1 Introduction

Claudio Borri
University of Florence

1.1 OBJECTIVES

The project “LIFE-CYCLE PERFORMANCE, INNOVATION AND DESIGN CRITERIA FOR STRUCTURES AND INFRASTRUCTURES FACING EOLIAN AND OTHER NATURAL HAZARDS” (2003-05, in the following referred to as **PERBACCO**, according the semi-acronym that the participants unanimously accepted), within the Research Projects of National Interest (PRIN) of MIUR, has been launched and carried out as a natural follow-up of two previous projects in the same line, namely: “WIND AND INFRASTRUCTURES: DOMINATING EOLIAN RISK FOR UTILITIES AND LIFELINES” (WINDERFUL, 2001-03) and “ANALYSIS, CONTROL AND MITIGATION OF AEOLIAN RISK ON CONSTRUCTIONS AND URBAN ENVIRONMENT” (ACME CUE, 1999-01). These two “predecessors” were run almost by the same research teams as in PERBACCO and giving rise of many questions in terms of risk and performances of major structural systems facing the storm hazard.

It is important to underline, that the research group has reached, in recent years, a very high degree of synergy and cooperation, mainly due to the common large scale research facility given by the large Wind Engineering laboratory of CRIACIV, situated in Prato (nearby Florence) and managed by six Italian Universities (CRIACIV is the Italian acronym for “Interuniversity Research Centre for Building Aerodynamics and Wind Engineering”). About 35 researchers are working together from different places on common projects, including the series of PRINs (all financed in the last 15 years), with the main aim of promoting wind engineering and eolian risk in the country and internationally (important international/European cooperation have also been developed in the last years).

The present volume, which resumes the main outcome of the project, has a double aim: the first is to make the achievements more visible and sustainable for a wider scientific community & audience; the second arises from the more extensive version of the results which have been much deeply evaluated during the time elapsed after the project conclusion (about 4 months). Usually the closure of such a wide bi-annual project requires many efforts (inclusive the administration ones) and the scientific results are normally suffering a reduced space (also due to the web procedures tool available: the MIUR/Cineca web-site).

Performance of Wind Exposed structures: results of the PERBACCO project. ISBN-10: 88-8453-453-4 (online), ISBN-10: 88-8453-454-2 (print) © Firenze University Press

As an introduction, the present Chapter is far from pretending to exhaust the wide range of activity carried out: in the following 8 Chapters, the contributions of all research Units will be developed and widely presented, under the coordination of a Chapter responsible.

The main objective of the project was to introduce, in the current practice of building construction, the idea of the minimization of the ratio between costs and benefits, rather than the simple minimization of costs, for the entire cycle of life of structures and infrastructures.

This goal is achieved by means of the following intermediate strategic actions:

A) To furnish a unique method to evaluate the concept of "expected performance" and of "risk due to wind and other natural hazards", involving building and infrastructural works, for their full cycle of life, which would be acceptable for all the people involved in the building process, from the owners until the customers;

B) To develop models and tools to the dynamic/evolutionary monitoring of the performances of structures under wind action, integrated in an especially built procedure;

C) To pick up, to record, to refine, to spread and to promote the specific knowledge as it could be received and adopted by the building industry.

A further transversal work is intended to be done, looking for a stricter integration of the national research project with the European one, in the circle of 6 PQ of RST, area 3.3 (New production processes and devices).

The actual project, in fact, is a component of a bigger and all-embracing European project (PERBRISK, proposed and coordinated by CERTH from Thessalonica, GR), in which each of the workgroups (under the guide of the same Institution coordinating the present proposal), is involved specifically in the analysis of the influence of naturals hazards on the performance indicators of some classes of structures, for their entire cycle of life.

