

**GRUPPO NAZIONALE PER LA DIFESA DAI TERREMOTI
FRAMEWORK PROGRAM 2000-2002**

COORDINATED PROJECT PROPOSAL

TOPIC 1

Seismic Risk Assessment of the Residential Real Estate at National Scale

SAVE

**Updated Tools for the Seismic Vulnerability Evaluation
of the Italian Real Estate and of Urban Systems**

RESPONSIBLE OF THE PROJECT: Mauro Dolce

SCIENTIFIC COORDINATORS OF THE PROJECT: Mauro Dolce, Giulio Zuccaro

Research Units: Università della Basilicata - DiSGG -Potenza -UNIBAS
Università di Napoli - LUPT (Eureka, ISIG) – Napoli - LUPT
Università di Genova – DISEG – Genova - UNIGE
Gruppo Nazionale Difesa dai Terremoti - L'Aquila – GNDT-AQ

Consulting: Prof. Robin Spence (Cambridge University)

BACKGROUND

The study of the seismic vulnerability of constructions is fundamental for any seismic risk approach. The Italian scientific community started to work on this subject in the early eighties, just after the 1980 Southern Italy Earthquake. The availability of data on the structural characteristics and suffered damage of about 38000 buildings in 41 municipalities subjected to the earthquake, collected in an extensive and complete survey supervised by GNDT, created the first opportunity to set up a statistical vulnerability approach leading to Damage Probability Matrices (DPM's) [Braga et al. 1982, 1983]. The availability of the first operational tools favoured the development of the first risk analysis models, which integrated vulnerability, hazard and exposure [Zuccaro et al., 1986, Baratta et al., 1986]. Then the studies on the seismic vulnerability of ordinary buildings became a central theme of the GNDT research all over the eighties and during the first half of the nineties. Several methods were devised, that differ not only for the detail level of information required, and then of the statistical scatter of the results, but also for the kind of approach (statistical, mechanichal-numerical, Hybrid, etc.), as well as for the type of vulnerability measure (DPM's, Fragility Curves – FC, Conventional Vulnerability indices, Historical Damage Index – HDI, etc.) [see for example Baratta 1979, 1985, Benedetti-Petrini 1984, Braga et al. 1986, 1987, Bernardini-Modena, 1987, Zuccaro, 1989, Giuffrè-Carocci, 1996]. Several classifications of vulnerability methods for ordinary buildings were proposed to summarise the work made in this lively scientific scenario [Braga et al.1987, Angeletti et al. 1988, Corsanego-Petrini 1990, Dolce et al.1994, Dolce 1996]. Other works tried to combine several aspects of the same problem by using multicriterion analyses [Zuccaro, 1996, 1997]. At the same time the vulnerability methods were more and more applied to practical problems of seismic risk evaluation [GNDT 1993, Baratta-Zuccaro 1989, 1995a, 1996, 2000, Colonna et al. 1994, Meroni et al. 2000, Bernardini ed. 2000]. In this reference framework the contribution of the National Seismic Survey (Servizio Sismico Nazionale – SSN) was fundamental, especially in the second half of the nineties, and it is now, especially to finalise to vulnerability studies to the seismic risk analyses of the entire Italian residential building stock [Bramerini et al. 1995, Zuccaro et al. 1999, Lucantoni et al. 2001], or of urban centres of considerable importance [Zuccaro et al. 1995b, Dolce et al. 1996], and to develop new methods suitable for the available data.

The need to extend vulnerability studies to objects other than ordinary buildings was mainly acknowledged in the nineties. Monumental buildings [Gavarini 1991], especially churches [Doglioni et al. 1994], industrial buildings [Alessi et al. 1993], bridges [Braga et al. 1987], as well as lifelines [Corsanego-Del Grosso 1987, Ciampoli et al. 1992], became the subject of vulnerability studies. The proposed solutions, however, have not yet been finalised to risk analyses of large territorial portions with approaches useful for large scale analyses.

In the meanwhile, mainly in the areas struck by the low-medium intensity earthquakes occurred in Italy from 1980 to the early nineties, a great amount of data was collected, mainly by the researchers working for GNDT. The usability of the relevant data bases was, however, strongly conditioned upon their physical dispersion and by the different criteria used to collect the information and store them in the database. GNDT promoted the collection, rationalisation and organisation in a unique database of all the data available already computerised, in order to homogenise them and make them available to the interested researchers. The complete vulnerability database was released in 1994. It is, probably, the most important vulnerability database in the world, as far as amount and quality of data are concerned [Zuccaro 1994]. The same research unit transferred, on behalf of GNDT, the database developed in DOS environment to the mainframe of SSN, in UNIX environment [Zuccaro 1995b].

In the second half of the nineties, several Socially Useful Work projects (Lavori Socialmente Utili – LSU) were started and completed. They were promoted by the Department of Civil Defence and supported by the Ministry of Work, Co-ordinated and supervised by GNDT and produced large data bases on the vulnerability of public and private buildings, of monuments in national and regional parks and of lifelines in small centres. The availability of these databases, up to now subjected to preliminary elaborations only [Cherubini et al. 1999a, 1999b, 2001, Di Pasquale 2000], put the basis for further and important developments and finalisation of the investigations and the vulnerability methods.

The development of the activities in the area of vulnerability, as above sketched, had GNDT, since 1980 up to 1998, and SSN, since the half of nineties up to now, as main actors. In the GNDT organisation there always was a Research Line that was, implicitly or explicitly, relevant to the seismic vulnerability of buildings. It funded and co-ordinated the activities on such topic up to the Executive Project of 1997. In the Executive Project of 1998 several Research Projects included important activities relevant to vulnerability (PR. 5 Evaluation of the national seismic risk, Pr. 6 Interventions after the Umbria-Marche earthquake, Pr.7 Tools and strategies for the seismic risk reduction, Pr. 9 Vulnerability of monuments - LSU). It is mainly in the activities of the PE 98 that intense collaborations between SSN and GNDT, even through the formation of informal working groups which produced important scientific results. In the subsequent triennial program the GNDT researches on vulnerability could have been satisfactorily continued by the project MARS – second generation Seismic Risk MAs. This project included the most active researchers of GNDT and SSN on hazard, vulnerability and exposure to produce a complete analysis of the National seismic risk. It would have lead to risk maps of residential and public buildings on the entire national territory or on a large part of it. The project was

organised in seven tasks. Two of them (tasks 4 and 5) were totally devoted to the vulnerability of private residential buildings and public buildings respectively.

The project was not funded and this fact produced the sudden stop of the research activities on vulnerability at national scale within GNDT. Nevertheless, the good judgement given by the referees kept the possibility of proposing a modified version of this project open. In the modifications, the topics related to seismic vulnerability had to be privileged.

In the meanwhile, to compensate the total stop of the studies on vulnerability at national level, waiting for the time when the modified project could be proposed again, SSN has constituted a Technical-Scientific Commission, of one year duration. It is mainly devoted to the compilation of an updated atlas of the inventory of the private and public building stocks and to the setting up of new vulnerability functions. GNDT researchers and university professors, formerly responsible of GNDT research units, are members of such commission. In the meanwhile SSN goes on with its specific studies on vulnerability of urban systems, monuments, specific building types, even with contracts.

The present project GNDT-SAVE is proposed as a modified version of the Project MARS. It focuses the attention mainly on the vulnerability aspects. The problems of the private and public building stocks is dealt with in SAVE, as well as in MARS, to make evaluations at national scale and to draw the relevant maps, by utilising the existing data bases (specifically ISTAT census and LSU). Moreover the field of study is extended to monumental buildings, particularly churches, to the lifelines and urban systems, with the aim of investigating deeply the relevant problems and define fully operational methods which can be applied to existing databases. To complete the project and fully attain the objectives of subthemes 1.7 and 1.8, also the aspects relevant to the exposure of human lives and economical activities are dealt with, in order to make, based on the most updated hazard studies, risk maps of the national territory.

The researchers and the research units of GNDT mostly engaged on these themes in the last years will contribute to the activities of this project. To get the best possible results and the maximum consensus on them, it is necessary that the activities are co-ordinated and strongly integrates with the SSN activities in progress and put in continuity with the activities developed by the Technical-Scientific Commission of SSN, whose works will end at June 2002. This aspect has been taken into account when formulating the new project, paying particular attention in avoiding duplications of activities which make use of consolidated methods. In case of approval of SAVE, all the procedures necessary to formalise and regulate the co-ordination and collaborations between GNDT and SSN will be set up.

References

- Alessi, R., P.P. Diotallevi, S. Simonazzi, "Rilevamento e vulnerabilità sismica di strutture a tipologia particolare: fabbricati industriali", *Atti del 6° Convegno L'ingegneria Sismica in Italia*. Perugia 1993.
- Angeletti, P., A. Bellina, E. Guaganti, A. Moretti, V. Petrini, "Comparison between Vulnerability Assessment and Damage Index, Some Results", *Proceed. 9th World Conference on Earthquake Engineering*, Tokyo-Kyoto, 1988.
- Baratta, A.: An Ultimate Approach to Cumulative Seismic Damage, *Meccanica*, Vol.14, No. 2, June, 1979.
- Baratta, A.: "The Role of Historical Data in Assessing Seismic Safety of Old Buildings: The Likelihood Approach", *ICOMOS Information*, n.2. 1985
- Baratta A. 'Seismic risk to structures in Campania', Verso il New Planning" 1st International Convention on Methods and Tools for Planning, University of Naples, Faculty of Architecture, Napoli, 1986.
- Baratta, A., G. Zuccaro, "Vulnerabilità di base e rischio sismico del centro storico di Napoli", ", *Atti del 4° Convegno L'ingegneria Sismica in Italia*. Milano 1989.
- Baratta, A., G. Zuccaro, "Valutazione preliminare di rischio sismico per gli insediamenti urbani (il centro storico di Napoli)", ", *Atti del 7° Convegno L'ingegneria Sismica in Italia*. Siena 1995a.
- Benedetti, D., V. Petrini, "Sulla vulnerabilità sismica degli edifici in muratura: un metodo di valutazione", *L'Industria delle Costruzioni*,n. 149, Roma, 1984.
- Bernardini A., C. Modena, "Un modello per le analisi di vulnerabilità sismica di gruppi di edifici in muratura", *Atti del 3° Convegno L'ingegneria Sismica in Italia*. Roma 1987.
- Bernardini A.ed. " Valutazione a scala nazionale della Vulnerabilità degli Edifici ordinari", CNR-GNDT 2000.
- Braga, F., M. Dolce, C. Fabrizi, D. Liberatore, "Evaluation of a Conventionally Defined Vulnerability of Buildings Based on Surveyed Damage Data", *Proceed. 10th European Conference on Earthquake Engineering*, Lisbon 1986.
- Braga, F., M. Dolce, D. Liberatore, "Southern Italy November 23, 1980 Earthquake: A Statistical Study on Damaged Buildings and an Ensuing Review of the M.S.K.-76 Scale", *pubblicazione CNR-PFG n.503*, Rome. 1982.
- Braga, F., M. Dolce, D. Liberatore, "Influence of Different Assumptions on the Maximum Likelihood Estimation of the Macroseismic Intensities", *Proceed. 4th International Conference on Applications of Statistics and Probability in Soil and Structural Engineering*, Firenze, 1983.
- Braga, F., M. Dolce, G. Lepidi, "Un sistema esperto per la valutazione del rischio sismico dei ponti Atti del 3o Congresso Ingegneria Sismica in Italia, Roma, 1987.

