# DESIGN , TECHNOLOGY, REFURBISHMENT AND MANAGEMENT OF BUILDINGS

## 37th IAHS World Congress on Housing Science

Santander (Spain), 26-29 October 2010

GRUPO DE TECNOLOGÍA DE LA EDIFICACIÓN. UNIVERSIDAD DE CANTABRIA

INTERNATIONAL ASSOCIATION FOR HOUSING SCIENCE

DESIGN , TECHNOLOGY, REFURBISHMENT AND MANAGEMENT OF BUILDINGS

2010

Collaborating Entities:

University of Cantabria

www.iahshousing2010.unican.es

iahshousing2010@unican.es

# 37th IAHS World Congress on Housing:

## "DESIGN , TECHNOLOGY, REFURBISHMENT AND MANAGEMENT OF BUILDINGS"

**Santander (Spain) 26-29 October 2010**

International Association for Housing Science


GRUPO DE TECNOLOGÍA DE LA EDIFICACIÓN.
ETS. Ing. De Caminos. Edif. Laboratorios.
Avda. Los Castros s/n. 39005 SANTANDER-SPAIN.

GTED-UC

Tfnos. 942 201 743 (38). Fax. 942 201 747 (03)
E-mail: gted@unican.es
Www.gted.unican.es

# UPDATED: 7th September

## 37th IAHS World Congress on Housing
## "DESIGN, TECHNOLOGY, REFURBISHMENT AND MANAGEMENT OF BUILDINGS"

**Santander (Spain) 26-29 October 2010**



SECRETARIAT

**37th WORLD CONGRESS IAHS**
Universidad de Cantabria
E.T.S. de Ingenieros de Caminos, Canales y Puertos de Santander
Departamento de Ingeniería Estructural y Mecánica
Grupo I+D de Tecnología de la Edificación (GTED-UC)
Avda. Los Castros s/n 39005 SANTANDER (SPAIN)
Tel: +34 942 201 738 (43) Fax: +34 942 201 747
E-mail: iahshousing2010@unican.es
www.iahshousing2010.unican.es

37TH IAHS World Congress on Housing (2010)

DESIGN , TECHNOLOGY, REFURBISHMENT AND MANAGEMENT OF BUILDINGS

This World Congress has been organized by:

UNIVERSITY OF CANTABRIA (Spain)
Deparment of Structural and Mechanical Engineering
Building Technologhy R&D Group
Telf: (34) 942 201 743; Fax: 0034 942 201 747
gted@unican.es; www.gted.unican.es
iahshousing2010@unican.es; www.iahshousing2010.unican.es

INTERNATIONAL ASSOCIATION FOR HOUSING SCIENCE (IAHS)
Florida International University (USA), IAHS Headquarters
P.O. Box 340254
Coral Gables/Miami, Florida 33134 USA
Fax: (305) 461-0921
uraloktay@aol.com

37TH IAHS World Congress Chairmen
Professor PhD Eng. Luis Villegas
Professor PhD Eng. Oktay Ural
Professor PhD Eng. Vitor Abrantes

37TH IAHS World Congress Coordinators
Lecturer PhD Eng. Ignacio Lombillo
Eng. Clara Liaño

Editors
Professor PhD Eng. Luis Villegas
Professor PhD Eng. Oktay Ural
Professor PhD Eng. Vitor Abrantes
Lecturer PhD Eng. Ignacio Lombillo
Eng. Clara Liaño



ISBN:
XXX-XX-XXX-XXXX-X

Depósito Legal:
SA-XXX-2010

Imprime:
Gráficas IGuña, S. A

## Sponsors / Funders

Spanish Government
Cantabria Government
Santander City Council
University of Cantabria