The contribution of this Research Program of National Interest (Italian) to the requirements of the European Project Work Package 5a is focused on the following points:

- Innovation of processes and methods;
- Integration of design and demolition/removal phases in the life cycle of the structure;
- Developing/Promotion of new materials and/or innovative procedures to reduce vulnerability;
- Updating of building methods/processes;
- Probabilistic approach to the performance evaluation methodology (expected performances);
- Reduction of construction costs and/or reduction of the ratio costs/benefits;
- Increase of sustainability in the building process and in the quality of living;
- Increase of transport safety.

Even if, formally, it is not possible to joint Research Units out of the University, (Companies, Research Corporations, Insurances, Consulting Companies, Professional Institutions), this project works for positioning itself in the innovative way of strong interaction with building industry and other research institutions (out of the Academy). In cooperation with some of them, several points have been have been identified and analyzed as CASE STUDIES. In particular, with reference to such case studies, the analysis of performance indexes for the full cycle of life (including design and demolition/removal phases), considered crucial for the final objectives, was considered.

Main topics, corresponding, roughly speaking, to the operative research units, are identified as follows: definition of the risk to natural hazards and to the "expected performance" during the full cycle of life; tools and experimental techniques for wind tunnel, cable systems (power lines), bridges and large infrastructures like "life-lines"; towers, pylons and line-like structures; control and damping of vibrations, building and industrial implants, (as, for example, offshore structures and cooling towers); light-weight roofs, mixed deformable structures; telecommunication systems (spars, guyed mast); comfort in urban sites.

The performances for the full cycle of life, the innovation and the updating of design criteria could be referred to a certain number of "key parameters", which would be considered, in each case, amongst safety, resistance, ductility, lightness, durability, sustainability, innovation (of materials and structures), possibility of removal, renewability, quality of life.

In order to define such "key parameters", the Project has taken charge of the following tasks:

- Analysis of extreme events or events which are strongly penalizing the performance of the systems;
- Definition of analysis processes and achievement of the performances;
- Analysis of the key performance factors, by means of the evaluation of the "key indicators";
- Develop of prediction models for the performances;
- Application of the models to the case studies for the determination of the "expected performance"
- Analysis of costs and benefits, each of them corresponding either to a single part or to a full work phase within each Operative Unit, with the goal, in any case, to analyze the already recalled case studies.

1.2 OUTCOMES

In closing this research, the coordinator wishes to emphasize that once again the group of research units have worked with much synergy, passion and competence. The research units have put human resources and own equipments in order to fulfil the proposed aims. As already mentioned before, the wind engineering laboratory of CRIACIV in Prato has been again the binding element from the experimental point of view (an aspect of absolute importance in research activities such as this one). An example of that is the support to the experimental activity of the Units of Perugia (on cable systems), of Chieti-Pescara (on multi-box bridge decks), of Reggio Calabria and Trieste (on vortex-shedding from cylindrical bodies).

In the detail, the activities carried out may be summarised out of the 9 research Units as in the following.

1.2.1 Research Unit of Rome “La Sapienza”

Although the Performance-Based Design (PBD) has developed above all in the field of seismic engineering, it can be extended also to other fields of engineering, among which wind engineering. The research Unit of Roma “La Sapienza” has developed a first attempt to such extension, a particular category of structures has been considered for sake of simplicity, i.e. high buildings.

Suitable target performances has been identified and categorized in two groups:

- Low performance levels:
  1. The probability to exceed the limit state of structural collapse of the building is less than PF1 for a given value of the average return period
  2. The probability to exceed a given level of damage of the facade of the building is less than PF2 for a given value of the average return period
- High performance levels:
  1. The probability that the occupants of the last level of the building feel seek due to the wind induced oscillations is less than PF3 for a given value of the average return period
  2. The probability that discomfort conditions for the pedestrians take place in the surrounding zone of the building, due to wind flow around the building itself, is less than PF4 for a given value of the average return period

According to the selected performance objectives, it is possible to define suitable damage measures (DM) and suitable parameters of structural response (EDP). The damage measure may be based on the evaluation of the repairs required to restore the undamaged state and represented through the fragility curves. It remains opened the problem to develop fragility curves to wind for specific classes of buildings. In this research several methodologies have been proposed.