- Braga, F., M. Dolce, D. Liberatore, "Statistical Calibration of Second Level Seismic Vulnerability of Buildings", *Atti della 5th ICOSSAR*, Vancouver, 1987.
- Braga, F., M. Dolce, D. Liberatore, Rassegna critica dei metodi di valutazione della vulnerabilità. Atti del 30 Congresso Ingegneria Sismica in Italia, Roma, 1987.
- Bramerini, F., G. Di Pasquale, G. Orsini, A. Pugliese, R. Romeo, F. Sabetta, "Rischio sismico del territorio italiano", *Atti del 7° Convegno L'ingegneria Sismica in Italia*. Siena 1995
- Cherubini, G. Di Pasquale, M. Dolce, A. Martinelli, Vulnerability assessment from quick survey data in the historic centre of Catania. THE CATANIA PROJECT , Pubblicazione GNDT, Dicembre 1999, Roma.
- Cherubini, L. Corazza, G. Di Pasquale, M. Dolce, A. Martinelli, V. Petrini, Censimento di vulnerabilità degli edifici pubblici, strategici e speciali nelle regioni Abruzzo, Basilicata, Calabria, Campania, Molise, Puglia e Sicilia – Cap. 4: Risultati del Progetto. Dipartimento della Protezione Civile, 1999, Roma.
- Cherubini, G. Di Pasquale, M. Dolce, A. Martinelli, Censimento relativo alle emergenze a carattere monumentale e ambientale nei Comuni ricadenti in tutto e in parte all'interno di Parchi naturali nazionali e regionali – Cap. 3.4 (pagg. 337-365): Elaborazioni di Rischio Sismico. Dipartimento della Protezione Civile, 2001, Roma.
- Ciampoli, M., R. Giannini, T. Pagnoni, "Seismic Reliability Assessment of Power Transmission Networks by Simulation Technique", *Proceed. 10th World Conference on Earthquake Engineering*, Madrid, 1992.
- Colonna, E., C. Molina, V. Petrini, "Criteri di valutazione della vulnerabilità sismica del patrimonio edilizio esistente sul territorio nazionale", *Ingegneria Sismica*, Vol. 1, 1994.
- Corsanego A., A. Del Grosso, "Vulnerabilità sismica dei sistemi territoriali: approccio per un sistema esperto", *Atti del 3° Convegno L'ingegneria Sismica in Italia*. Roma 1987.
- Corsanego A., V. Petrini, Seismic Vulnerability of Buildings - Work in Progress. *Proc. SEISMED 3*. Trieste, 1990.
- Di Pasquale, G., M. Dolce, A. Martinelli, Censimento di vulnerabilità a campione dell'edilizia corrente dei Centri abitati nelle regioni Abruzzo, Basilicata, Calabria, Campania, Molise, Puglia e Sicilia – Cap. 2.2 (pagg. 76-106): Analisi della Vulnerabilità. Dipartimento della Protezione Civile, 2000, Roma.
- Doglioni, F., A. Moretti, V. Petrini, Ed., "Le chiese e il terremoto", Edizioni Lint. Trieste, 1994.
- Dolce, M., A. Kappos, G. Zuccaro, A.W. Coburn, "State of the Art Report of W.G. 3 - Seismic Risk and Vulnerability", *Proceed. 10th European Conference on Earthquake Engineering*, Wien 1994.
- Dolce, M. *Vulnerability Evaluation and Damage Scenarios*, Atti del US-Italian Workshop on "Seismic Evaluation and Retrofit", Dicembre 1996, New York City.
- Dolce, M., F.Sabetta, R.Colozza, "Seismic Risk Assessment in the Historical Centre of Rome", *Proceed. 11th World Conference on Earthquake Engineering*, Acapulco 1996.
- Gavarini, C. "CA.RI.S.MA.: Un approccio sistematico alla catalogazione, al rilevamento, alla sorveglianza e alla manutenzione programmata dei monumenti, impostazione generale e prime ipotesi di sviluppo" *Atti del 5° Convegno L'ingegneria Sismica in Italia*. Milano 1991
- GNDT, "Rischio sismico di edifici pubblici", 1993.
- Giuffrè, A., C. Carocci, "Vulnerability and Mitigation in Historical Centres in Seismic Areas", *Proceed. 11th World Conference on Earthquake Engineering*, Acapulco 1996.
- Lucantoni, A., V. Bosi, F.Bramerini, R. De Marco, T. Lo Presti, G. Nato, F. Sabetta "Il Rischio sismico in Italia", *Ingegneria Sismica XVIII*, N. 1, 2001
- Meroni, F., V. Petrini, G. Zonno,. Distribuzione nazionale della vulnerabilità media comunale, in "Valutazione a scala nazionale della Vulnerabilità degli Edifici ordinari", Bernardini A. ed. CNR-GNDT, Roma, 2000.
- Zuccaro G., Coburn A.W., Spence R. "Seismic Risk to Population in Campania - The Preparation of SISMA, a Seismic Impact Simulation Model for Regional Planning - Progress Report April - The Martin Centre Press 1986.
- Zuccaro G. ed. "Una Banca Dati di Vulnerabilità" Rapporto Finale Progetto di Ricerca GNDT , Roma, 1994.
- Zuccaro G., ed. "Valutazione del Rischio Sismico nei Centri Storici, il Caso di Benevento" Rapporto Tecnico Servizio Sismico Nazionale n° RT/95/8, Novembre 1995b.
- Zuccaro G., ed. "The TOSQA Project - Earthquake Protection for Historic Town Centres", Rapporto Finale dell'attività di ricerca del: "Dip. di Scienza delle Costruzioni" nell'ambito del progetto TOSQA finanziato dal programma "Environment", Contratto n° EV5V - CT93-0305 Napoli, Aprile 1996
- Zuccaro G. - "Metodi di Analisi di Vulnerabilità e Matrici di Probabilità del Danno" -*Proc. Of "La Meccanica delle Murature tra Teoria e Progetto"*, Messina, 1996.
- Zuccaro, G., Papa, F. "Multi-criteria analysis in vulnerability assessment". Proc. EGQUAKE 2 - Second Egyptian Conference on Earthquake Engineering. Aswan - Egypt, November 1-3, 1997
- Zuccaro G. ed. "Vulnerabilità di base del patrimonio edilizio nazionale" Rapporto Finale della convenzione con il Servizio Sismico Nazionale, rep. n.013, febbraio 1999.
- Zuccaro, G., Papa F., Baratta A.. Aggiornamento delle mappe a scala nazionale di vulnerabilità sismica delle strutture edilizie, in "Valutazione a scala nazionale della Vulnerabilità degli Edifici ordinari", Bernardini A. ed. CNR-GNDT, Roma, 2000.

GRUPPO NAZIONALE PER LA DIFESA DAI TERREMOTI
PROGRAMMA QUADRO 2000-2002
PROPOSTA DI PROGETTO COORDINATO

1. RESEARCH AREA

Seismic Risk Evaluation of the Residential Building Structures at National Scale (Topic 1)

2. PROJECT TITLE

SAVE - Updated Tools for the Seismic Vulnerability Evaluation of the Italian Real Estate and of Urban Systems

3. PROJECT DURATION

Two years

4. GENERAL INFORMATION ABOUT THE PROPONENT

4.1 SCIENTIFIC COORDINATORS OF THE PROJECT:

Mauro Dolce (Responsible of the project)

Position: Professor of *Earthquake Engineering*

Affiliation: Università della Basilicata - DiSGG.

Address: Campus Macchia Romana, 85100 – Potenza, Italia

Telephone: 0971 205 107 / 106 / 052

Fax: 0971 205 070

E-mail: dolcerom@libero.it, dolce@unibas.it

Giulio Zuccaro

Position: Associate Professor

Affiliation: Centro Interdipartimentale di Ricerca LUPT “Federico II”.

Address: Via Toledo, 402, Napoli - 80134

Telephone: 081 5519437 – 081 5521011

Fax: 081 5513495

E-mail zuccaro@unina.it

4.2 CURRICULUM VITAE OF THE COORDINATORS

Professor Mauro Dolce was born in Rome, Italy, 19.7.1953 and took his degree in Civil Engineering, summa cum laude, at the University of Rome “La Sapienza”, in 1978.

He is currently Professor of Earthquake Engineering at the Faculty of Engineering of the University of Basilicata, since 1.11.1994. He has been also Head of the Department of Structures, Soil Mechanics and Applied Geology since January 1995, Head of the Laboratory of Structures since November 1999 and Deputy Dean of the faculty of Engineering since January 1999.

His research activity is mainly related to Earthquake and Structural Engineering problems, resulting in about 200 papers on national and international reviews and conference proceedings as well as in 6 patents, 3 scientific videos and 2 CD-ROM's.

His papers mainly deal with the seismic behaviour and vulnerability of masonry and R/C buildings, of bridges, the use of advanced materials (high dissipation rubber, shape memory alloys, stainless steel) and techniques (passive control) for the seismic protection of bridges and buildings. Particular attention has been paid to seismic retrofitting techniques. Four of the six patents are relevant to devices for passive control based on the hysteretic properties of steel and on the superelastic properties of shape memory alloys, while the other two are relevant to devices and systems for the strengthening of masonry structures.

Professor Dolce is or was also:

- Permanent consultant of the Italian National Seismic Survey (Servizio Sismico Nazionale) since 1991, member of the Scientific Committee of GNDT, of the Steering Committees of ANIDIS (Italian National Association of Earthquake Engineering) and of GLIS (Working Group for Seismic Isolation), since 1995.
- Member of several international (CEN, ISO) and national boards for seismic regulations, specifically regarding passive control of vibrations.
- Coordinator of Task Group 3 ("Seismic Risk and Earthquake Scenarios"), formerly Working Group 3, of the European Association on Earthquake Engineering, since 1990, and of ENSeRVES (European Network for Seismic

Risk, Vulnerability and Earthquake Scenarios), funded by the European Commission within the INCO-Copernicus program.

- National Co-ordinator of the COFIN'99 MURST Project "Shape Memory Alloys for vibration damping of large structures",
- Scientific Co-ordinator of the Project TREMA (Valore 1 250 000 Euro) of MURST (2002-04)
- Responsible of research units of research projects funded by D.G.XII of the E.C. (MANSID, ENESE, ECOEST II, ECOLEADER)
- Responsible GNDT Research Units from 1989 to 1997.
- President of the Organising Committe of the 10th National Conference on Earthquake Engineering ANIDIS
- Responsible of several research contracts up to 500 000 Euro.
- Referee of important scientific national and international and member of scientific committees of several national and international congresses

Giulio Zuccaro was born in Naples in 1955. He has fully qualified in Architecture cum laude at University of Naples, Italy, in 1980.

Since twenty years he is involved in the field of Seismic Risk, especially in building vulnerability analyses at urban, regional and national scale and in the innovative technologies aimed to seismic risk reduction.

He has been teaching Structures at the Faculty of Architecture of University of Naples "Federico II" since 1985, and now he is Associated Professor at the same Faculty holding the courses of Science of Construction and Structure Theory; moreover since 1985 he co-ordinates the research section of *Seismic Analyses and Planning* at the Interdepartmental Centre of Research - LUPT of the University of Naples "Federico II".

He has been the scientific responsible in several projects on seismic Risk Assessment and structural behaviour with many Italian and International Institutions, among them: the "Italian National Seismic Survey", the "Vesuvian Observatory", the GNDT, the Martin Centre of the University of Cambridge (UK), the XII Commission of the European Community, the European Bank of Reconstruction and Development.

In '92 he has been "Visiting Professor" at the Stochastic Mechanic Centre -Florida Atlantic University (USA). He is member of the Task Group 3 on "Seismic Risk and Earthquake Scenarios" of the European Association of Earthquake Engineering. He is consultant of the European Bank of Reconstruction and Development on Civil Protection issues.

His research activity began in 1982 in the field of masonry mechanics. In 1985 his involvement in the LUPT Centre make him approach to the Seismic Engineering issues. Particularly he has laced a fruitful collaboration with the Martin Centre of the Cambridge University (UK), carrying out a large number of researches in the field of Structural Vulnerability and Seismic Risk. This circumstance induced him to amplify his interest horizon with particular attention to Modelling and Simulation of seismic input, Structures Theory, Stochastic Dynamic and Structural Control.

He is the author of more than 70 scientific papers, reports and books showing his continuous research activity in the field of structural engineering, seismic risk modelling and evaluation, innovative seismic risk reduction techniques.

Prof. Giulio Zuccaro, moreover has been:

- the scientific co-ordinator in the project for upgrading the actual vulnerability maps at national scale within the GNDT project 1998-2000;
- the co-ordinator of the Unit of Research of the Federico II University involved in the project "Human Casualties and Structural Vulnerability in the Vesuvian Area" supported by the EU February of the 2000;
- the co-ordinator of a Research Unit in the Project on the evaluation of the seismic vulnerability of the vesuvian villages supported by the Civil Protection and co-ordinated by the Vesuvian Observatory, June 2001;
- the co-ordinator of the Research Unit of Naples University "Federico II" involved in the project "Pyroclastic effect on the structures of possible eruptions in the Campi Flegrei, funded by GNV for 2000 - 2002.

Most relevant publications pertaining to the project

F. Braga, M. Dolce, D. Liberatore, Southern Italy November 23, 1980 Earthquake: A Statistical Study on Damaged Buildings and an Ensuing Review of the M.S.K.-76 Scale. Presentato alla 7th EUROPEAN CONFERENCE ON EARTHQUAKE ENGINEERING, Settembre 1982, Atene; pubblicazione CNR-PFG n.503, 1982, Roma.

F. Braga, M. Dolce, D. Liberatore, Influence of Different Assumptions on the Maximum Likelihood Estimation of the Macroseismic Intensities. Atti della 4th INTERNATIONAL CONFERENCE ON APPLICATIONS OF STATISTICS AND PROBABILITY IN SOIL AND STRUCTURAL ENGINEERING, Giugno 1983, Firenze.

M. Dolce, Evaluating Damage Probability Matrices from Survey Data. Atti del JOINT USA/ITALY WORKSHOP ON REPAIR AND RETROFIT OF EXISTING BUILDINGS, Maggio 1984, Roma.

F.Braga, M.Dolce, C. Fabrizi, D.Liberatore, Evaluation of a Conventionally Defined Vulnerability of Buildings Based on Surveyed Damage Data. Atti della 8th EUROPEAN CONFERENCE ON EARTHQUAKE ENGINEERING, Settembre 1986, Lisbona.