## Collaborators Entities

Colegio de Arquitectos
Colegio de Arquitectos Técnicos
Colegio de Ingenieros de Caminos, C. y P.
Colegio de Ingenieros Técnicos de Obras Públicas
Colegio de Ingenieros Industriales
Colegio de Ingenieros Técnicos Industriales
Colegio Oficial de Ingenieros de Telecomunicación
Fundación Marcelino Botín
Fundación Comillas
Fundación Laboral de la Construcción
Fundación Leonardo Torres Quevedo
Sociedad para el Desarrollo Regional de Cantabria
Parque Científico y Tecnológico de Cantabria
Cámara de Comercio de Cantabria
Puerto de Santander
AIDICO - Instituto Tecnológico de la Construcción de la Comunidad Valenciana
IECA - Instituto Español del Cemento y sus Aplicaciones
INTEMAC - Instituto Técnico de Materiales y Construcciones
TECNALIA - Corporación Tecnológica del País Vasco
Banco Santander
Caja Cantabria

# ÍNDICE


1. Honorary Committee 1
2. Introduction 2
3. Sponsors / Funders 3
4. Collaborators Entities 4
5. Scientific commitee 5
6. Organizing committee 7

Local organizing committee 7

Organizing committee for the iahs 7

7. PAPERS - Statistics 8
8. TOPICS - Statistics 9
9. Conference venue 10
10. Congress schedule 12
11. Conference rooms 13
12. Opening 16
13. Plenary sessions 17
14. Technical sessions 29

October 26th, 2010 29

October 27th, 2010 37

October 28th, 2010 46

15. Clossing 54
16. Social program 55

Trip A: Maritime Museum + Pedreña (Only for Companions) 56

Reception cocktail by the Mayor of Santander 58

Trip B: Castillo's caves + Puente Viesgo (Only for Companions) 59

Reception by the Headmaster of Tourism of the Cantabria Government 61

Gala dinner 63

Post-Congress Trip (Optional) 65

17. Santander's map 67
18. Abstracts of the congress 68

Topic I – Materials and methods of construction. 69

Topic II – Design for sustanibility and refurbishment. 123

Topic III – Sociocultural aspects of housing projects. 170

Topic IV – Health, comfort and safety policies. 194

Topic V – Design for house projects. 208

Topic VI – Urban and city planning. Transport policies. 227

Topic VII – Economy and financing policies. 258

Topic VIII – Management schemes and maintenance. 264

Topic IX – Building technology and construction: Structures, services and claddings. 283

Topic X – Pathology and rehabilitation. 329

# 1. Honorary Committee

**Excma. Sra. Dª. Beatriz Corredor Sierra**
**Ministra de Vivienda del Gobierno de España**

**Excma. Sra. Dª. Cristina Garmendia Mendizabal**
**Ministra de Ciencia e Innovación del Gobierno de España**

**Excmo. Sr. D. Agustín Ibáñez**
**Delegado del Gobierno de España en Cantabria**

**Excmo. Sr. D. Miguel Ángel Revilla Roiz**
**Presidente de Cantabria**

**Excmo. Sr. D. José María Mazón Ramos**
**Consejero de Obras Públicas, Ordenación del Territorio, Vivienda y Urbanismo**

**Excmo. Sr. D. Francisco Javier López Marcano**
**Consejero de Cultura, Turismo y Deporte**

**Excmo. Sr. D. Íñigo de la Serna Hernáiz**
**Alcalde del Excmo. Ayuntamiento de Santander**

**Ilmo. Sr. D. César Díaz Maza**
**Concejal de Infraestructuras, Urbanismo y Vivienda del Excmo. Ayto. de Santander**

***Excmo. y Magfco. Prof. D. Federico Gutiérrez-Solana Salcedo***
***Rector de la Univ. de Cantabria***

***Ilmo. Prof. D. Pedro Serrano Bravo***
***Director de la E.T.S. de Ingenieros de Caminos, Canales y Puertos de Santander***

# 2. INTRODUCTION

The International Association for Housing Science (IAHS), this year 2010, is celebrating the 37th Congress. They are a tradition and annually, held in a different country. Last Congress was held in Kolkata, India. Before it, it was Melbourne, Australia.