1.2.2 Research Unit of Florence at CRIACIV

The research Unit of Florence (at CRIACIV, i.e. the coordinating Unit) has investigated the risk connected to aeroelastic instability of structures, with regard to the evaluation of the vulnerability in serviceability condition and to the collapse limit state. In particular, experimental campaigns and numerical studies have been carried out on the phenomena of the vortex-synchronization and flutter.

A) Analysis of the vibration level induced by vortex-shedding. The aeroelastic model of a chimney has been studied experimentally varying the intensity of turbulence of the incoming flow and the mechanical characteristics of the physical model. The results led to the definition of numerical models for the evaluation of the response in synchronization regime and for the fatigue risk assessment. The model has been tested on 27 real chimneys, using the actual distribution of probability of the wind in the location of the chimneys under investigation.

B) Aeroelastic analysis of bridge decks. The research unit has proposed a probabilistic approach to flutter allowing of the definition of the critical wind velocity in a statistical way. Moreover, the possibility of simplifying the approach to the problem has been considered, by reducing the number of the aeroelastic derivatives of interest. This method may be very useful during the preliminary design phase of a bridge. The model has been validated thanks to several data in the literature and also performing experimental tests on a bridge-deck model with trapezoidal cross-section with lateral cantilevers. Moreover, the possibility of using the indicial functions to evaluate the bridge performances has been considered. This part of the research also included the simulation of structural nonlinearities and the evaluation of the effectiveness of different structural schemes. Finally, the research unit has studied the behaviour of a real footbridge in Ruffolo (Siena) under wind excitation.

1.2.3 Research Unit of Chieti/Pescara

Aeolian risk in bridges was the mainly focused and investigated by the Unit at Univ. of Chieti “G. D’Annunzio”, Pescara campus). During the first year, an experimental campaign to measure real wind has been carried out. The objective was to obtain information on the actual characteristic of the turbulence in urban and extra-urban areas. Large area has been put under investigation, considering distances up to several hundred meters. This way, it has been tried to fill a gap in the scientific literature, and the measures may be useful for bridges of different length. As far as the recurrent eolian actions, the research included structural monitoring. In particular, techniques and algorithms for the structural identification has been developed, based on ambient vibration (wind, traffic), without the need of measuring them directly (unknown input).

During the second year of research the aerodynamic and aeroelastic behaviour of multi-box bridge decks has been investigated, from the whole-structure performance point of view. In particular, it has been lead a parametric study on the aeroelastic response of multi-box deck bridges varying the distance between the boxes. The experience acquired by the local coordinator of the unit during the studies for the design of Messina Strait Crossing has been useful in this part of the project. Those studies aimed to the best performances in that specific situation (3300 m main span and the exceptional deck width of 60 m with 10 lanes, two maintenance lanes and two rail tracks). In that situation it was immediately clear that the standard suspension scheme did not require further modification (with the shape of the main cable produced by their self-weight and by the weight of the deck transmitted by the hangers). Therefore, the study of the aerodynamics (although complex) was sufficient to guarantee optimal performances in terms of aeroelastic stability and of vortex-induced vibrations. To date, it is necessary to extend the study for the Messina Bridge to different span lengths and different suspension schemes.

The research aimed to investigate the relationship between the required performances of such a bridge in terms of suspension system, traffic volume and span length. The research theme is the opportunity of accept bridge decks with lower aerodynamic characteristics in the cases in which these might be less expensive (as it happens in case of shorter spans). Different structural solutions (such as crossed hangers) may be used to the purpose of obtaining greater torsional stiffness, in such a way as to achieve the same acceptable performances in terms of aeroelastic stability (“flutter”), vortex shedding, etc.

In this project theoretical and numerical analyses and wind tunnel experimental tests has been carried out. Even if one gives only a comparative value to the results obtained so far, they already appear as very encouraging. It is highlighted in fact the possibility of building decks for very long span bridges which are stable even considering a separation between the boxes of the deck which is much smaller of the one that has been considered so far. This reduction of the deck width would result in a remarkable reduction of the building costs.