- F.Braga, M.Dolce, D.Liberatore, Assessment of the Relationship between Macroseismic Intensity, Type of Building and Damage, Based on the Recent Italy Earthquake Data. Atti della 8th EUROPEAN CONFERENCE ON EARTHQUAKE ENGINEERING, Settembre 1986, Lisbona.
- F.Braga, M.Dolce, D.Liberatore, Statistical Calibration of Second Level Seismic Vulnerability of Buildings. Atti della 5th INTERNATIONAL CONFERENCE ON APPLICATIONS OF STATISTICS AND PROBABILITY IN SOIL AND STRUCTURAL ENGINEERING, Maggio 1987, Vancouver.
- F.Braga, M.Dolce, D.Liberatore, Seismic Vulnerability and Damage Indices by Canonical Correlation Analysis. Atti della 5th INTERNATIONAL CONFERENCE ON APPLICATIONS OF STATISTICS AND PROBABILITY IN SOIL AND STRUCTURAL ENGINEERING, Maggio 1987, Vancouver.
- F. Braga, M. Dolce, D. Liberatore, Rassegna critica dei metodi di valutazione della vulnerabilità. Atti del 3o CONGRESSO INGEGNERIA SISMICA IN ITALIA, Settembre 1987, Roma.
- H.Sandi, M.Dolce, A.W.Coburn, B.Goschy, Working Group 3 : Vulnerability and Risk Analysis. Report to the 9th European Conference on Earthquake Engineering. Atti della 9th EUROPEAN CONFERENCE ON EARTHQUAKE ENGINEERING, Settembre 1990, Mosca.
- M.Dolce, F.Sabetta, R.Colozza, Seismic Risk Assessment in the Historical Centre of Rome. Atti della 11th World conference on earthquake engineering, Giugno 1996, Acapulco.
- M. Dolce, Vulnerability Evaluation and Damage Scenarios. Atti del US-Italian Workshop on SEISMIC EVALUATION AND RETROFIT, Dicembre 1996, New York City.
- M. Dolce, C. Lucia, A. Masi, M. Vona, Analisi delle tipologie strutturali della Basilicata ai fini di una valutazione di vulnerabilità. Atti dell'8^o CONGRESSO INGEGNERIA SISMICA IN ITALIA, Settembre 1997, Taormina.
- M. Dolce, V. Schenk, EAEE – ESC Task Group 3 – Seismic Risk and Earthquake Scenarios Report of the Activities. Atti della 10th EUROPEAN CONFERENCE ON EARTHQUAKE ENGINEERING, Settembre 1998, Parigi
- M. Dolce, C. Lucia, A. Masi, M. Vona, Analisi della vulnerabilità degli edifici in muratura del Comune di Tolve (PZ). Atti del 9^o CONGRESSO INGEGNERIA SISMICA IN ITALIA, Settembre 1999, Torino.
- A. Cherubini, G. Di Pasquale, M. Dolce, A. Martinelli, Vulnerability assessment from quick survey data in the historic centre of Catania. THE CATANIA PROJECT , Pubblicazione GNDT, Dicembre 1999, Roma.
- A.Cherubini, L. Corazza, G. Di Pasquale, M. Dolce, A. Martinelli, V. Petrini, Censimento di vulnerabilità degli edifici pubblici, strategici e speciali nelle regioni Abruzzo, Basilicata, Calabria, Campania, Molise, Puglia e Sicilia – Cap. 4: Risultati del Progetto. Dipartimento della Protezione Civile, 1999, Roma.
- A.Cherubini, G. Di Pasquale, M. Dolce, A. Martinelli, Vulnerability assessment from quick survey data in the historic centre of Catania. THE CATANIA PROJECT , Pubblicazione GNDT, Dicembre 1999, Roma.
- A.Cherubini, L. Corazza, G. Di Pasquale, M. Dolce, A. Martinelli, V. Petrini, Censimento di vulnerabilità degli edifici pubblici, strategici e speciali nelle regioni Abruzzo, Basilicata, Calabria, Campania, Molise, Puglia e Sicilia – Cap. 4: Risultati del Progetto. Dipartimento della Protezione Civile, 1999, Roma.
- M. Dolce, D. Liberatore, D. Palermo, G. Spera, Vulnerabilità sismica di alcune tipologie strutturali di centri storici pugliesi, Atti del DiSGG n. 5/2000.
- A. Masi, A. Goretti, M. Dolce, Analogie del comportamento sismico di edifici in muratura di buona qualità e edifici in c.a.. INGEGNERIA SISMICA n. 3/2000, Settembre-Dicembre 2000, Bologna.
- M. Dolce, M. Marino, A. Masi, M. Vona, Seismic Vulnerability Analysis and Damage Scenarios of Potenza, International Workshop on Seismic Risk and Earthquake Scenarios of Potenza, 13 and 14 November 2000, Potenza (Italy).
- A.Cherubini, G. Di Pasquale, M. Dolce, A. Martinelli, Censimento relativo alle emergenze a carattere monumentale e ambientale nei Comuni ricadenti in tutto e in parte all'interno di Parchi naturali nazionali e regionali – Cap. 3.4 pagg. 337-365: Elaborazioni di Rischio Sismico. Dipartimento della Protezione Civile, 2001, Roma.
- M.Dolce, E.Speranza, Calibrazione e controllo della vulnerabilità sismica a scala urbana: il caso di Serra dei Conti (AN), Atti del 10^o CONVEGNO L'INGEGNERIA SISMICA IN ITALIA, Settembre 2001, Potenza/Matera.
- G. Di Pasquale, A. Goretti, M. Dolce, A. Martinelli, Confronto fra differenti modelli di vulnerabilità degli edifici, Atti del 10^o CONVEGNO L'INGEGNERIA SISMICA IN ITALIA, Settembre 2001, Potenza/Matera.
- A.Masi, M. Vona, M. Dolce, F.R. Telesca, A. Goretti Resistenza sismica di telai in c.a. relativi ad edifici esistenti con e senza tamponature, Atti del 10^o CONVEGNO L'INGEGNERIA SISMICA IN ITALIA, Settembre 2001, Potenza/Matera.
- M. Dolce, C. Moroni, L. Samela, M. Marino, A. Masi, M. Vona, Una procedura di normalizzazione del danno per la valutazione degli effetti di amplificazione locale, Atti del 10^o CONVEGNO L'INGEGNERIA SISMICA IN ITALIA, Settembre 2001, Potenza/Matera.
- G. Zuccaro, F. Papa, A. Masi, M. Dolce, Remarks on the Seismic Damage in the Recent Earthquakes in Europe, Atti della 10th EUROPEAN CONFERENCE ON EARTHQUAKE ENGINEERING, Settembre 2002, Londra

M. Dolce, A. Goretti, Site Effects Evaluation from Surveyed Typological and Damage Data, Atti della 10th EUROPEAN CONFERENCE ON EARTHQUAKE ENGINEERING, Settembre 2002, Londra.

- Baratta A., Colozza R., Zuccaro G. "Valutazione del Rischio Sismico nei Centri Storici, il Caso di Benevento" by Giulio Zuccaro, Technical Report, National Seismic Survey n° RT/95/8, Novembre 1995.

Zuccaro G. & AA. VV. "The TOSQA Project - Earthquake Protection for Historic Town Centres", Final Report of the research of: "Dep. of Scienza delle Costruzioni" within the project TOSQA funded by "Environment", Contract n° EV5V - CT93-0305 Napoli, Aprile 1996.

Zuccaro G., M. Dolce, A. Kappos, A.W. Coburn, "State of the Art Report of W.G.3 – Vulnerability and Risk Analysis", Working Group - *X European Conference on Earthquake Engineering*, Vienna, agosto 1994, A.A. Bakema, Rotterdam, Brookfields.

Baratta A., Colletta T., Zuccaro G. - "Seismic Risk of Historic Centres - A Preliminary approach to the Naples' case" - *Istituto Italiano per gli Studi Filosofici, ed. La Città del Sole*, Napoli, marzo 1996.

Zuccaro G. - "Metodi di Analisi di Vulnerabilità e Matrici di Probabilità del Danno" – Proceeding of *La Meccanica delle Murature tra Teoria e Progetto*, Messina 18-20 settembre 1996, Pitagora ed. Bologna.

Zuccaro G., A. Baratta, "Fast Seismic Strength Analysis of Masonry Buildings with unknown Data for Vulnerability Purposes" - *Atti del XI World Conference on Earthquake Engineering*, Acapulco, giugno 1996, Elsevier Scienze Ltd.

Zuccaro G.- F. Papa, "Applicazioni di Analisi Multicriterio in Problemi di Rischio Sismico" - *8° Convegno Nazionale - L'ingegneria Sismica In Italia*, Taormina, settembre 1997.

Zuccaro G.- " Seismic Vulnerability in the Vesuvian Villages -Structural Distributions and a Possible Scenario. SISM-98 –Cambridge (UK) 26-27 November, 1998.

Zuccaro G., F. Papa, "Inspection minutes process for the measurement of the seismic damage" – *International workshop on Measure of Seismic Damage to masonry buildings*, Monselice, giugno 1998, A.A. Balkema publishers, Rotterdam, Netherlands.

Zuccaro G., R. Spence, D. D'Ayala, B. Martin, J. Marinescu, F. Sabetta - "The Umbria Marche Earthquake of 26 september 1997" – *Field Report by EEFIT*, Institution of Structural Engineers, ottobre 1998.

Zuccaro G. " Valutazione a Scala Nazionale della Vulnerabilità degli Edifici Ordinari " – *9° Convegno Nazionale - L'ingegneria Sismica In Italia*, Torino, settembre 1999.

Zuccaro G., Della Bella M., Papa F. " Caratterizzazione tipologico strutturale a scala nazionale " – *9° Convegno Nazionale - L'ingegneria Sismica In Italia*, Torino, settembre 1999.

4.3 LIST OF THE RESEARCH UNITS

Research Unit	Institution	Scientist Responsible	Position	Total Man Month
DiSGG UNIBAS	Università della Basilicata	Mauro Dolce	Professor	64
Centro LUPT LUPT	Università di Napoli “Federico II”	Giulio Zuccaro	Associate Professor	72
DISEG UNIGE	Università di Genova	Sergio Lagomarsino	Professor	40
GNDT (AQ) GNDT-AQ	Consiglio Nazionale Ricerche	Antonio Martinelli	Researcher	56
TOTALE MESI/UOMO				232

CONSULTANT FOR THE PROJECT

1. Prof. Robin Spence (Università di Cambridge)
rjs2@cus.cam.ac.uk

4.4 INFORMATION ON INDIVIDUAL RESEARCH UNITS

See attached forms.

RESEARCH UNIT FORM

Centro Interdipartimentale di Ricerca LUPT University of Naples «Federico II»

1. Tasks covered

- *Task 1. – Inventory and vulnerability of the residential buildings of the national territory; seismic risk maps and socio-economic losses.*
- *Task 2. – Inventory and vulnerability of the public and strategic buildings of Southern Italy (for which LSU data are available)*
- *Task 4. – Inventory and vulnerability of urban systems.*

2. Responsible of the Research Unit: Giulio Zuccaro

- *Position:* Associate Professor
- *Affiliation:* Centro Interdipartimentale di Ricerca LUPT –University of Naples “Federico II”.
- *Address:* Via Toledo, 402, Napoli - 80134
- *Telephone:* 081 5519437 – 081 5521011
- *Fax:* 081 5513495
- *E-mail:* zuccaro@unina.it

Curriculum

Giulio Zuccaro was born in Naples in 1955. He has fully qualified in Architecture cum laude at University of Naples, Italy, in 1980.

Since twenty years he is involved in the field of Seismic Risk, especially in building vulnerability analyses at urban, regional and national scale and in the innovative technologies aimed to seismic risk reduction.

He has been teaching Structures at the Faculty of Architecture of University of Naples “Federico II” since 1985, and now he is Associated Professor at the same Faculty holding the courses of Science of Construction and Structure Theory; moreover since 1985 he co-ordinates the research section of *Seismic Analyses and Planning* at the Interdepartmental Centre of Research - LUPT of the University of Naples “Federico II”.

He has been the scientific responsible in several projects on seismic Risk Assessment and structural behaviour with many Italian and International Institutions, among them: the “Italian National Seismic Survey”, the “Vesuvian Observatory”, the GNDT, the Martin Centre of the University of Cambridge (UK), the XII Commission of the European Community, the European Bank of Reconstruction and Development.

In '92 he has been “Visiting Professor” at the Stochastic Mechanic Centre -Florida Atlantic University (USA). He is member of the Task Group 3 on "Seismic Risk and Earthquake Scenarios" of the European Association of Earthquake Engineering. He is consultant of the European Bank of Reconstruction and Development on Civil Protection issues.

His research activity began in 1982 in the field of masonry mechanics. In 1985 his involvement in the LUPT Centre make him approach to the Seismic Engineering issues. Particularly he has laced a fruitful collaboration with the Martin Centre of the Cambridge University (UK), carrying out a large number of researches in the field of Structural Vulnerability and Seismic Risk. This circumstance induced him to amplify his interest horizon with particular attention to Modelling and Simulation of seismic input, Structures Theory, Stochastic Dynamic and Structural Control.

He is the author of more than 70 scientific papers, reports and books showing his continuous research activity in the field of structural engineering, seismic risk modelling and evaluation, innovative seismic risk reduction techniques.

Prof. Giulio Zuccaro, moreover has been:

- the scientific co-ordinator in the project for upgrading the actual vulnerability maps at national scale within the GNDT project 1998-2000;
- the co-ordinator of the Unit of Research of the Federico II University involved in the project “Human Casualties and Structural Vulnerability in the Vesuvian Area” supported by the EU February of the 2000;
- the co-ordinator of a Research Unit in the Project on the evaluation of the seismic vulnerability of the vesuvian villages supported by the Civil Protection and co-ordinated by the Vesuvian Observatory, June 2001;
- the co-ordinator of the Research Unit of Naples University “Federico II” involved in the project “Pyroclastic effect on the structures of possible eruptions in the Campi Flegrei, funded by GNV for 2000 - 2002.

3. List of the participants

position (PO = Full Prof., PA= Associated Professor, RC = Researcher. Conf., DR = PHD Student, CE = External Expert, D = Manager, RS= Researcher Senior, RJ= Researcher Junior)

Surname	Name	Position	Institution	Man Month
Zuccaro	Giulio	PA	Università di Napoli	1.5, 1.5
Baratta	Alessandro	PO	Università di Napoli	1.5, 1.5
Petrazzuoli	Stefano	CE		3, 3
Cacace	Francesco	CE		6, 6
Della Bella	Marianna	CE		6, 6
Esposito	Gennaro	CE		6, 6
Ianniello	Domernico	CE		3, 3
Nardone	Stefano	CE		3, 3
Binetti	Anna	CE		3, 3
De Angelis	Emilia	CE		3, 3
TOTALE	MESI UOMO			72

4. Most relevant publications of the participants, pertaining to the project (Max 10)

- Baratta A., Colozza R., Zuccaro G. "Valutazione del Rischio Sismico nei Centri Storici, il Caso di Benevento" by Giulio Zuccaro, Technical Report, National Seismic Survey n° RT/95/8, Novembre 1995.