As the issues related to human habitat are important and global, IAHS dwells on these issues, identifies them, searches knowledge based solutions to them. These congresses are the effective way to gather competent experts on various fields, to join together and create an environment for discussions. The outcome of these deliberations are published in the IAHS Journal and the Congress Proceedings.

IAHS was established at the University of Missouri, USA in 1972 as a Non-Profit Scientific Organization. It is a member of the United Nations as a Non-Governmental organization with accreditations in New York, Geneva, Vienna.

The IAHS Motto is: Progress through interdisciplinary cooperation and research. This emphasizes the importance of the expansion of knowledge based actities to help improve the global shelter problems. People wants better homes and better environment for their families. This is a correct and continuous aspirations. A genuine concern, fom our part, is mandatory and necessary to find ways to help. IAHS is in this venture for good. And it is doing its share.

The University of Cantabria (UC) – Spain, through its R & D Group of Building Technology (GTED), was invited to co-organize and manage this Congress at the beginning of 2009. UC welcomed this project with great interest and saw it as an important challenge: In fact, it affects and strengthens the strategic goal of internationalization of our university, in line with the honor and award of "Cantabria International Campus" that we have achieved in 2009.

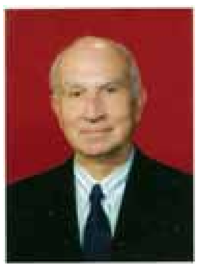
From the beginning, three Administrations decided to promote this Conference: The Government of Spain, the Government of Cantabria and the City of Santander. Also, the Professional Associations linked to the multidisciplinary Building field and other Entities of the Region added their support: The combination of all these forces has made possible to reach the target.

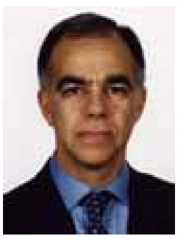
Also, for the UC School of Civil Engineering, aimed in teaching and research in the world of Construction in general and, therefore, in the Building in particular (which means, in Spain and Europe, approximately 75% of the construction sector) and for its R & D Group of Building Technology, the celebration of this Congress is an important milestone in our history of more than 40 years. In fact, it reinforces our project of giving a specific universitary degree in the Building field.

Finally, IAHS and UC are deeply grateful to all who have made this 37th Congress possible: Sponsors, Collaborators Entities, Keynote speakers, Scientific Committee, Authors who have submitted their Papers and Congressmembers in general. Thank you very much, again, everybody.



**Prof. Oktay Ural**
President of the International Association for Housing Science (IAHS)





**Prof. Luis Villegas**
World Congress Chairman
Full Professor. University of Cantabria

## 3. SPONSORS / FUNDERS

| SPONSOR | PERSON | POST |
|---|---|---|
| GOBIERNO DE ESPAÑA | Excma. Sra. Dña. Beatriz Corredor Sierra. | Ministra de Vivienda. |
| | Excma. Sra. Dª. Cristina Garmendia Mendizabal | Ministra de Ciencia e Innovación |
| | Excmo. Sr. D. Agustín Ibáñez | Delegado del Gobierno de España en Cantabria |
| GOBIERNO de CANTABRIA; Oficina de la Vivienda Cantabria | Excmo. Sr. D. Miguel Ángel Revilla. | Presidente de Cantabria. |
| | Excmo. Sr. D. José María Mazón Ramos | Consejero de Obras Publicas, Ordenación Territorio, Vivienda y Urbanismo |
| | Excmo. Sr. D. Francisco Javier López Marcano | Consejero de Cultura, Turismo y Deporte. |
| | Ilmo. Sr. D. Francisco Javier Gómez Blanco | Director General de Vivienda y Arquitectura |
| | Ilmo. Sr. D. Justo Barreda Cueto | Director General de Cultura |
| AYUNTAMIENTO DE SANTANDER; Palacio de la Magdalena; SANTANDER 2016 | Excmo. Sr. D. Iñigo de la Serna | Alcalde de Santander |
| | Ilmo. Sr. D. Cesar Díaz Maza | Concejal de Infraestructuras, Urbanismo y Vivienda. |
| | Ilma. Sra. Dª Gema Igual Órtiz | Concejala de Turismo y Protocolo |

# 4. COLLABORATORS ENTITIES

Colegio de Arquitectos

Colegio de Arquitectos Técnicos

Colegio de Ingenieros de Caminos, C. y P.