1.2.4 Research Unit of Perugia

Dynamic behaviour of cables under wind action may be origin of several discomfort, fatigue and other sources of risk; the Unit at Univ. of Perugia has focused its attention on it. This has been done through experimental tests in the wind tunnel (in cooperation with the research Unit at CRIACIV). A specific model has been built and tested under laminar and turbulent flow. At the same time, a numerical model has been developed and the numerical and experimental results have been compared. The numerical model may be used to perform the stochastic characterization of the response by varying the geometrical and mechanical parameters of the cable and of the wind turbulence. A specific experimental campaign for the evaluation of wind action (drag, lift, and moment) on real-scale part of structural system for mobile phone communication has been also carried out, varying the configuration of antennas and parabolic dishes as well as wind direction and velocity. Moreover, in order to improve the performances of such systems, a new typology of cable-stayed antenna has been developed. This is characterized by a specific lattice connection between the body and the stays, which has a positive effect on the moments on the body and increases the elastic stability threshold.

Methods for the estimation of the expected maxima of wind action (applied to low buildings) have been analyzed, together with a mixed model for the correct modelling of pressure field. Finally, a multi-objective optimization procedure has been developed for the dynamic of the considered structural typologies.

Following goals have been fulfilled:

- identification of the parameters required for the description of the structural behaviour of telecommunication towers (considering the single structural elements and the overall system);
- characterization of the force acting on these structures through wind tunnel experimental tests;
- estimation of the maxima starting from finite length time histories;
- identification of the parameters for the evaluation of the expected performances and of the serviceability;
- criteria of optimization of structural systems with following increase of the ratio benefits/costs.

1.2.5 Research Unit of Venice

The research Unit at Univ. IUAV in Venice has developed its work according to the phases summarized in the following.

1. and 2.: analysis of events that penalizes the performance of the structure and definition of the processes of analysis and of performance determination. Load models have been developed through the combination of wind tunnel experimental tests and numerical simulations. Moreover, structural models for the study of the overall mechanical response and for the determination of the expected performance, accounting for the fluid-structure interaction (according to the structural typology: rigid or aeroelastic structures) have been also developed. Simplified analyses based on the proper orthogonal decomposition (POD) of signals have been validated, leading to the synthesis of possible application in the field of structural design;

3.: analysis of performance factors through the calculation of the ‘key-indicators’. As far as the light roofs, a synthesis of performance factors have been sketched up through the identification of ‘key-indicators’, their quantification and the creation of relevance tables between the value of the indicator and the performance level;

4.: development of performance prediction models. The design methodology developed for the large roofs considers the realization of a system ‘open’ to retrofit solution in case the monitoring of the structures would highlight the necessity of that. This has been applied to the new Braga Stadium;

5.: development and promotion of new materials and of devices for vulnerability reduction: cables equipped with viscous damping systems in their final part near the connections with the deck have been studied. The results show that these systems are more efficient than those with localized damping in the mitigation of vibrations for the modes higher than those for which the system has been optimized;

6.: application to study cases for the evaluation of the expected performance. The above exposed techniques have found an interesting application again in the Braga Stadium (Portugal), which has been analyzed both with simplified analysis tools and with numerical models coupling fluid and structures and including geometrical nonlinearities. These simulations have highlighted that the development of specific numerical models allows a better characterization of the structural response of complex systems like the case studied.