Zuccaro G. & AA. VV. "The TOSQA Project - Earthquake Protection for Historic Town Centres", Final Report of the research of: "Dep. of Scienza delle Costruzioni" within the project TOSQA funded by "Environment", Contract n° EV5V - CT93-0305 Napoli, Aprile 1996.

Zuccaro G., M. Dolce, A. Kappos, A.W. Coburn, "State of the Art Report of W.G.3 – Vulnerability and Risk Analysis", Working Group - *X European Conference on Earthquake Engineering*, Vienna, agosto 1994, A.A. Bakema, Rotterdam, Brookfields.

Baratta A., Colletta T., Zuccaro G. - "Seismic Risk of Historic Centres - A Preliminary approach to the Naples' case" - *Istituto Italiano per gli Studi Filosofici, ed. La Città del Sole*, Napoli, marzo 1996.

Zuccaro G. - "Metodi di Analisi di Vulnerabilità e Matrici di Probabilità del Danno" – Proceeding of *La Meccanica delle Murature tra Teoria e Progetto*, Messina 18-20 settembre 1996, Pitagora ed. Bologna.

Zuccaro G., A. Baratta, "Fast Seismic Strength Analysis of Masonry Buildings with unknown Data for Vulnerability Purposes" - *Atti del XI World Conference on Earthquake Engineering*, Acapulco, giugno 1996, Elsevier Scienze Ltd.

Zuccaro G.- F. Papa, "Applicazioni di Analisi Multicriterio in Problemi di Rischio Sismico" - *8° Convegno Nazionale - L'ingegneria Sismica In Italia*, Taormina, settembre 1997.

Zuccaro G.- " Seismic Vulnerability in the Vesuvian Villages -Structural Distributions and a Possible Scenario. SISM-98 –Cambridge (UK) 26-27 November, 1998.

Zuccaro G., F. Papa, "Inspection minutes process for the measurement of the seismic damage" – *International workshop on Measure of Seismic Damage to masonry buildings*, Monselice, giugno 1998, A.A. Balkema publishers, Rotterdam, Netherlands.

Zuccaro G., R. Spence, D. D'Ayala, B. Martin, J. Marinescu, F. Sabetta - "The Umbria Marche Earthquake of 26 september 1997" – *Field Report by EEFIT*, Institution of Structural Engineers, ottobre 1998.

Zuccaro G. " Valutazione a Scala Nazionale della Vulnerabilità degli Edifici Ordinari " *9° Convegno Nazionale - L'ingegneria Sismica In Italia*, Torino, settembre 1999.

Zuccaro G., Della Bella M., Papa F. " Caratterizzazione tipologico strutturale a scala nazionale " *9° Convegno Nazionale – L'ingegneria Sismica In Italia*, Torino, settembre 1999.

Troise C., De Natale G., Pingue F., Petrazzuoli S.M. (1998). Evidences for static stress interaction among earthquakes in South-Central Apennines(Italy). *Gophysical Journal International*.

Il Responsabile dell'Unità di Ricerca
Prof. Giulio Zuccaro

Il Direttore Tecnico del Centro LUPT
Prof. Guglielmo Trupiano

5. Costi (in Euro)

TABLE OF COSTS (Euros) – Research Unit of Naples			
Cost Typology	COSTS PER YEAR		
	I Year	II Year	
Durable material (Description NOT REQUIRED)	7500	2500	
Consumables and other general costs			
- Consumables costs (telephone, stationery, colour copy etc)	3000	3000	
- Aerial photos	5000		
- Overheads (about 10% of project costs per year of the RU)	10000	6000	
Partial costs	18000		9000
Travel and subsistence			
Missions for meetings	3000		3000
Contracts for temporarily employed personnel			
<i>No. person : 2</i>	21000		21000
<i>Specify number of people: 6</i>			
<i>Expertise : aerophotog. Interpret., survey coordin,</i>			
<i>structural engineering</i>			
<i>length of employment: see table</i>			
Meetings and Congresses			
two annual meetings (missions for foreigners)	4000		4000
External Services			
collection of data, data base elaboration in the communes chosen	56000		25000
Publications			
4 pubblicazioni per i due anni, così suddivise, 2, 2	500		500
Other costs			
helicopter rent, video and, photographic documentation	4000		2000
Totali	114000		67000

Grand Total: 181 000 Euro

SCHEDA DELL'UNITA' DI RICERCA

**Università della Basilicata (UNIBAS), Dipartimento di Strutture,
Geotecnica, Geologia applicata all'ingegneria (DiSGG)**

1. Tasks covered

- *Task 1. – Inventory and vulnerability of the residential buildings of the national territory; seismic risk maps and socio-economic losses.*
- *Task 2. – Inventory and vulnerability of the public and strategic buildings of Southern Italy (for which LSU data are available)*
- *Task 3. – Inventory and vulnerability of the monumental buildings of the national and regional parks of Southern Italy*
- *Task 4. – Inventory and vulnerability of urban systems.*

2. Responsible of the Research Unit: Dolce Mauro

- *Position:* Professor
- *Affiliation:* Università della Basilicata (UNIBAS), Dipartimento di Strutture, Geotecnica, Geologia applicata all'ingegneria (DiSGG)
- *Address:* Campus Macchia Romana, 85100 – Potenza, Italy
- *Telephone:* 0971 205107
- *Fax:* 0971 205070
- *E-mail:* dolce@unibas.it, dolcerom@libero.it

Curriculum

Professor Mauro Dolce was born in Rome, Italy, 19.7.1953 and took his degree in Civil Engineering, summa cum laude, at the University of Rome “La Sapienza”, in 1978.

He is currently Professor of Earthquake Engineering at the Faculty of Engineering of the University of Basilicata, since 1.11.1994. He has been also Head of the Department of Structures, Soil Mechanics and Applied Geology since January 1995, Head of the Laboratory of Structures since November 1999 and Deputy Dean of the faculty of Engineering since January 1999.

His research activity is mainly related to Earthquake and Structural Engineering problems, resulting in about 200 papers on national and international reviews and conference proceedings as well as in 6 patents, 3 scientific videos and 2 CD-ROM's.

His papers mainly deal with the seismic behaviour and vulnerability of masonry and R/C buildings, of bridges, the use of advanced materials (high dissipation rubber, shape memory alloys, stainless steel) and techniques (passive control) for the seismic protection of bridges and buildings. Particular attention has been paid to seismic retrofitting techniques. Four of the six patents are relevant to devices for passive control based on the hysteretic properties of steel and on the superelastic properties of shape memory alloys, while the other two are relevant to devices and systems for the strengthening of masonry structures.

Professor Dolce is or was also:

- Permanent consultant of the Italian National Seismic Survey (Servizio Sismico Nazionale) since 1991, member of the Scientific Committee of GNDT, of the Steering Committees of ANIDIS (Italian National Association of Earthquake Engineering) and of GLIS (Working Group for Seismic Isolation), since 1995.
- Member of several international (CEN, ISO) and national boards for seismic regulations, specifically regarding passive control of vibrations.
- Coordinator of Task Group 3 ("Seismic Risk and Earthquake Scenarios"), formerly Working Group 3, of the European Association on Earthquake Engineering, since 1990, and of ENSeRVES (European Network for Seismic Risk, Vulnerability and Earthquake Scenarios), funded by the European Commission within the INCO-Copernicus program.

- Scientific Co-ordinator of the Project TREMA (Valore 1 250 000 Euro) of MURST (2002-04)
- Responsible of research units of research projects funded by D.G.XII of the E.C. (MANSIDE, ENESE, ECOEST II, ECOLEADER)
- Responsible GNDT Research Units from 1989 to 1997.
- President of the Organising Committe of the 10th National Conference on Earthquake Engineering ANIDIS
- Responsible of several research contracts up to 500 000 Euro.
- Referee of important scientific national and international and member of scientific committees of several nationa and international congresses

3. List of the participants

position (PO = Full Prof., PA= Associated Professor, RC = Reseacher. Conf., DR = PHD Student, CE = External Expert, D = Manager, RS= Reseascher Senior, RJ= Reseascher Junior)

Surname	Name	Position	Institution	Man Month
Dolce	Mauro	PO	Università della Basilicata	1,5, 1,5
Cherubini	Alberto	CE		2, 2
Liberatore	Domenico	PO	Università della Basilicata	1,5, 1,5
Masi	Angelo	PA	Università della Basilicata	2, 2
Laterza	Michelangelo	R	Università della Basilicata	2, 2
Ponzo	Felice C.	R	Università della Basilicata	2, 2
Spera	Giuseppe	AR	Università della Basilicata	3, 3
Marino	Maria	DR	Università della Basilicata	3, 3
Antonio	Cacosso	DR	Università della Basilicata	3, 3
Tiziana	Cappa	DR	Università della Basilicata	3, 3
Assegnista		AR		6, 12
TOTALE	MESI UOMO			64

4. Most relevant publications of the participants, pertaining to the project (Max 10)

- M. Dolce. *Evaluating Damage Probability Matrices from Survey Data*. JOINT USA/ITALY WORKSHOP ON REPAIR AND RETROFIT OF EXISTING BUILDINGS, Maggio, 1984, Roma.
- M.Dolce, F.Sabatella, R.Colozza, *Seismic Risk Assessment in the Historical Centre of Rome*. 11th WORLD CONFERENCE ON EARTHQUAKE ENGINEERING, Giugno 1996, Acapulco.
- M. Dolce, *Vulnerability Evaluation and Damage Scenarios*. US-Italian Workshop on “Seismic Evaluation and Retrofit”, Dicembre 1996, New York City.
- Masi, M. Dolce, F. Caterina. *Seismic Response of Irregular Multi-storey Building Structures with Flexible Inelastic Diaphragms*. INTERNATIONAL JOURNAL THE STRUCTURAL DESIGN OF TALL BUILDINGS, Vol. 6, pgg. 99-124, Giugno 1997.
- M. Dolce, F.C. Ponzo. *Comportamento sismico in campo non-lineare di edifici in calcestruzzo armato progettati secondo le regole degli eurocodici 2 e 8 per differenti livelli di duttilità' e di intensità' sismica*. 8^o CONGRESSO INGEGNERIA SISMICA IN ITALIA, Settembre 1997, Taormina.
- M. Dolce, V. Schenk. *EAEE – ESC Task Group 3 – Seismic Risk and Earthquake Scenarios Report of the Activities*, 10th EUROPEAN CONFERENCE ON EARTHQUAKE ENGINEERING, Settembre 1998, Parigi.
- M. Dolce, D. Liberatore, D. Palermo, G. Spera, Vulnerabilità sismica di alcune tipologie strutturali di centri storici pugliesi, Atti del DiSGG n. 5/2000.
- M. Dolce, M. Marino, A. Masi, M. Vona, Seismic Vulnerability Analysis and Damage Scenarios of Potenza, International Workshop on Seismic Risk and Earthquake Scenarios of Potenza, 13 and 14 November 2000, Potenza (Italy).
- A. Masi, M. Vona, M. Dolce, F.R. Telesca, A. Goretti Resistenza sismica di telai in c.a. relativi ad edifici esistenti con e senza tamponature, Atti del 10^o CONVEGNO L'INGEGNERIA SISMICA IN ITALIA, Settembre 2001, Potenza/Matera.
- M. Dolce, A. Masi, M. Marino, EAEE-ESC Task Group 3 – Seismic risk and earthquake scenarios - report of the activities, Atti della 12th European CONFERENCE ON EARTHQUAKE ENGINEERING, Settembre 2002, Londra

Il Responsabile Scientifico
 Prof. Ing Mauro Dolce

Il Direttore del Dipartimento
 Prof. Ing. Mauro Dolce

TABLE OF COSTS (Euros) – Research Unit of Potenza - UNIBAS

TABLE OF COSTS (Euros) – Research Unit of Potenza - UNIBAS			
Cost Typology	COSTS PER YEAR		
	I Year	II Year	
Durable material (Description NOT REQUIRED)	8 000	4 000	
Consumables and other general costs			
- Consumables costs (telephone, stationery, colour copy etc)	2000	2000	
- Overheads (about 10% of project costs per year of the RU)	6000	6000	
Partial costs	8 000	8 000	
Travel and subsistence			
Missions for meetings	3 000	3 000	
Contracts for temporarily employed personnel and fellowships			
	26 000	26 000	
Meetings and Congresses			
two annual meetings (missions for foreigners)	3 000	3 000	
External Services			
collection of data, data base elaboration in the communes chosen	35 000	15 000	
Publications			
	2 000	2 000	
Other costs			
Total	85000	61000	

Grand Total: 146 000 Euro

SCHEDA DELL'UNITA' DI RICERCA
Gruppo Nazionale Difesa dai Terremoti (GNDT)

1. Tasks covered

- *Task 1. – Inventory and vulnerability of the residential buildings of the national territory; seismic risk maps and socio-economic losses.*
- *Task 2. – Inventory and vulnerability of the public and strategic buildings of Southern Italy (for which LSU data are available)*
- *Task 3. – Inventory and vulnerability of the monumental buildings of the national and regional parks of Southern Italy*
- *Task 4. – Inventory and vulnerability of urban systems.*

2. Responsible of the Research Unit: Antonio Martinelli

- *Position:* Researcher
- *Affiliation:* Gruppo Nazionale Difesa dai Terremoti (GNDT)
- *Address:* Ex Ospedale di Collemaggio - 67100 L'AQUILA
- *Telephone:* 0862 311883 - 0862 27777
- *Fax:* 0862 313524 - 0862 28400
- *E-mail:* gndtaq@regione.abruzzo.it

Curriculum

Dr. Antonio Martinelli, born in Toricella Peligna 13.10.1952, took his degree cum laude in Civil Engineering at the University of L'Aquila, in 1979. Currently he is researcher of GNDT. He was dealing with preservation and restoration of monumental buildings at the "Soprintendenza B.A.A.A.S. of L'Aquila. Then he carried research and professional activities at the GNDT technical Office of consultancy for the repair of seismic damage of the 1984 earthquake. He also took part, even as a coordinator, at the vulnerability/damage survey after several Italian earthquakes, until 1998. During these activities and other research studies, he got the knowledge of the methods relevant to the seismic vulnerability assessment procedures developed in Italy, of their evolution and of the relevant results. In the last years he has actively participated to the Useful Social Works (LSU) projects of GNDT, relevant to the study of vulnerability of constructions in Southern Italy. He was coordinator of the LSU-1996 Project for the census of the public and strategic buildings of Southern Italy, and was a member of the commission of GNDT for the elaboration of the data relevant to the three LSU projects, with particular attention to the data bank preparation.

