the retrofitting techniques.

For safety evaluation of monumental buildings new formulations are necessary, with a philosophy different from the one which is implicit in the current codes for new modern constructions. The difficulty and originality of the problem suggests to form a special committee for a preliminary feasibility study.

RETROFITTING TECHNOLOGIES

This line concerns a very delicate sector: the so called "new technologies", related to modern materials, when utilized heavily and acritically, have often given rise to questionable results in terms of compatibility, reversibility and durability. The technicians usually justify such utilization by safety requirements, in particular seismic safety, with the aspect of the responsability for them which assumes a paramount role, and generally produces an automatic unproper transfer to the sector of monumental buildings of concepts, methods, criteria which were introduced for modern materials, structures, typologies without thinking of monuments. Viceversa the utilization of "traditional techno-

logies", which often could be fit for the case is hindered by at least four reasons: the plain ignorance of the existence of such techniques, the absence of qualified workers in the field, the mechanism of prices, the difficulties in obtaining numerical evaluations of the retrofitting efficiency.

In front of such a situation, radical behaviours sometimes appear, of opposite sign, which are reductive in their simplicity and are in conclusion ascientific. It is viceversa the interdisciplinary approach and research which can give order to the matter and offer serious elements for evaluations and decisions.

The first important contribution, although indirect, to the problem of seismic retrofitting of monumental buildings, results from the better knowledge of the real seismic behaviour of such constructions; such a contribution will come from the first three research lines. In fact, if the seismic behaviour of the construction were well known, in many cases the retrofitting provisions could even be quite avoided, or at least reduced, and possibly a simple provision of reduction of occupancy could be enough to meet the goal as far as safety for people is concerned.

Moreover the better knowledge on seismic behaviour should lead to justify the validity of traditional tecnologies and finally, when a new tecnology appears to be useful and efficient, a scientific demonstration should be given of the fitness of such a provision, again in terms of efficiency, compatibility, reversibility and durability.

Keeping in mind the above considerations the following objectives arise:

1) Study and rediscovery of traditional technologies.

2) Study of the possibilities to actualize traditional technologies, through rationalization, optimization, use of modern equipments, reintroduction of ancient working capacities, applications to case studies, study of methods and criteria for safety evaluation.

3) Study of the new technologies which are presently used in the field, operating on a scientific and systematic basis, in order to obtain valid results on the aspects previously mentioned, with the opportunity of looking for modifications and optimizations and possibly entirely new provisions.

4) Acceptability of the new technologies, with the final goal of obtaining a kind of code, or instruction, or recommendation, containing the requirements and criteria about the acceptability itself. Obviously this problem is very important and delicate, with considerable interdisciplinary bonds, so that a special committee should work on the matter.

CASE STUDIES

The researches proposed within the four research lines are in most of the cases mainly monodisciplinary; they are very important, but not sufficient. Another kind of research activity is essential, in which the interdisciplinary aspects are preminent together with the concreteness of the applicative global problems. So a series of case studies will be proposed both in the field of single monumental buildings and in the field of historical centers considered as a whole. Of course an active correlation with the research activity undertaken in the frame of the four research lines will be not only useful but also necessary.

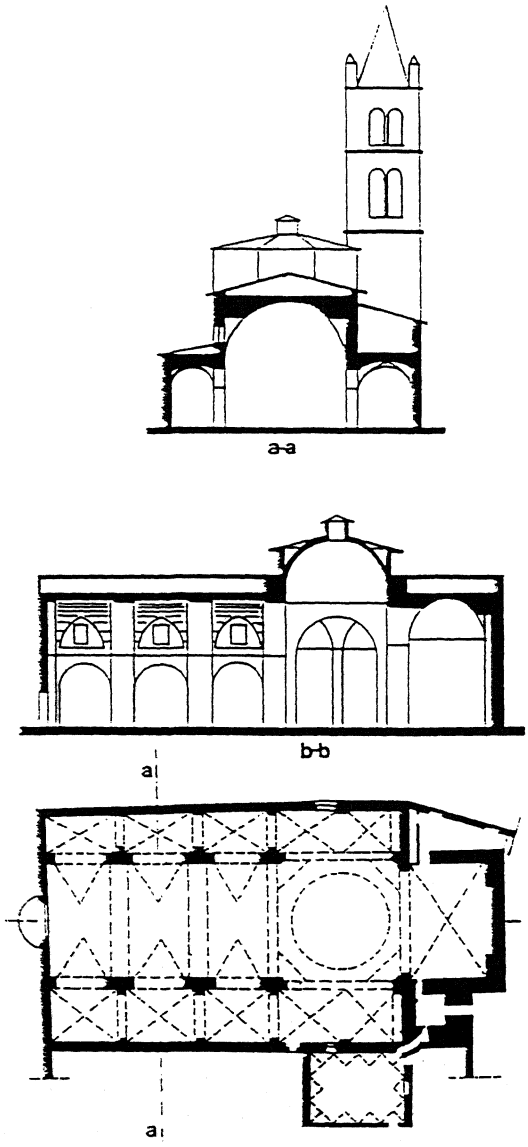

Fig. 03: In the case of monuments an accurate drawing is necessary to give the architectural and structural aspect of the construction

The case studies will consist first in an analysis of the existing situation, then in the study of solutions for the future seismic protection. Such "transversal" studies, together with the monodisciplinary researches carried on within the four RL, should furnish valuable results in terms of methodologies, criteria and guidelines.