1.2.6 Research Unit of Trieste

According to the initial plan, investigations on risk due to vortex shedding of chimneys and slender structures was carried out by the research Unit at Univ. Trieste, which has reported of following main outcomes:

a) Experimental campaign of aeroelastic model in the wind tunnel.
b) Further development of the experimental campaign on aeroelastic model in the wind tunnel of the CRIACIV, in cooperation with the Firenze-CRIACIV research unit.
c) Real-scale experimental campaign. An experimental campaign has been carried out on the chimney of the new incinerator in Trieste. Displacement and acceleration time-histories at the chimney top have been measured through satellite positioning techniques, together with the wind direction and velocity.
d) Numerical and analytical modelling of the load due to vortex shedding. Simplified laws have been found in lock-in regime, relating the amplitude of the oscillations to the magnitude of the load, its frequency and phase with respect to the oscillation of the structure.
e) In a first phase an iterative analytical procedure has been developed. In a second phase, a numerical model has been derived, based on the same simplified empirical laws.

f) The analyses on the behaviour of suspension bridges in serviceability condition have been further developed in cooperation with the research unit of Chieti-Pescara, with particular regard to vortex induced vibrations.

1.2.7 Research Unit of Reggio Calabria

The problem of comfort analysis under wind action in urban environment has been faced through the analysis of results available in the literature and through experimental tests. The research Unit at Univ. Mediterranea of Reggio Calabria, in particular, analysed the literature reports on experimental and numerical results of the characteristics of the eolian circulation at low heights in the urban environment. These studies were aimed to define the way how polluting substances are diffusing within cities and urban areas. Although the results are very limited in number, they provide useful qualitative and quantitative information on the parameters of the eolian circulation in street canyons. Consequently, the available data have been integrated with those obtained from experimental tests in CRIACIV boundary layer wind tunnel, where the components of wind velocity have been measured on a model of urban area with simple regular geometry. The measurements led to the definition of average velocity profiles, of turbulence indexes and turbulence scales, of Reynolds stresses, of probability density functions and spectra of turbulent components, and of the peak factors. The set of results available has been used for the definition of criteria for the estimate of the characteristics of eolian flow in urban environment.

A second research topic was dealt with by the same Unit, which concerns with the discomfort induced by structural vibrations. Here the literature information has been analyzed, developed and organized. As regard to the particular case of vibrations in pedestrian bridges, an experimental program on pedestrians crossing very flexible footbridges has been started. The first results are already available and have been used to define design criteria for flexible structures.

1.2.8 Research Unit of Naples “Federico II”

The research activities of the Unit at Univ. of Naples "Federico II" have concerned with mainly two topics: the definition of life-long design strategies of control devices (A) and the development of micro-macro behaviour models of the devices (B).

With regard to the topic A, the response to eolian a seismic actions of footbridges and buildings, where passive and semi-active control systems have been installed, has been studied. The results obtained demonstrate that the usage of such devices not only avoid the structural collapse under exceptional events in an economically convenient way, but also completely avoid structural damage with great benefits in terms of the overall durability of the building. The activities consisted in the development and optimization of dynamic control systems included the definition of suitable design methodologies for footbridges and buildings. Studies have been carried out also on the applicability of passive isolation systems and devices for the reduction of the vibrations induced by trains. For the latter aspect, simplified analytical models have also been developed.

As for the topic B, phenomenological models of the control devices have been developed. The validity of such models has been demonstrated in the prediction of the dynamic response of different structures under several vibration inputs. In particular semi-active devices based on magneto-reologic fluid have been considered. For these devices, detailed experimental tests have been performed, aiming to the evaluation of the delays induced by the control electronics and by the mechanic response.

A further result that may be considered a product of the research due to the synergic work of the research units of the PERBACCO project (CRIACIV and Napoli units above all) has been the presentation of a proposal of European project by the CRIACIV, answering to the "Collective Research" notification of the VI Program (published in December 2004) and called MOISER (Market Oriented Innovative SEismic Rehabilitation).