His publications are mainly relevant to the seismic behaviour and vulnerability of constructions.

He also is:

- Responsible of the preparation and manager of the GNDT Data Bank of vulnerability.
- Member of the technical-scientific Commission for the updating of the vulnerability of residential and public buildings and for the compilation of a glossary on the main terms of vulnerability, exposure and seismic risk, of the Servizio Sismico Nazionale.

3. List of the participants

position (RI = Researcher, TE = Technologist, T = technician, CE = external expert)

Surname	Name	Position	Institution	Man Month
Martinelli	Antonio	RI	GNDT	3,3
Cifani	Giandomenico	RI	GNDT	2,2
Corazza	Livio	TE	GNDT	3,3

Cialone	Giovanni	TE	GNDT	2,2
Mutignani	Carlo	TE	GNDT	1,1
Petracca	Aurelio	TE	GNDT	2,2
Di capua	Giuseppe	TE	GNDT	2,2
D'alessandro	Sandro	T	GNDT	2,2
Lazzaro	Domenico	T	GNDT	1,1
Petrucci	Gabriele	T	GNDT	2,2
Lemme	Alberto	CE		4,4
Antonacci	Elena	CE		2,2
Peppoloni	Silvia	CE		2,2
TOTALE	MESI UOMO			56

4. Most relevant publications of the participants, pertaining to the project (Max 10)

1. Cifani, G, Martinelli A., Corazza L., et al. "Terremoto del Messico del 19 settembre 1985: osservazioni preliminari sul comportamento delle costruzioni e sui danni" in Ingegneria Sismica n.3, 1985.
 2. Cifani, G, Martinelli A. et al. "Retrofitting of old buildings - Case study of Barrea (middle Italy)" Proceedings of the Ninth World Conference on Earthquake Engineering, Tokyo 1988.
 3. Cifani, G, "Terremoto del maggio 1984: l'esperienza della riattazione in Abruzzo" al Convegno "I terremoti e il culto di S.Emidio", Castiglione a Casauria 1989.
 4. Antonacci E., Genovese F., Vestroni F., "Indagine sperimentale sul comportamento dinamico di una casa in muratura", atti del convegno su "La meccanica delle murature tra teoria e progetto", Messina 1996.
 5. Cifani, G, Corazza L., Martinelli A., et al. "The performance of the damage survey and safety evaluation form in Marche region" , Proceedings of the international workshop on "Measures of seismic damage to masonry building", Monselice (PD) 25-27 giugno 1998, AA. Balkema/Rotterdam/Brookfield, 1999.
 6. Martinelli A., "The damage survey and safety evaluation form employed in Marche region struck by the September 1997 earthquake" Proceedings of the international workshop on "Measures of seismic damage to masonry building", Monselice (PD) 25-27 giugno 1998, AA. Balkema/Rotterdam/Brookfield, 1999.
 7. A.Cherubini, G. Di Pasquale, M. Dolce, A. Martinelli, Vulnerability assessment from quick survey data in the historic centre of Catania. THE CATANIA PROJECT, Pubblicazione GNDT, Dicembre 1999, Roma.
 8. A.Cherubini, L. Corazza, G. Di Pasquale, M. Dolce, A. Martinelli, V. Petrini, Censimento di vulnerabilità degli edifici pubblici,strategici e speciali nelle regioni Abruzzo, Basilicata, Calabria, Campania, Molise, Puglia e Sicilia – Cap. 4: Risultati del Progetto. Dipartimento della Protezione Civile, 1999, Roma.
 9. G. Di Pasquale, M. Dolce, A. Martinelli, Censimento di vulnerabilità a campione dell'edilizia corrente dei Centri abitati nelle regioni Abruzzo, Basilicata, Calabria, Campania, Molise, Puglia e Sicilia – Cap. 2.2: Analisi della vulnerabilità. Dipartimento della Protezione Civile, 2000, Roma.
 10. A. Cherubini, G. Di Pasquale, M. Dolce, A. Martinelli, Censimento relativo alle emergenze a carattere monumentale e ambientale nei Comuni ricadenti in tutto e in parte all'interno di Parchi naturali nazionali e regionali – Cap. 3.4 pagg. 337-365: Elaborazioni di Rischio Sismico. Dip. della Prot. Civ., 2001, Roma.
 11. G. Cialone, G. Cifani, Censimento relativo alle emergenze a carattere monumentale e ambientale nei Comuni ricadenti in tutto e in parte all'interno di Parchi naturali nazionali e regionali – Cap. 3.1 pagg. 113-121 e Cap. 3.2 pag. 123-134: Elaborazioni di Rischio Sismico. Dipartimento della Protezione Civile, 2001, Roma.
 12. G. Di Pasquale, A. Goretti, M. Dolce, A. Martinelli, Confronto fra differenti modelli di vulnerabilità degli edifici, Atti del 10° CONVEGNO L'INGEGNERIA SISMICA IN ITALIA, Settembre 2001, Potenza/Matera.

Il Responsabile Scientifico

Ing. Antonio Martinelli

Il Presidente del GNDT

Prof. Claudio Eva

TABLE OF COSTS (Euros) – Research Unit of GNDT		
Cost Typology	COSTS PER YEAR	
	I Year	II Year
Durable material (Description NOT REQUIRED)	4 000	2 000
Consumables and other general costs		
- Consumables costs (telephone, stationery, colour copy etc)	1 000	1 000
- Overheads (about 10% of project costs per year of the RU)	4 000	2 000
Partial costs	5 000	3 000
Travel and subsistence		
Missions for meetings	2 000	2 000
Contracts for temporarily employed personnel		
2 persons	15 000	15 000
Meetings and Congresses		
two annual meetings (missions for foreigners)	3 000	3 000
External Services		
Consultancies, data base elaborations, software development and GIS applications	20 000	10 000
Publications		
	1 000	1 000
Other costs		
Total	50 000	36 000

Grand Total: 86 000 Euro

SCHEDA DELL'UNITA' DI RICERCA

Università di Genova (UNIGE), Dipartimento di Ingegneria
Strutturale e Geotecnica (DISEG)

1. Tasks covered

- *Task 1. – Inventory and vulnerability of the residential buildings of the national territory; seismic risk maps and socio-economic losses.*
- *Task 3. – Inventory and vulnerability of the monumental buildings of the national and regional parks of Southern Italy*
- *Task 4. – Inventory and vulnerability of urban systems.*

2. Responsible of the Research Unit: Lagomarsino Sergio

- *Position:* Professor
- *Affiliation:* Università degli Studi di Genova (UNIGE), Dipartimento di Strutture e Geotecnica, (DISEG)
- *Address:* via Montallegro 1, 16145 Genova
- *Telephone:* tel. 010 3532521
- *Fax:* 010 3532534
- *E-mail:* lagomarsino@diseg.unige.it

Curriculum:

Sergio Lagomarsino was born in Genoa on 13 April 1959 and graduated cum laude in Civil Engineering in 1984; in 1989 he obtained a Ph.D. in Structural Engineering. Currently he is full professor of Structural Engineering and is teacher in the courses of *Seismic Risk* and *Structural Rehabilitation*; furthermore, he is a lecturer on the course *Consolidation of Historic Buildings*, in the School of Specialisation in Restoration of Monuments of the Faculty of Architecture of Genoa, and member of the Teaching Body for the Ph.D. in Earthquake Engineering of the Polytechnic of Milan. He has been invited to many congresses and panel sessions on the problem of seismic vulnerability, some of which were abroad; in addition he has carried out an intense activity to make others aware, through courses and seminars on the theme of seismic improvement interventions, organised by the Civil Protection Department, by the Ministry of Cultural and Environmental Heritage, by Regional Authorities and by the Professional Associations. He is author of more than a hundred papers, 17 in journals and many in international congress proceedings. His research is characterised by a strong leaning towards the applied openings; in particular the most significant results are recalled: a) his model for forecasting structural damping has been adopted in the Eurocode 1; b) he has elaborated, in collaboration with other colleagues, the map of the extreme winds on the Italian territory, published in the codes (D.M.LL.PP. 16.1.96; Eurocode 1); c) the constitutive models for masonry, developed together with Gambarotta, are often quoted and, in some cases, used by other researchers as a basis for their research; d) the form for damage survey and vulnerability of churches has been used for the surveying of the churches damaged by the earthquake in Umbria and the Marches (more than 3000 churches). He has been responsible for numerous research activities, financed by the CNR (National Research Council - he has been head of a GNDT research unit since 1994), by MIUR, by the European Community and by Public and private bodies. He has been member of the Committees set up by the *Civil Protection* following seismic events; in particular he was president of the CTS for the earthquake in Monte Amiata (Ord. DPC no. 2705/97), member of the CTS Valtiberina (Ord. DPC no. 2668/97) and member of the CTS Cultural Heritage of the Umbria-Marches earthquake. In addition he was member of the *Working Group* that co-ordinates the Project *Lavori Socialmente Utili Parchi* (Socially Useful Work Parks), relative to the "Mitigation of seismic risk for the monumental and environmental patrimony in the villages situated totally or partially inside the National and Regional natural parks and reserves in Southern Italy".

3. List of the participants

position (PO = Full Prof., PA= Associated Professor, RC = Reseacher. Conf., DR = PHD Student, BR = Fellow, CE = External Expert, D = Manager, RS= Reseascher Senior, RJ= Reseascher Junior)

Surname	Name	Position	Institution	Man Month
Lagomarsino	Sergio	PO	Università di Genova	2,2
Magenes	Guido	PA	Università di Pavia	1,1
Podestà	Stefano	BR	Università di Pavia	3,3
Giovinazzi	Sonia	DR	Università di Genova	3,3
Penna	Andrea	AR	Università di Genova	2,2
Resemini	Sonia	DR	Università di Genova	2,2
Lazzoni	Luca	BR	Università di Genova	4,4
Maggiolo	Laura	CE	Università di Genova	3,3
TOTALE	MESI UOMO			40

4. Most relevant publications of the participants, pertaining to the project (Max 10)

1. Corsanego, A. and Lagomarsino, S. 1993, Structural mechanics and seismic vulnerability of old towns, in *New Developments in Structural Mechanics*, Proc. of the International Meeting in memory of Manfredi Romano, Catania, 1990, pp. 351-376.
 2. Gambarotta, L. and Lagomarsino, S. 1994, A microslip model for the seismic response analysis of drained cohesionless soil deposits, *Earthquake Engineering and Structural Dynamic*, **23**, pp. 1047-1067.
 3. Gambarotta, L. and Lagomarsino, S. 1997, Damage models for the seismic response of brick masonry shear walls. Part I: the mortar joint model and its applications, *Earthquake Engineering and Structural Dynamics*, **26**, pp. 423-439.
 4. Gambarotta, L. and Lagomarsino, S. 1997, Damage models for the seismic response of brick masonry shear walls. Part II: the continuum model and its applications, *Earthquake Engineering and Structural Dynamics*, **26**, pp. 441-462.
 5. Lagomarsino, S. 1999, Damage survey of ancient churches: the Umbria-Marche experience, in *Seismic Damage to Masonry Buildings* (A. Bernardini Ed.), Proceeding of the International Workshop on "Measures of seismic damage to masonry buildings", Monselice, Padova, Italy, June 25-26, 1998, Balkema, Rotterdam, pp. 81-94.
 6. S. Cocina, S. Lagomarsino & S. Podestà, 1999. "Analisi di vulnerabilità della facciata nelle chiese di Catania", *Atti del 9° Convegno Nazionale L'ingegneria sismica in Italia*, Torino, 20-23 settembre 1999.
 7. S. Lagomarsino, S. Brun, S. Giovinazzi, C. Idri, A. Penna, S. Podestà, S. Resemini e B. Rossi, 1999. "Modelli di calcolo per il miglioramento sismico delle chiese", *Atti del 9° Convegno Nazionale L'ingegneria sismica in Italia*, Torino, 20-23 settembre 1999.
 8. Lagomarsino S., Maggiolo L., Podestà S., "Vulnerabilità sismica delle chiese: proposta di una metodologia integrata per il rilievo la prevenzione ed il rilievo del danno in emergenza", Atti del X Convegno Nazionale "L'ingegneria sismica in Italia", Potenza 2001.
 9. Galasco A., Lagomarsino S., Penna A., "Analisi sismica non lineare a macroelementi di edifici in muratura", Atti del X Convegno Nazionale L'ingegneria sismica in Italia" Potenza 2001
 10. Giovinazzi S. e Lagomarsino S., "Una metodologia per l'analisi di vulnerabilità sismica del costruito", Atti del X Convegno Nazionale L'ingegneria sismica in Italia", Potenza 2001.