Colegio de Ingenieros Técnicos de Obras Públicas

Colegio de Ingenieros Industriales

Colegio de Ingenieros Técnicos Industriales

Colegio Oficial de Ingenieros de Telecomunicación

Fundación Marcelino Botín

Fundación Comillas

Fundación Laboral de la Construcción

Fundación Leonardo Torres Quevedo

Sociedad para el Desarrollo Regional de Cantabria

Parque Científico y Tecnológico de Cantabria

Cámara de Comercio de Cantabria

Puerto de Santander

Banco Santander

Caja Cantabria

AIDICO - Instituto Tecnológico de la Construcción de la Comunidad Valenciana

IECA - Instituto Español del Cemento y sus Aplicaciones

INTEMAC - Instituto Técnico de Materiales y Construcciones

TECNALIA - Corporación Tecnológica del País Vasco

## 5. SCIENTIFIC COMMITEE

| Name | | Organization | Name | | Organization |
|---|---|---|---|---|---|
| Adriana Matei | - | *Technical University in Cluj* | Diego Ferreño | - | *University of Cantabria* |
| Agustin Valcarce | | *TEICAN* | Donato Abruzzese | - | *University of Rome* |
| Al Borvice | - | *Preservation Corporation* | Elisa Valero | - | *University of Granada* |
| Albert de la Fuente | - | *UPC - Barcelona - TECH* | Elżbieta Trocka-Leszczyńska | - | *Wroclaw Univ. of Tech.* |
| Alessandra Bellicoso | - | *University of L'Aquila* | Eusebio Martínez | - | *University of Cartagena* |
| Alfonso Lozano | - | *University of Oviedo* | F. Brandao Alves | - | *University of Porto* |
| Alfonso Cobo | - | *UPM - Madrid TECH* | Fabio Fatiguso | - | *Polytechnic Univ. of Bari* |
| Alfredo Soreiro | - | *FEUP Porto* | Fernando Branco | - | *University of Coimbra* |
| Almudena da Costa | - | *University of Cantabria* | Fernando Viadero | - | *University of Cantabria* |
| Amira Osman | - | *CSIR* | Francisco Gomez | - | *INSAGO* |
| Ana Sánchez-Ostiz | - | *University of Navarra* | Graça F. Vasconcelos | - | *University of Minho* |
| Andras Zold | - | *Budapest University* | Gerónimo Lozano | - | *University of Oviedo* |
| Ángel Aragón | - | *University of Burgos* | Giorgio Monti | - | *University of Rome* |
| Antonio Aguado | - | *UPC - Barcelona TECH* | Gulsun Saglamer | - | *Istanbul Technical University* |
| Antonio Frattari | - | *University of Trento* | Ignacio Lombillo | - | *University of Cantabria* |
| Antonio Garrido | - | *Cartagena University TECH* | Ildefonso Lucea | - | *UPM - Madrid - TECH* |
| Antonio Rolando | - | *UPM - Madrid TECH* | Iraj Etessan | - | *University of Teheran* |
| Ario Ceccotti | - | *Universiti of Florence* | Isabel Torres | - | *University of Coimbra* |
| Armando Silva | - | *University of Aveiro* | Isidro A. Carrascal | - | *University of Cantabria* |
| Atila Lawrence | - | *University of Nevada* | Iván Flores | - | *Univ. of Vasque Country* |
| Aurora Monge | - | *Universidad de Navarra* | Jaime Fernández-Gómez | - | *UPM - Madrid TECH* |
| Carlos Renedo | - | *University of Cantabria* | Javier Díaz de Güemez | - | *SIKA* |
| Carlos Thomas | - | *University of Cantabria* | Javier Garabito | - | *University of Burgos* |
| Cesar Alvárez | - | *University of Cantabria* | Javier Moreno | - | *University of Granada* |
| Cesar Diaz | - | *UPC - Barcelona TECH* | Javier Torres | - | *University of Cantabria* |
| Cesar Sagaseta | - | *University of Cantabria* | Javier Yuste | - | *AIDICO* |
| Clara Liaño | - | *University of Cantabria* | Jesús Gómez-Hermoso | - | *UPM - Madrid TECH / FCC* |
| Cristina Vázquez | | *University of La Coruña* | Jesús Setién | - | *University of Cantabria* |
| Daniel Alvear | - | *University of Cantabria* | João Lanzinha | - | *University of Beira Interior* |
| Daniel Castro | - | *University of Cantabria* | Joaquín Fernández | - | *University of La Coruña* |
| Daniel V. Oliveira | - | *University of Minho* | Jorge Cañizal | - | *University of Cantabria* |
| David Dewar | - | *University of Cape Town* | Jorge Elices | - | *University of Cantabria* |
| David García | - | *TECNALIA* | Jorge Moreira da Costa | - | *University of Porto* |
| Delfín silió | - | *University of Cantabria* | Jorge R. Hernández | - | *University of Cantabria* |
| Derin Ural | - | *Istambul Tech. University* | José A. Álvarez | - | *University of Cantabria* |