1.2.9 Research Unit of Florence

The research activity at Univ. of Florence, Dept. of Civil Engineering (Firenze-DIC) has almost entirely followed what has been originally planned, i.e. 1. “Global wind actions on structures”, 2. “Local actions on building claddings and surfaces” and 3. “Assessment of eolian vulnerability and risk”

Within topic 1. and 2., Modelling and simulation of non-Gaussian pressure field on the surface of largely extended structures (like an isolated cooling tower) has been performed through a transfer function applied to a Gaussian field for which expressions of the mean and spectral structure have been given. Reconstruction of non-Gaussian pressure field have been measured on wind tunnel models. Some new large roofs of sport plants/arenas have been analyzed in close cooperation with the Unit at CRIACIV, namely: the Olympic soccer stadium in Pyraeus, the new roof of Delle Alpi stadium in Turin, and the new roof of the small Manfredonia stadium.

The research Unit has developed a numerical procedure for the reconstruction, through radial basis neural networks, of non-Gaussian pressure fields based on wind tunnel measures. Simulation of non-Gaussian pressure time-histories through non-linear auto-regressive models has been carried out, developing a non-linear auto-regressive model based on radial basis neural networks. The generation of a scalar progress has been implemented.

As for topic 3., the possibility of reducing the computational cost for the non-linear analysis of the behaviour of cracked reinforced concrete or masonry structures through principal coordinate decomposition of the motion has been studied. Reliable results have been obtained on cooling towers but the methodology does not apply in a satisfactory way to different structures (such as masonry chimneys).

1.3 SOME PRELIMANARY CONCLUSIONS

The previous (allow me to use the expression “impressive”) overview, shows very clearly the outstanding vitality of the research group and its capability to work with a very high synergy effect. Although this might be a natural, long lasting phenomenon due to the many previous projects that the group has performed in previous years, the research outcomes may be considered unique in the entire national scientific scenery.

For sure, the group working in PERBACCO has represented the most accredited and entitled research pole in Wind Engineering in Italy, for a long period, thanks to a successful and efficient cooperation strategy which has become, nowadays, well consolidated.

The Author of this Introductory Chapter, being at the same time the national Scientific the Coordinator of the project, gives the chance to acknowledge sincerely everybody’s contribution to the project in the past 2 years. It would be too long here to mention and thank all the participants (Ph.D students, technicians and administrative staff, research engineers and associates, Professors) who have contributed actively, at different levels.

Only a great “Thank you!” I cannot omit here and this goes to the four Editors of this volume, Prof. Gianni Bartoli (Florence), Prof. Francesco Ricciardelli (Reggio Calabria), Prof. Anna Saetta (Venice) and Prof. Vincenzo Sepe (Chieti/Pescara), and to Dr. Chiara Bullo, of Firenze University Press, for their heavy work and supportive commitment.

1.4 RESEARCH UNITS

Unit #1

Dipartimento di Ingegneria Strutturale e Geotecnica – Università degli Studi di Roma “La Sapienza”

Research Theme:	**General approach to risk evaluation for combined natural hazards and to design criteria aimed at optimal lifelong performances**	
Coordinator:	Giuliano AUGUSTI	Full Professor
Components:	Carlo PAULOTTO	PhD
	Paolo Maria MARIANO	PhD

Unit #2

CRIACIV (Centro di Ricerca Interuniversitario di Aerodinamica delle Costruzioni ed Ingegneria del Vento) – Università degli Studi di Firenze

Research Theme:	**Risk levels definition and performance analysis**	
Coordinator:	Claudio BORRI	Full Professor
Components:	Gianni BARTOLI	Associate Professor
	Serena CARTEI	Secretary
	Carlotta COSTA	PhD student
	Claudio MANNINI	PhD student
	Stefano PASTÒ	PhD student
	Lorenzo PROCINO	Technician

Unit #3

PRICOS (Dipartimento di Progettazione Riabilitazione e Controllo delle Strutture Architettoniche) – Università degli Studi “G. D’Annunzio” di Chieti-Pescara