Il Responsabile Scientifico
Prof. Ing Sergio Lagomarsinio

Il Direttore del Dipartimento
Prof. Ing. Giovanni Solari

TABLE OF COSTS (Euros) – Research Unit of Genova - UNIGE

TABLE OF COSTS (Euros) – Research Unit of Genova - UNIGE			
Cost Typology	COSTS PER YEAR		
	I Year	II Year	
Durable material (Description NOT REQUIRED)	8 000	6 000	
Consumables and other general costs			
- Consumables costs (telephone, stationery, colour copy etc)	2000	2000	
- Overheads (about 10% of project costs per year of the RU)	4000	3000	
Partial costs	6 000	5 000	
Travel and subsistence			
Missions for meetings	3 000	2 000	
Contracts for temporarily employed personnel and fellowships			
	22 000	18 000	
Meetings and Congresses			
two annual meetings (missions for foreigners)	2 000	2 000	
External Services			
collection of data, data base elaboration in the communes chosen	2 000	2 000	
Publications			
	1 000	1 000	
Other costs			
Total	44 000	36 000	

Grand Total : 80 000 Euro

5.1 OBJECTIVE OF THE PROJECT

- Realising updated maps of seismic vulnerability and risk of the Italian residential building stock, of the public buildings inventoried by the Lavori Socialmente Utili (LSU) project in Southern Italy and by other initiatives, of the monumental buildings of some areas of great environmental and monumental value (parks), of some small urban systems.
- Completing and rationalising the most important existing data-bases, particularly those relevant to LSU projects.
- Comparing and improving the methods for the evaluation of the vulnerability of different structural types (ordinary buildings, monumental and historical buildings, churches), when applied to the above mentioned data bases, in order to integrate and harmonise them.
- Development of models for the evaluation of the indirect losses and of the socio-economical consequences of the earthquakes

5.2 STATE OF ART

The seismicity of the Italian territory is one of the highest both at European and at world level (220 destructive events over the last thousand years; 150.000 casualties in the last two centuries; more than 70 billion Euros of damage in the last 25 years). Moreover, the ratio between the damage caused by earthquakes and the energy related to them is much higher in Italy than in other countries with strong seismicity, such as California or Japan. For instance recent earthquakes, occurred in California in 1989 and in Umbria and Marche in 1997, produced a similar damage scenario in spite of the fact that the energy of the Umbria earthquake was 30 times lower than the Californian one.

The reason for these large differences is probably to be ascribed to the high vulnerability of the Italian real estate. This is due to the high number of historical and old buildings which do not guarantee adequate seismic resistance, to the deterioration of suburbs in the large urban areas and to the illegal buildings, particularly diffused in the Centre-South of Italy, where the hazard is higher.

The seismic risk mitigation has been developed, since the 1908 earthquake of Reggio Calabria and Messina, through the seismic zoning of the national territory in three different categories and the application of the building code for new constructions. The seismic zoning, whose last updating dates back to 1981 and that is currently under revision, includes 37% of the Municipalities, 45% of the territory and 40% of the population. Nevertheless only 35% of the buildings, in the classified municipalities, have been built after the date of the zoning, and are protected from the seismic action, though insufficiently due to the inadequateness of the old seismic codes. Hence the main problem in Italy, considering also the recent contraction of the building market, is to develop an adequate prevention policy for the strengthening and retrofitting of old buildings, rather than to apply the building code to new constructions.

Therefore, considering the limited amount of the economic resources, the seismic risk assessment of the Italian territory is of primary importance in order to set up a priority list, allowing the Civil Defence to promote a risk mitigation strategy.

In 1996, in the frame of a specific Working Group SSN-GNDT-ING, seismic risk maps of the Italian territory have been realised and delivered to the Department of Civil Defence. Such maps represent, in Italy, the first approach to the problem of the risk assessment at national level and are characterised, therefore, by many uncertainties and susceptible of improvements that will be the objective of this proposal.

It is well known that the seismic risk can be defined as the probability of observing a given loss due to seismic events, in a fixed time interval. The risk is evaluated by the convolution product of *hazard* (probability that a seismic event, of given intensity, occurs in a fixed period of time) by *vulnerability* (probability that an assigned structural type suffers a given damage level due to a given intensity event) by *exposure* (quantitative and qualitative evaluation of goods and population exposed to risk).

In the present project the attention is focused on the assessment of the vulnerability of constructions and of urban systems. Several problems are still open, related to both the methodological and the application aspects, although several operative proposals have been developed in Italy, mainly, and all over the world. They are based either on purely statistical or purely numerical approaches, or even on hybrid approaches. The variety of approaches is obviously caused by the variety of structural types (reinforced concrete or masonry buildings, monumental buildings, churches, historical centres, etc.) on one hand, and by the availability of inventories at different detail level, with different kinds of information (census ISTAT data, first and second level forms, fast inspection forms, aerial views, etc.). Actually any vulnerability estimation method must always consider the availability of direct or indirect data on the structural characteristics of the constructions at hand and/or their cost of collection and improvement.

The *vulnerability* evaluations of the real estate at national scale are, at the moment, based on the use of the so called «poor data» derived from the ISTAT census 1991 (structural typology and construction age), calibrated on the base of specific surveys of some Italian regions, performed by several research groups. Unfortunately such a data, as recent experiences have shown, are characterized by a low level of reliability. Therefore, new collection of data have

been asked in several regions of Italy in order to understand and/or adjust the original Istat data. Among these: the survey on the ordinary buildings, performed by aero-photogrammetric techniques and statistical correction of the error, of a sample of 85 Communes (LUPT on behalf of SSN and GNDT); the collection of data co-ordinated by GNDT, within the Social Useful Works (LSU) Project, for a sample of residential and strategic buildings in several Communes of Southern Italy, that will be available in the second half of 2000.

As far as *vulnerability* models and damage evaluation of ordinary buildings at national scale are concerned, two methodologies based on vulnerability functions, Damage Probability Matrices (DPM) and Fragility Curves (FC) respectively, are available. The former ones are derived from the correlation Typology - Damage - Intensity (Braga et al. 1982, Di Pasquale et al. 1996, Zuccaro et al. 1999), elaborated on the base of the observed damage after recent seismic events, the latter ones (Petrini et al. 1989, Sabetta et al. 1998) exploit the correlation Typology - Damage - Acceleration also derived from the observed damage. Similar correlation's have been recently proposed based on the damage data collected since 1997 with the usability and damage inspection form (AeDES), set up by SSN and GNDT, according to an approach more consistent with EMS98 (Di Pasquale et al, 2001). More recently attempts have been made to set up vulnerability assessment methods based on mechanical-numerical approaches. They are particularly useful either when observed damage data are not available or whenever hazard is expressed by instrumental parameters (PGA) or response spectra, but they also need of careful calibrations. In general a further effort is needed by the researchers operating on vulnerability to harmonise the different approaches and to find an elaboration key of the different survey forms containing information at different detail levels.

Public buildings play a very important role in seismic problems, in relation to both the strategic feature of many of them, hospitals first of all, and to the human life exposure for special categories of them, school first of all, and the possibility of their use as shelters and rescue centres. Such importance was well understood by the Civil Defence Department, which promoted a census of the public buildings in Southern Italy along with the Ministry of Work. The census was carried out thanks to a special law on the Socially Useful Works (LSU) in 1996-1997. The data base of public buildings (about 42000 buildings) now available covers a great part of the Italian territory classified in seismic area of Southern Italy and was initially analysed to provide a first picture of the vulnerability condition of the public building stock. Its utilisation has been only partial and it can be better exploited and used to compare different methods of processing and of evaluation of vulnerability.

Monumental buildings deserve a special care, particularly churches. On one hand they cannot be treated with the methods available for ordinary buildings, and, on the other hand, no national data base exists from which it is possible to draw useful information for a vulnerability evaluation of the entire national heritage. Inspection methods for the damage and vulnerability evaluation of churches have been set up and tested after the recent Umbria-Marche earthquakes (1997) and of Pollino (1998). They, however, need careful calibrations for a correct use of the information on the characteristics of the single church, even based on numerical-mechanical approaches. The data-bases derived from the activities of LSU-parchi and the recent post-earthquake surveys, though relevant to limited areas, provide excellent test-cases to set up and compare methods for vulnerability evaluation and the construction of vulnerability maps of areas of great environmental and monumental interest, such as national and regional parks.

Finally the availability of vulnerability data on urban systems drawn from fast survey of buildings and lifelines (transport, water, power, gas, etc.) collected by LSU-infrastrutture makes the problem of urban system vulnerability approachable even from a practical point of view. This question is of great interest and yet requires a methodological improvement to get to define an overall vulnerability of the urban system. It is doubtless that GIS shall play a fundamental role for this issue, much more than for the other ones.

5.3 RESEARCH PROGRAM

The SAVE project will deal with the contents of topic 1 of the Framework Programme, by developing the items relevant to the methods and analyses of seismic vulnerability. The aim is to realise updated vulnerability maps to be combined with suitable hazard maps, in order to improve risk estimation.

From the analysis of the current state of the art, reported in the previous paragraph, it is clear that the project starts from the following two fundamental exigences:

- The need for vulnerability maps at different territorial scales, from the entire national territory to the "Regione" and municipality territories, relevant to different building types, such as residential, public and monumental buildings as well as to urban systems;
- The need to compare, integrate and, at least, harmonise the various approaches now available for the seismic vulnerability evaluations of different objects, as well as to set up new evaluation methods for some peculiar building types and for urban systems, which take into account the data actually available and that are actually applicable to such data.

Quantitatively and qualitatively important data bases are today available, which could be fruitfully utilised to fulfil the above needs, conditioned upon their full computerisation, their rationalisation and that they are made available to the vulnerability researchers. A large part comes from the several projects of "Lavori Socialmente Utili" – LSU (Socially Useful Works), promoted by the Department of Civil Defence (DPC) and the Ministry of Work and co-ordinated by GNDT. They are relevant to public buildings (LSU), residential buildings (LSU and LSU-bis), monumental buildings (LSU-Parchi), lifelines (LSU-Infrastrutture). Like other databases, particularly those relevant to post-earthquake investigations, only part of them have been exploited from a scientific point of view, and represent a great deal of precious information to make vulnerability maps and compare and set up different methodologies.

According to the types of objects on which the specific studies to get directly usable products, such as vulnerability maps, the activities will be organised in the following four tasks:

Task 1. – Inventory and vulnerability of the residential buildings of the national territory; seismic risk maps and socio-economic losses.

Task 2. – Inventory and vulnerability of the public and strategic buildings of Southern Italy (for which LSU data are available)

Task 3. – Inventory and vulnerability of the monumental buildings of the national and regional parks of Southern Italy

Task 4. – Inventory and vulnerability of urban systems.

The above tasks will be developed up to reaching the final result, according to the specific development paths that, in all the cases, will need the following general steps:

- a) Completion of the computerisation (when necessary), rationalisation (when necessary), quality control (when necessary) and putting at disposal of the working group of the most important existing databases, particularly those coming from LSU activities;
 - b) Comparison and improvement of the vulnerability evaluation methods for the single categories (residential masonry and reinforced concrete buildings, public and strategic buildings, monumental and istorical buildings, churches, urban centres, lifelines), in order to integrate and harmonise them.
 - c) Final application of the implemented or improved evaluation methods as in point b) to the databases of point a), get the final research products, i.e. the vulnerability maps of the single categories of objects at the territorial scale the data bases are available.
 - d) Diffusion of the project's results through the implementation of an atlas and of a CDROM containing the risk maps and the data-bases needed for the consultation and reproduction of the different themes.

The above said activities will be specialised and differently calibrate according to the current development stage of the databases and of the evaluation methods.

The project will take advantage by the consulting of one of the greatest international experts in the field of vulnerability, Prof. Robin Spence (Cambridge University). His advise will be carried on through his participation at three seminars, one for each year of the project activity, where the definition, the methodology and the results of the project will be discussed.

The project can also take advantage of the results of similar activities in progress, particularly of those carried by SSN, with which formal and informal co-operation groups will be established.

The working group, including university professors and researchers and GNDT research and technical staff, which in cooperation with the scientific and technical staff of SSN, would develop the present proposal, is made of researchers that in the past have been fully involved in the activities of data collection, elaboration of the databases, implementation of methods of investigation and evaluation of vulnerability, by taking part in a synergic manner to the main working groups that have been dealing with the various aspects of seismic vulnerability since 1980 for GNDT, SSN and DPC. Its composition constitutes a guarantee for the attainment of the objectives that the project will pursue, due to the full availability of the needed know-how and tools, as well as for the full understanding obtained during several years of active and fruitful cooperation.

5.4 MANAGEMENT AND ORGANIZATION STRUCTURE OF THE PROJECT

Task 1. – INVENTORY AND VULNERABILITY OF THE RESIDENTIAL BUILDING STOCK IN ITALY, SEISMIC RISK MAPS AND SOCIO-ECONOMIC LOSSES

Scientist Responsible: Giulio Zuccaro (LUPT-UNINA)
Research Units: LUPT, UNIBAS, GNDT-AQ, UNIGE
Reference sub-themes: 1.7, 1.8

FINAL OBJECTIVES

The main goals of this task are the following:

- definition of a typological and structural distribution map of the Italian building stock;
- analyses of the vulnerability functions at present utilized: DPMs and Fragility Curves, comparison with innovative methods based on numerical-mechanical techniques having probabilistic approaches;
- improvement of the vulnerability and damage evaluation tools by last generation survey forms (AEDES);
- improvement of vulnerability evaluation for reinforced concrete structures divided into typological classes;
- creation of a national vulnerability map.
- Improvement of risk maps at national scale
- First evaluation of the socio-economic losses

The following working phases are identified:

Revision and updating of the Italian building Inventory (LUPT, GNDT-AQ, UNIBAS).