| Name | | Organization | Name | | Organization |
|---|---|---|---|---|---|
| José A. Roig | - | *MP Ascensores* | Paul Stouten | - | *Delft University of Tech.* |
| José A. Martínez | - | *University of Burgos* | Paulo B. Lourenço | - | *University of Minho* |
| José L. Ruiz | - | *ACRON* | Paz Morer | - | *University of Navarra* |
| José M. Adam | - | *UPV - Valencia TECH* | Pedro A. Calderón | - | *UPV - Valencia TECH* |
| José M. López-Higuera | - | *University of Cantabria* | Pedro Díaz-Simal | - | *University of Cantabria* |
| Jose P. Fernández | - | *University of Oviedo* | Pere Roca | - | *UPC - Barcelona TECH* |
| Jose R. Aranda | - | *University of Cantabria* | Peter Kuroshi | - | *Covenant University* |
| José T. San José | - | *TECNALIA* | Peter Schmid | - | *Eindhoven Univ. of Tech.* |
| Jose V. Fuente | - | *AIDICO* | Pilar Alonso | - | *University of Valladolid* |
| Jozef Junák | - | *Tech. University of Košice* | R. Mendes da Silva | - | *University of Coimbra* |
| Juan A. Polanco | - | *University of Cantabria* | Ramadam Belgasem | - | *University of Al-Fateh* |
| Juan Monjó | - | *UPM - Madrid TECH* | Ramón Collado | - | *University of Cantabria* |
| Julian Díaz del Valle | - | *University of Cantabria* | Ramón Losada | - | *Univ. of Vasque Country* |
| Luc Schueremans | - | *UK Leuven* | Ramón Sancibrián | - | *University of Cantabria* |
| Luigi Mollo | - | *Second University of Naples* | Renato Iovino | - | *University of Naples* |
| Luis Agulló | - | *UPC - Barcelona TECH* | Robert Masztalski | - | *Wroclaw Univ. of Tech.* |
| Luis Villegas | - | *University of Cantabria* | Rogelio Olavarri | - | *University of Cantabria* |
| Mariela de Fino | - | *Polytechnic Univ. of Bari* | Romeu da Silva Vicente | - | *University of Aveiro* |
| Maria R. Veiga | - | *N. L. of Civil Eng. - LNEC* | Rosa Bustamente | - | *UPM - Madrid TECH* |
| Mª Victoria Biezma | - | *University of Cantabria* | Rui Calejo | - | *University of Porto* |
| Manuel Manso | - | *University of Burgos* | Salvatore Losco | - | *Second University of Naples* |
| Manuel Ruiz | | *Teican* | Sebastiano D'urso | - | *University of Catania* |
| Manuela Grecchi | - | *Politecnico de Milán* | Sevim Ateş | - | *Yeditepe University* |
| Maria J. Casati | - | *UPM - Madrid TECH* | Sahar Hassan | - | *University of Cairo* |
| Mariana Brumaru | - | *Tech. Univ. of Cluj-Napoca* | Salvador Ivorra | - | *University of Alicante* |
| Massimo Piccoto | - | *University of Pescara* | Senthivel Ramakrishnan | - | *ACCIONA I+D* |
| Miguel A. Serna | - | *University of Cantabria* | Santiago Sánchez-Beitia | - | *Univ. of Vasque Country* |
| Miguel Cavique | - | *Polytech. Institute of Setúbal* | Sara Fasana | - | *Politecnico de Torino* |
| Miguel Gonçalves | - | *University of Porto* | Sayed Ettouney | - | *University of Cairo* |
| Mª Luisa Ruiz-Bedia | - | *University of Cantabria* | Sergio Cicero | - | *University of Cantabria* |
| Narcisa Hadzic | - | *University of the IUS* | Soledad Nogués | - | *University of Cantabria* |
| Nasamat Abdel-Kader | - | *Cairo University* | Stefania Marletta | - | *University of Catania* |
| Nelson Tuesta | - | *Europ. Univ. M. de Cervantes* | Subrata Chattopadhyay | - | *Institute of Technology Diamond Harbour Road* |
| Nihal Arioglu | - | *Istanbul Technic. University* | Teh Kem Jin | - | *National Univ. of Singapur* |
| Oktay Ural | - | *Florida Internat. University* | Tom Hughes | - | *Nottingham Trent University* |
| Oluwole Alagbe | - | *Covenant University* | Vasco Peixoto da Freitas | - | *FEUP Porto* |
| Orlando Rincón | - | *University of La Salle* | Vitor Abrantes | - | *FEUP Porto* |
| Pablo Gómez | - | *University of Cantabria* | | | |