GUIDELINES FOR SEISMIC PROTECTION

Within some years the above described researches should give useful information and guidelines, but meanwhile something had to be done to avoid further artistical destructions performed in the name of claimed seismic safety. So the National Committee decided to issue a text of "Recommendations concerning the provisions on monumental buildings in seismic zones" (1986); this text, which was based on the concepts illustrated above, was followed in 1989 by a more effective document indicated as "Guidelines"; both documents follow strictly the cultural lines indicated by the well known international document "Recommendations Skopye", adopted as a conclusion of the "1st International Seminar on modern principles in conservation and restoration of urban and rural cultural heritage ir. seismic-prone regions", Skopje, Yugoslavia, october 1988; they have been adopted by the Ministry of Cultural and Environmental Heritage. This important question is discussed in a companion paper in this Conference (Corsanego, D'Agostino).

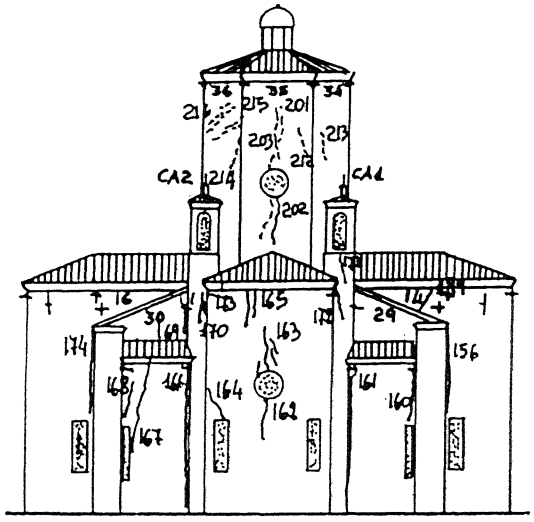

Fig. 04: The patterns of cracks are of paramount importance for monumental buildings, so that they must be imported in the Data Bases

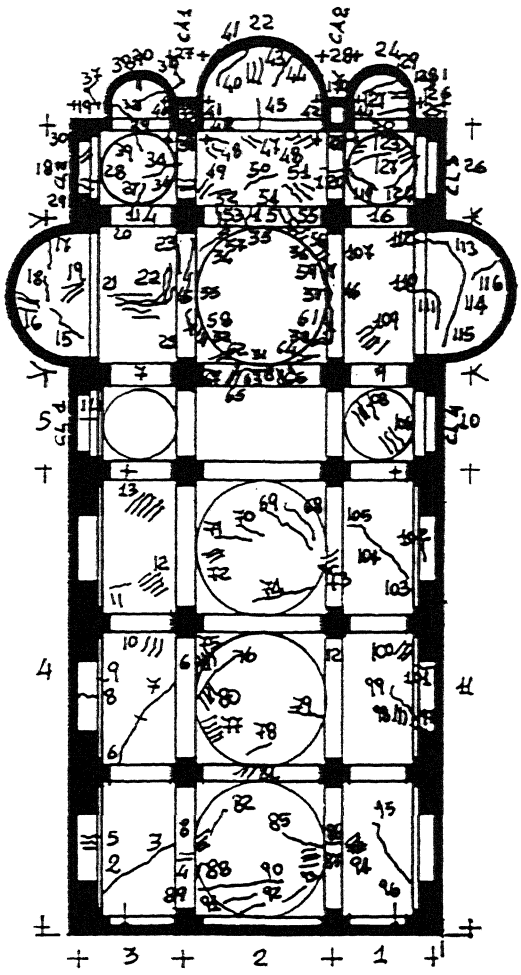

Fig. 05

SEISMIC SURVEY OF MONUMENTAL BUILDINGS

The last topic treated by the Committee which should be of interest for the WCEE is connected with the problem of collecting and treating data related to seismic hazard and vulnerability of monuments, in order to create a National Data Bank and a general System for monitoring and reduction of risk. Again in this field the required specificity for the approach is evident (fig. 03, 04 and 05), and a companion paper in this Conference (Gavarini) is concerned with the argument.

CONCLUSIONS

Our country is full of ancient monumental buildings and historical centers made up of many

little buildings, maybe not valuable as single units but of great cultural value and interest taken as a whole; most of such constructions are under seismic risk and our modern views, together with the evidence offered by recent earthquakes, say that something must be done in order to prevent further decay and damage from future earthquakes. An effort is presently being made in order to individuate the correct way to provide the seismic protection efficiently but without destroying the artistic value of such constructions. The problem is difficult, partly for economical reasons (because the amount of required money is very large) and partly in itself, because our present technical culture is too much affected by the attention to problems pertaining to new constructions and new materials: we must start again studying existing materials and constructions, discover again old typologies and techniques; in a word we must establish a new field of engineering: the Engineering of Existing Constructions!