The data-base collected in the LSU/96 and LSU bis projects, related to the centre southern Italy, of the ordinary buildings, requires a completion work regarding the computerization and some checking based on the original documents archived by the Civil Protection. A wide and thorough campaign of data collection, already available in Italy and not yet utilized as a whole, will be performed in order to estimate the inventory of the national building heritage; it has been referred essentially to those data derived from the LSU projects, from the post-event surveys of the last earthquakes in Italy (Umbria-Marche, Pollino) plus other vulnerability evaluation campaigns carried out in several Italian regions, like Sicily, Catania project by GNDT or like in Basilicata

By University of Basilicata or, again, in Campania in the villages of Vesuvian belt and Campi Flegrei environment by LUPT-GNDT-INGV-OV.

These further samples will be merged to the data-base of about 80 communes already available by previous collaborative projects by SSN-GNDT-LUPT. Analyses of representativeness, quality and harmonization of the whole data-base will be performed; to this purpose comparing tests on a suitable sample chosen among the Communes will be done, in that group by which the typological distribution has been randomly collected, with the help of areophotogrammetric method (Baratta and Zuccaro 1989), or verified by survey on field. The new database will be used to adjust the inventory at national scale of the structure typological distribution of the ordinary building stock, based on the census data of the present ISTAT 91 or, if available, the census 2001, tuned on the base of more detailed data now available.

Based on further available data, the working group (WG) will upgrade the characterization study of the structural typology in the Italian urban settlements, derived by previous research experiences of LUPT-GNDT-SSN. This will be performed through the merging between: the data-base available, the compilation of the guided interview protocol, supervised by technicians of the Communes, the

Collection of bibliographical data on a significant number of parameters which will be part of a multimedial database of structural typological characterization at national scale.

Vulnerability of ordinary buildings (LUPT, GNDT-AQ, UNIBAS, UNIGE)

Analyses of the present vulnerability functions: DPMs and Fragility Curves (FG); use of regional DPM and/or representative at national scale and correlated with macroseismic intensity; CF, correlated to the characteristic parameters of the ground shaking (peak ground acceleration, real acceleration, response spectra), and comparison with FC by numerical mechanical methodologies.

The project will investigate on the most upgraded DPMs available (SSN '96, GNDT '2000, WG SSN, etc.) and it will evaluate if could be assumed as representative at National Scale. To this purpose comparative analyses with other vulnerability evaluation methods (CF, Numerical-Mechanical) will be performed, taking advantage from probabilistic and Multi Criteria analyses.

The evaluation of the synthetic evaluation derived by the Communal Vulnerability Index (CVI) introduced by the GNDT '98 project, will be improved; this will be possible through the analysis of the typological distribution of the wider sample of Communes available after the first year of the present project. Therefore the improvement of the

statistical robustness of the “Central Typological Distribution” CTD relevant to the single Communal Vulnerability Class will be possible.

It will be investigated the possibility to achieve at the definition of theoretical statistical parameters that could provide the best fit of the CTD characteristic of the Communal Vulnerability Classes.

To this purpose it will be investigate on the feasibility of possible correlations between the typological characterizations and the vulnerability functions addressed to regional use of them.

Vulnerability of reinforced concrete buildings (LUPT, UNIBAS, GNDT-AQ, UNIGE)

The study of the r.c. buildings will start from the analysis of the operative proposals available at moment and from the data(I and II levels) collected in the surveys performed, in order to determine the analogies between the different approaches, either under the methodological aspects or in terms of results obtained. It will be evaluated the possibility to apply these different approaches to the data available and derived from surveys on the ordinary building heritage. (LSU, LSUbis, etc.). A correlation between the data available from the ISTAT census and the vulnerability characteristics will be then estimated.

The study will be performed on the original drawings of reinforced concrete structures built in different times and regions, comparing the results obtained by the application of the different methodologies.

The reinforced concrete structural typologies typical of Italian settlements (LUPT) and having features which are sensitive to the seismic response (infill panels, soft floors, etc.) will be identified also based on the damages observed in recent Italian and European earthquakes (Umbria, Marche, Turkey, Greece).

Improvement of the damage and vulnerability analyses tools (LUPT, GNDT-AQ, UNIBAS, UNIGE)

The possibility to merge different approaches developed in the past and related to the information derived from the survey forms of I and II level and, more recently, from the AEDES form will be investigated. This effort will be particularly useful in order to maximise the benefit of the information already available or to be collected in the future. To this purpose comparison between different methods making use of the same sample of buildings containing data at different level of detail will be carried out. Regarding the AEDES form possible adjustment in order to improve either its application on the field or the future use addressed to vulnerability evaluation and damage estimation will be studied.

Vulnerabilità Maps (LUPT, GNDT-AQ, UNIBAS)

Realization of seismic vulnerability maps of the building heritage, expressed in terms of Communal Vulnerability Classes and assessed by a Communal Vulnerability Index correlated to the Vulnerability Functions.

Seismic Risk Maps (LUPT)

Realization of National seismic risk maps of the building heritage at communal detail. To this aim the most updated and reliable hazard analysis available and/or possible available hazard studies from project in progress will be used.

First evaluation of damages and indirect losses (LUPT)

The annual evaluation of the economic impact connected with the direct and indirect economic losses, cultural losses and social losses (people involved) will be performed. The analysis will be focused on the identification of suitable functions of correlation between the probability-based seismic input and the level of “expected loss” through the use of existing data, collected on a macro-scale for different earthquakes in Italy and in the world.

The activities will be distributed as follows:

Evaluation of direct economic losses in the residential building stock (LUPT)

They will be estimated through damage-repair and improvement costs correlation, adjusted per different levels of structural and non structural damage (revision and update of cost models). Nation-wide cost-benefit analyses of alternative disaster mitigation policies will also be performed.

Evaluation of indirect losses in the economic production system (LUPT)

The losses stemming from interruption of activity (industry, tourism, commerce, etc.) will be analyzed. The “Sistema Starter” will be employed which includes more than 1000 province-based territorial indicators, 600 of which also contain details at municipality level. The database will feed data to a statistical model based on multivariate analysis techniques. It will first be adjusted on a pilot area recently involved in a seismic event – both pre- and post-event conditions will be assessed (settlement configuration, quality of buildings, levels of production in the three economic sectors, etc.) –; it will then be tested on other pilot areas in order to stabilize the estimates of the regression parameters and to evaluate indirect annual costs stemming from the destruction/activity interruption on a national scale.

Evaluation of casualties (deaths, injured , homeless) (LUPT)

They will be estimated as a function of the structural damage, which in world statistics is given 75% of total losses in case of seismic event. The evaluation model will assess the occupation level of both residential and public buildings, the age distribution of the people, the use of buildings connected with the vulnerability level, and will estimate min and max loss intervals under more or less favourable conditions (time of the day, period of the year). The Istat database will be employed plus LSU data if any. Any other data source will be explored, able to provide indicators of “social vulnerability”.

MILESTONES

First year: *a) Inventory and typological characterization:* Acquisition and harmonization of the data relevant to the LSU campaigns and to others data base already available in Italy (LSUbis, post-event surveys Umbria-Marche and Pollino, Vesuvian Area, etc.). *b) Integration of data:* Feasibility study and integration of the data; check of reliability through identification of a test sample and subsequent collection of data to verify the data base, this will be performed by areophotogrammetric techniques and/or random surveys, if necessary, on the field. *c) Building Vulnerability:* Review of the vulnerability evaluation methods available either of statistical approach or numerical-mechanical; selection of the more representative vulnerability functions. State of the art on the evaluation of the reinforced concrete building vulnerability. State of the art on the parameters of earthquake destructivity and on the correlation with the macroseismic intensity, and choice of the most significant parameters. Improvement of the damage and vulnerability analysis tools through last generation forms (AEDES). *d) Analysis damage-repair costs correlation for the evaluation of direct economic losses in the residential building stock, churches and monumental buildings ; statistic model calibration for the indirect economic losses assessment; methodology in casualties assessment.*

Second year: *a) Inventory and typological characterization:* Analysis of the new data base and definition of the inventory at national scale of the structural typology distributions of the residential building heritage, based on the ISTAT '91 census data or, if available, the 2001 census. New distributions of Communal Vulnerability Indexes per typological class; *b) Building Vulnerability:* Report on the structural features of reinforced concrete buildings built in different times and complying with different codes in Italy, report on the evaluation of the response of frame structures with and without infill panels. Individuation and development of innovative vulnerability techniques based on numerical and mechanical approaches and comparison of these with DPM and CF evaluated for masonry and r.c. structures. Evaluations of the vulnerability functions representative at national and/or regional scale, derived also on the base of the local typological characterizations; *c) Multicriteria Evaluation:* Multicriteria analysis of the parameters concerning the vulnerability evaluation. *d) Vulnerability maps at national scale:* National map of the typological distribution and relevant vulnerability. *e) Seismic Risk maps at national scale:* National map of the seismic risk at communal details compatible with the SSN Data Base, and evaluation of the relevant losses; *f) cost-benefit analyses for mitigation policies;* data collection and elaboration for the evaluation of direct economic losses; check on test area for the evaluation of indirect economic losses; data collection and elaboration for the casualties evaluation; *g) evaluation at national scale of casualties and direct and indirect economic losses.*

Task 2. – INVENTORY AND VULNERABILITY OF THE PUBLIC AND STRATEGIC BUILDINGS OF SOUTHERN ITALY

Scientist Responsible: Mauro Dolce (UNIBAS)
Research Units: UNIBAS, GNDT AQ, LUPT
Reference sub-themes: 1.7, 1.8

FINAL OBJECTIVES

- Inventory and vulnerability of the public and strategic buildings of a wide part of the national territory
- Improvement of the vulnerability evaluation of the Italian public buildings, with particular reference to schools and hospitals,
- Mappa di vulnerabilità degli edifici pubblici per quella parte del territorio nazionale per cui sono disponibili i dati di inventario

The following working phases are identified:

Analysis and integration of the LSU database (UNIBAS, GNDT-AQ)

The database of public buildings (more than 42 000 records) collected by the LSU/96 project, relevant to the mid-southern Italy, requires a quality check on part of them, by verifying the original documents at the Civil Defence Centre. Such database will be integrated with available similar data relevant to some other Italian regions and carefully re-examined, to be included in the new database. It will be elaborated in order to evaluate its reliability, identify the main characteristics of the Italian public building stock, for the different categories of use, carry out a first estimation of the structural vulnerability of buildings based on the available data, define a sample of buildings for the different categories of use, to be further investigated, as explained in the following paragraphs.

Analysis of the characteristics and of the vulnerability of school buildings (UNIBAS, GNDT-AQ)

A characterisation of the school building stock will be made, by determining the statistics of the main parameters that can affect the seismic behaviour of the buildings, so as to single out some representative buildings. The information relevant to the selected sample will be improved through detailed analyses carried out on design plans of schools, to be collected in the special regional offices and by specific surveys. The applicability of the current methods for vulnerability evaluation. On a subset of them, suitably chosen on the base of their typical features, numerical simulation analyses will be carried out, using models at different levels of detail, in order to evaluate their seismic behaviour, vulnerability and fragility curves. In particular the vulnerability estimations derived from the classical first and second level approaches will be compared with mechanical-numerical approaches.

Analysis of the structural and functional vulnerability of hospitals (UNIBAS, GNDT-AQ)

The information relevant to the selected sample will be improved through a detailed analysis carried out on the design plans of hospital buildings, to be collected in the competent offices and by purposely made surveys. At least 20 buildings will be examined. On a subset of them, suitably chosen on the base of their typical features, numerical simulation analyses will be carried out, using models at different levels of detail.

Analysis of the structural and functional vulnerability of other public buildings (UNIBAS, GNDT-AQ)

The investigation will be mainly carried out on the base of the already available information of the LSU database, with the above said improvement and integration. The vulnerability evaluations will also make use of the results obtained for the school and hospital buildings, as well as of the results obtained for task 1, relevant to those residential buildings which are structurally similar to the examined public buildings.

Vulnerability Maps (UNIBAS, GNDT-AQ)

Realisation of seismic vulnerability maps of the public building stock for which data on the structural characteristics are available. The maps will be at least relevant to Southern Italy, for which the LSU data are available.

MILESTONES

First year: **a)** an analysis and extension of the existing data base will be carried out to rationalise it and get statistical parameters, as well as to make it usable by all the research units; **b)** The peculiar characteristics of the structural types of school and hospital buildings will be identified; **c)** further data on the buildings for school and civil use will be collected possibly in Abruzzo, Molise, Puglia, Basilicata, Calabria, Toscana, Emilia and eventually in Umbria, Marche, Lazio and Sicilia; **d)** a part of the activities of the «analytical» vulnerability evaluation of schools and hospitals will be carried out.