Research Theme:	**Performance, service conditions and durability of bridges, life-lines and other large infrastructures subject to wind and to other natural loads**	
Coordinator:	Piero D’ASDIA	Full Professor
Components:	Cristina BRUSAPORCI	PhD
	Pasqualino CARUSI	PhD
	Mariella DIAFERIO	Assistant Professor
	Sofia FEBO	PhD student
	Massimiliano ORONZO	Technician
	Marcello PETRANGELI	Consulting Engineer
	Marco PETRANGELI	Associate Professor
	Vincenzo SEPE	Associate Professor
	Massimo TARQUINI GUETTI	Consulting Engineer
	Alberto VISKOVIC	Assistant Professor

Unit #4		
Dipartimento di Ingegneria Civile ed Ambientale – Università degli Studi di Perugia		
Research Theme:	**Expected performance and new design criteria for structural systems used to support communication devices affected by wind loads**	
Coordinator:	Vittorio GUSELLA	Full Professor
Components:	Marco BRECCOLOTTI	PhD student
	Federico CLUNI	PhD student
	Massimilano GIOFFRÈ	Assistant Professor
	Ilaria VENANZI	PhD student

Unit #5		
Dipartimento di Costruzione dell'Architettura – Università IUAV di Venezia		
Research Theme:	**Performance analysis and design criteria for flexible structures under eolian and other natural actions: lightweight roof and suspension systems**	
Coordinator:	Massimo MAJOWIECKI	Associate Professor
Components:	Nicola COSENTINO	PhD
	Massimiliano LAZZARI	PhD
	Emilio MEROI	Associate Professor
	Anna SAETTA	Associate Professor

Unit #6		
Dipartimento di Ingegneria Civile – Università degli Studi di Trieste		
Research Theme:	**Theoretical and experimental studies supporting design of slender structures under wind loads. Design criteria for towers, chimneys and masts**	
Coordinator:	Salvatore NOÈ	Associate Professor
Components:	Claudio AMADIO	Associate Professor
	Luca CARACOGLIA	Consulting Engineer
	Isaia CLEMENTE	PhD
	Boris SOSIC	Technician
	Tatiana SLUGA	PhD
	Gian Andrea RASSATI	Consulting Engineer
	Franco TREVISAN	Technician

Unit #7		
Dipartimento di Meccanica e Materiali – Università degli Studi "Mediterranea" di Reggio Calabria		
Research Theme:	**Wind and vibration induced discomfort on humans and human activities**	
Coordinator:	Francesco RICCIARDELLI	Associate Professor
Components:	Enrico T. DE GRENET	PhD student
	David A. PIZZIMENTI	PhD student
	Santo POLIMENO	Consulting Engineer
	Raffaele PUCINOTTI	Assistant Professor
	Alfonso SANTOSUOSSO	Associate Professor (Univ. of Napoli)

Unit #8		
DAPS (Dipartimento di Analisi e Progettazione Strutturale) – Università degli Studi "Federico II" di Napoli		
Research Theme:	**Innovative devices for life-long vulnerability reduction and performance improvement in constructions**	
Coordinator:	Giorgio SERINO	Full Professor
Components:	Maria Gabriella CASTELLANO	Consulting Engineer
	Paolo CLEMENTE	Consulting Engineer
	Mauro FONTANA	Consulting Engineer
	Mariela LUEGE	Consulting Engineer
	Antonio OCCHIUZZI	Associate Professor
	Concetta ONORII	PhD student
	Antonio ORLANDO	Consulting Engineer
	Emanuele RENZI	Consulting Engineer
	Maria Cristina SPIZZUOCO	PhD
	Simone ZANNELLI	Consulting Engineer

Unit #9		
DIC (Dipartimento di Ingegneria Civile) – Università degli Studi di Firenze		
Research Theme:	**Design criteria for buildings and industrial plants against wind loads and other natural hazards**	
Coordinator:	Paolo SPINELLI	Full Professor
Components:	Alberto ANTONELLI	PhD
	Michele BETTI	PhD
	Paolo BIAGINI	PhD student
	Luca FACCHINI	Associate Professor
	Maurizio ORLANDO	Associate Professor
	Enrico SIBILIO	PhD student