Second year: **a)** the collection of further data on the selected public buildings will be completed; **b)** The evaluation of seismic resistance of school and hospital buildings through numerical simulation of their seismic response will be

completed; **c**) on the base of the obtained results, a refinement of the survey methods and of the vulnerability evaluation procedures for public buildings will be made, also to get useful operational tools; **d)** the vulnerability of public buildings will be defined in terms of damage probability matrices and fragility curves; **e)** the results of the investigations will be summarised in seismic vulnerability maps, relevant to the different examined categories of public buildings, in the areas where adequate information are available;

Task 3. - INVENTORY AND VULNERABILITY OF THE MONUMENTAL BUILDINGS OF THE NATIONAL AND REGIONAL PARKS OF SOUTHERN ITALY

Scientist Responsible:

Sergio Lagomarsino (UNIGE)

Research Units:

UNIGE, GNDT-AQ, UNIBAS

Reference sub-themes:

1.7, 1.8

FINAL OBJECTIVES

- Data base of the inventory of the monumental buildings filed by the LSU projects for vulnerability analyses;
- Analysis of the vulnerability functions currently used: DPM's and Fragility Curves, comparison with innovative techniques based on mechanical-numerical techniques, also based on probabilistic approaches;
- Improvement of the vulnerability and damage analysis tools based on inspection forms;
- Vulnerability maps.

The following working phases are identified:

Analysis and integration of the database obtained in the LSU projects (UNIGE, GNDT-AQ, UNIBAS)

The information relevant to monuments collected in the LSU-parks and other LSU projects still require some work to be transformed into computerised complete and easy-to-use databases. Such work will be carried out in the present sub-task, by making the following operations shall be made:

- Organisation in a computerised database of the inventory of the churches of the city of Catania (Sicily), collected with fast inspection forms;
- Selection of the monumental buildings from the public building database;
- Continuation of the elaboration of the Check-lists of all the monumental objects filed in the LSU-parks project;
- Organisation in a computerised database and preliminary elaborations of the forms relevant to specific types: bell-towers, monasteries, castles, fortified walls, buildings, theatres, archaeological sites.

Improvement of the first level approaches (UNIGE, GNDT-AQ, UNIBAS)

The elaborations of the damage survey data collected after the recent Italian earthquakes have lead to a vulnerability evaluation method for monumental buildings that can now be used also for prevention scopes. The statistical analyses carried out on damage and vulnerability data of the earthquake of Umbria e Marche, Pollino, Arezzo, Lunigiana e Garfagnana, Lazio, Asti ed Alessandria, have permitted to set up methods similar to those used for ordinary buildings. Methods based on a typological classification with associated DPM's and methods based on a detailed evaluation leading to a vulnerability index for each building.

The LSU-parks project was devoted to the inventory of the monumental heritage in the national and regional parks of Southern Italy. A great amount of information at two detail levels are now available:

- a) Check lists: are simple lists of objects, with some information on the age, preservation state and exposure;
- b) Vulnerability forms specialised to the different typologies of monument, including more detailed information. For churches the forms of the Umbria-Marche earthquake have been used.

It is now time to exploit all the collected information and define a method for the vulnerability analysis of the monumental heritage, conceptually similar to the methods for ordinary buildings, which can be used in probabilistic analyses of the seismic risk or in earthquake scenarios.

The first level of analysis is one that uses «poor» data, i.e. collected with fast surveys. The present research is aimed to define a typological classification of monuments (church, tower, monastery, building, villa, arch bridge, etc.) and define an average vulnerability for each type. Such evaluation has already been made for churches, since the observation of the suffered damage permits to predict the expected damage distribution in a population of churches for a given earthquake (DPM). These distributions can be well approximated with binomial distributions and exhaustively described with a single damage parameter (*mean damage*). The trend of the mean damage while increasing the seismic intensity gives a *vulnerability curve* which permits to predict the seismic response of the churches in a given area for a given earthquake. In general churches are more damaged than buildings for low intensity earthquakes and similarly damaged for high intensity earthquakes.

The above considerations clarify that each monumental typology, according to the typical geometrical shape of the single objects (e.g. obelisk, tower, castle) and materials, has its own vulnerability curve. In other words each type of monument has a different damage activation threshold and a different slope of the vulnerability curve. The present subtask is aimed at defining the vulnerability curves for the different types of monuments, based on the observation of the damage occurred in the past earthquakes and simplified numerical and analytical models. The data available from the fast survey (check-lists) should permit to refine the evaluation of the typical behaviour of each typology. The preservation state, the quality of materials, the urban environment and the site conditions can be, among others, parameters to be taken into account in the vulnerability models.

Improvement of the second level approaches (UNIGE, UNIBAS)

The second level of analysis requires a more detailed information on the constructive and structural characteristics. The most effective approach is based on macro-elements, i.e. well defined architectural elements having a behaviour almost independent from the rest of the building. The «church» form used in Umbria and Marche is based on this concept and already includes a section for vulnerability evaluation that singled out the constructive inadequacies of the macro-element, emphasised by the earthquake. This approach is very effective for the usability judgement after an earthquake, but in view of its use for prevention it is less effective and often uncertainties of the surveyors come out. Part of the research activities will therefore devoted to some revision of the form, without introducing modifications that make the existing database of filled forms unusable. For example, in the case of large or irregularly shaped churches, the only eighteen collapse mechanism of the form generates often some confusion in attributing local vulnerabilities. The new form, then, shall consider a greater number of mechanisms, to improve the mode of use of the form.

New survey forms will be set up for other typologies of monuments

To improve the vulnerability estimation of churches and other monumental typologies, numerical dynamic analyses to study the tilting of masonry walls under seismic actions will be carried out. For buildings both the global tilting around the external edge of the base and partial tilting around rotation axis at the floor will be studied. The models will take account of the eventual connection to the orthogonal walls and of the influence of the horizontal structures. The thrust of vaults, the resistance to slipping of girders and the action of tie rods will be taken into account. The dynamic models for tilting around a horizontal hinge will be extended to consider more complex collapse mechanisms, where vertical and inclined hinges can form, which are particularly suitable for the analysis of churches.

The need of using a dynamic model in the study of the tilting response of slender element comes from the low frequency which characterise the tilting phenomena (0.2-0.5 Hz) and which makes the soil displacement to be the governing parameter. This can make the equivalent static analysis inadequate.

Vulnerability maps of monumental buildings (UNIGE, GNDT-AQ)

The first and second level methods will be implemented in a GIS, to evaluate automatically seismic risk and damage scenarios, for given hazard. In case of a large scale analysis (e.g. for the large database of LSU-parks) it is sufficient to refer to the administrative limits of municipalities or urban localities. In case of second level analyses it is necessary to consider the single monuments. For both levels some case studies will be examined.

MILESTONES

First year: **a)** Computerised data-base of the information on monuments obtained with the LSU activities (parks, Catania-church, public buildings); **b)** implementation of a first level methods for monuments; analysis of the data of the damage survey of Umbria and Marche to define a typological classification and single out the vulnerability parameters; **c)** Analysis of the form “church”, to include more collapse mechanisms and single out the constructive elements to be inspected; **d)** development of the GIS procedures for the analysis of vulnerability at regional scale, with poor data.

Second year: **a)** re-elaboration of the check-list data; elaboration of the data drawn from the forms of specific typologies (towers, monasteries, castles, theatres, etc.); **b)** Analysis of the data collected with the LSUparks project and implementation of a model which defines the vulnerability parameters from the check-list data; **c)** Numerical analyses with non linear models to quantify the influence of the surveyed parameters on vulnerability ; **d)** Vulnerability analyses on some areas for which LSUparks data are computerised; damage and loss scenarios based on the available hazard maps.

TASK 4. - INVENTORY AND VULNERABILITY OF URBAN SYSTEMS.

Scientist Responsible: **Alberto Cherubini**
Research Units: UNIBAS, GNDT-AQ, LUPT, UNIGE
Reference sub-themes: 1.7, 1.8

FINAL OBJECTIVES

- Data base of the inventory of the lifeline elements, of the building vulnerability and of the global evaluation of the vulnerability of the centres. All these elements contribute to determine the vulnerability of small urban systems.
- Set up of methods for the vulnerability evaluation of small urban systems;
- Realisation, as pilot applications, of seismic vulnerability maps of the urban system of one or more municipalities for which data bases relevant to both buildings and lifelines are available, with both analytical and global approaches.

The following working phases are identified:

Analysis and integration of the database derived from LSU projects (UNIBAS, GNDT-AQ)

From the LSU-lifeline project a great amount of information has been obtained and collected in specific forms. They are relevant to network and nodes of urban lifelines: transport, electrical power, water, gas, etc. A great part of the relevant forms have not been put in a computerised database. Preliminarily, it is then necessary to computerise at least part of the LSU-lifeline forms and integrate such data with those relevant to public and private buildings, focusing the attention on some case studies for which the information is complete.

Set up of an analysis method of the seismic vulnerability of the main lifelines (UNIBAS, GNDT-AQ)

With reference to the type of information drawn from LSU-lifelines, the most suitable methods for the vulnerability evaluation of urban lifelines, taking into account the vulnerability of the critical components and their distribution in the lifeline, will be studied and compared.

Set up of an analysis method of the seismic vulnerability of urban systems (UNIBAS, GNDT-AQ, LUPT, UNIGE)

Starting from the current analysis procedures for vulnerability evaluations, an integrated system for the analysis and the representation of the vulnerability at urban scale, taking into account the vulnerability of buildings and lifelines, with both an analytical approach and a global approach, will be developed. For the vulnerability of buildings, the approach is mainly based on the exploitation of the so-called *fast-method*, a procedure already used and suitable for the evaluation of the vulnerability of buildings of urban centres.

The integrated system is based on hierarchical information levels. Starting from the general typological information of a centre, it includes the vulnerability data of residential buildings and of the other buildings and lifelines (monuments, churches, industrial buildings, transport lifelines, etc.). The system operating on a unique computerised database, also in a GIS, is the best mode of representation for all the risk analyses, also to better understand and evaluate the different aspects of the seismic vulnerability in an urban environment (structural blocks, induced vulnerability, etc.).

The *fast method*, on which the attention will be focused, is relevant to ordinary buildings and is based on a suitably selected subset of the information required in the first and second level GNDT form, in order to speed up the survey operations. This technique has been used in the LSU and other projects, producing large databases, where also information of upper level are available. It is thus possible to set up and calibrate vulnerability evaluations based on the fast survey method and validate its effectiveness.

The potential of this approach will then be explored and all the necessary tools (inspection forms, manuals and software) will be improved and standardised, in order to make its use easy to all the possible users (National and local civil defence offices).

Seismic vulnerability maps of the urban systems of one or more case studies (UNIBAS, GNDT-AQ, UNIGE)

Realisation of case-studies for the application of the methods and the results which will be obtained from the previous activities in some urban centres. Vulnerability data of buildings at different level of detail and for different building types as well as data on the urban lifelines will be available. It will thus possible to apply and compare different methods for the vulnerability evaluation, to verify the ISTAT census data on the residential buildings and also to test the methods for the preparation of earthquake urban scenarios.

MILESTONES

First year: **a)** completion of the computerised database relevant to lifelines, fast method forms for buildings, urban centre forms; **b)** identification of the centres with the maximum and minimum information content; **c)** calculation of the distributions of the main parameters considered in the forms; **d)** State of the art on urban vulnerability and application of the different approaches.

Second year: **a)** selection of a centre with complete information to make more accurate analyses; **b)** set up of an analytical approach, based on puntual data on buildings and lifeline components, and of a global approach, based on the urban centre forms; **c)** set up of modes of representation to better display the seismic problems of the urban centres; **d)** preparation of the GIS of the selected small centre, testing the usefulness of the data directly for the preparation of risk maps, emergency scenarios and prevention.

5.5 TABLE OF THE RESEARCH OBJECTIVES AND ANNUAL MILESTONES

Task	Products	
	1 st year	2 nd year
1	Intermediate report Database of available vulnerability data of the residential buildings State of the art of the methods for vulnerability evaluations	Final report Vulnerability Maps of residential buildings at national scale Upgraded tools for the analyses of vulnerability and damage for ordinary buildings
2	Intermediate report Rationalised and integrated database of the information on the vulnerability of the public buildings of Southern Italy Characterisation of the most common structural types	Final report Vulnerability Maps of the public buildings of Southern Italy Upgraded tools for the analyses of vulnerability and damage for public buildings
3	Intermediate report Database of the vulnerability information on the monuments collected within LSU activities State of the art of the evaluation methods of the vulnerability of monuments.	Final report Vulnerability Maps of the monuments of national and regional parks of Southern Italy Upgraded tools for the analyses of vulnerability and damage of monuments of first and second level
4	Intermediate report Database of the vulnerability data drawn from fast surveys and of the lifelines in the centre surveyed by LSU projects State of the art of the evaluation methods of the vulnerability of urban systems.	Final report GIS of one or more centres for the representation of the seismic vulnerability of the urban system Upgraded tools for the analyses of vulnerability of urban systems

6. COST

Category of cost	LUPT		UNIBAS		GNDT-AQ		UNIGE		Total cat. of cost	
	Year		Year		Year		Year			
	I	II	I	II	I	II	I	II		
Durable	7500	2500	8000	4000	4000	2000	8000	6000	42000	
Consumables and other general costs	18000	9000	8000	8000	5000	3000	6000	5000	62000	
Travel and subsistence	3000	3000	3000	3000	2000	2000	3000	2000	21000	
Contracts and fellowships	21000	21000	26000	26000	15000	15000	22000	18000	164000	
Meetings and congresses	4000	4000	3000	3000	3000	3000	2000	2000	24000	
External services	56000	25000	35000	15000	20000	10000	2000	2000	165000	
Pulications	500	500	2000	2000	1000	1000	1000	1000	9000	
Other costs	4000	2000	0	0	0	0	0	0	6000	
Total I year	114000		85000		50000		44000		293000	
Total II year		67000		61000		36000		36000	200000	
Total		181000		146000		86000		80000	493000	

Costs are in Euro

The Co-ordinators of the Project

Prof. Mauro Dolce

Prof. Giulio Zuccaro