## LOCAL ORGANIZING COMMITTEE

- Prof. Dr. Luis Villegas. Full Professor of the University of Cantabria. Director of GTED-UC.
- Prof. Dr. Pedro Serrano. Director of the ETS Ingenieros de Caminos, C. y P. of the University of Cantabria.
- D. Benjamín Piña. Director of the Public Works Ministry in Cantabria.
- D. Francisco Javier Gómez. Director of Housing of the Government of Cantabria.
- D. Justo Barreda. Director of Cultura of the Government of Cantabria.
- D. Cesar Díaz. Works Councilor of the City of Santander.
- Dª. Gema Igual Ortiz. Tourism Councilor of the City of Santander.
- Dr. Ing. Ignacio Lombillo. Lecturer of the University of Cantabria. GTED-UC Coordinator.
- Ing. Clara Liaño. GTED-UC.
- Lic. Pablo Gómez. GTED-UC.
- Ing. Jorge Elices. GTED-UC.
- Ing. Cesar Carrasco. GTED-UC.

## ORGANIZING COMMITTEE FOR THE IAHS

President:

- Prof. Oktay Ural (Florida International University – Miami, USA)

Directors:

- Prof. Vitor Abrantes (University of Porto – Porto, Portugal)
- Prof. Robert Krapfenbauer (University of Vienna – Vienna, Austria)
- Prof. Fernando Tinoco (University of Miami – Miami, USA)
- Prof. H. W. Viswanath (University of Bangalore – Bangalore, India)
- Dr. Adel Fareed (Cairo, Egypt)

Treasurer:

- Prof. Le Roy Thompson (Florida International University – Miami, USA)

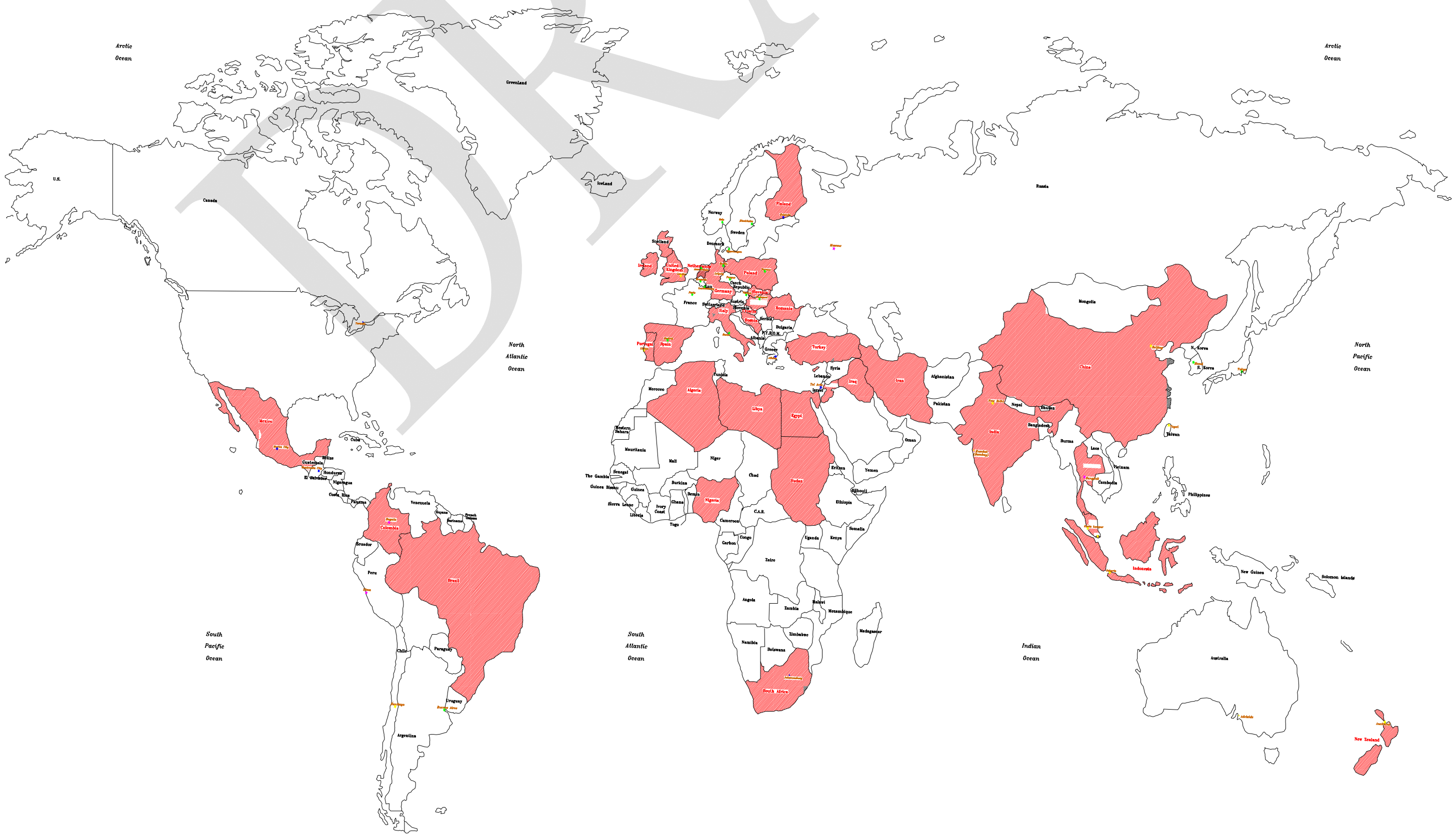
Secretary:

- Dr. Derin Ural-Serpengüzel (Technical University of Istanbul – Istanbul, Turkey)

**Papers in the 37th IAHS Wordl Congress of Housing: Stder.SPAIN, Oct. 2010**

| CONTINENT | COUNTRIES that send Papers | Nº total of Papers received | Country | Nº Papers |
|---|---|---|---|---|
| EUROPE | 16 | 271 | Spain | 131 |
| | | | Portugal | 49 |
| | | | Italy | 39 |
| | | | Turkey | 17 |
| | | | Slovakia | 12 |
| | | | Others | 23 |
| AFRICA | 6 | 21 | Egypt | 8 |
| | | | Nigeria | 6 |
| | | | South Africa | 2 |
| | | | Others | 5 |
| AMERICA | 3 | 13 | Brasil | 8 |
| | | | Mexico | 4 |
| | | | Others | 1 |
| ASIA and OCEANÍA | 8 | 18 | India | 4 |
| | | | Indonesia | 4 |
| | | | Irak | 2 |
| | | | Iran | 2 |
| | | | Others | 6 |
| TOTAL | 33 | 323 | Updated June 24th, 2010 | |





**TOPIC I: MATERIALS AND METHODS OF CONSTRUCTION**
New materials and composites
Old materials with new uses
Wood. Factories of stone and brick.
The traditional methods of construction
Innovating methods of construction
Use of local materials

**TOPIC II: DESIGN FOR SUSTAINABILITY AND REFURBISHMENT**
Criteria of design
Use of the renewable energies
Buildings of low power consumption.
Using natural resources
Refurbishment policies in cities
Environmental studies.

**TOPIC III: SOCIOCULTURAL ASPECTS OF HOUSING PROJECTS**
Social buildings
Financing systems
Participation of users
Supply of houses

**TOPIC IV: HEALTH, COMFORT AND SAFETY POLICIES**
The quality of the air in the interior
Inner microclimate
Systems of protection against fires
Toxicity of the construction equipments
Use of the power natural resources in the house
Control of the atmospheric contamination

**TOPIC V: DESIGN FOR HOUSE PROJECTS**
Criteria of design
Methods and materials
National and international legislation
Earthquakes resistant buildings

**TOPIC VI: URBAN AND CITY PLANNING. TRANSPORT POLICIES.**
Mountainous zones.
The urban infrastructure. Water resources management.
Planning of the sustainability
Topographic systems
Ecological establishments
Policies of house of the European Union
Policies and programs of house for construction of the nation.
Transports in cities.

**TOPIC VII: ECONOMY AND FINANCING POLICIES**
Measures of support to the private economy
Governments supporting the economy
Public and deprived companies
Investment funds.

**TOPIC VIII: MANAGEMENT SCHEMES AND MAINTENANCE**
Criteria of design
Management of the maintenance
Management of facilities
Management of the constructive process
Quality, Environment and Prevention of Labor Risks
Techniques, equipment and materials
Renovation and new ideas of management

**TOPIC IX: BUILDING TECHNOLOGY AND CONSTRUCTION: STRUCTURES, SERVICES AND CLADDINGS.**
Technological bases and concepts.
Evolution of the technology in the construction.
Industrialization and precast solutions. Intelligent buildings.
Technology of structures and geotechnic.
Services, equipment and facilities: Heating, air conditioning, lifts, electrical, plumbing, sewage, telecommunications, etc.
Technology of claddings and finished closings.

**TOPIC X: PATHOLOGY AND REHABILITATION**
Historical and archaeological studies of the patrimony.
Pathology of the construction
Technologies in the refurbishment.
Investigation and diagnose of damaged constructions.
Non destructive technologies in the buildings investigation



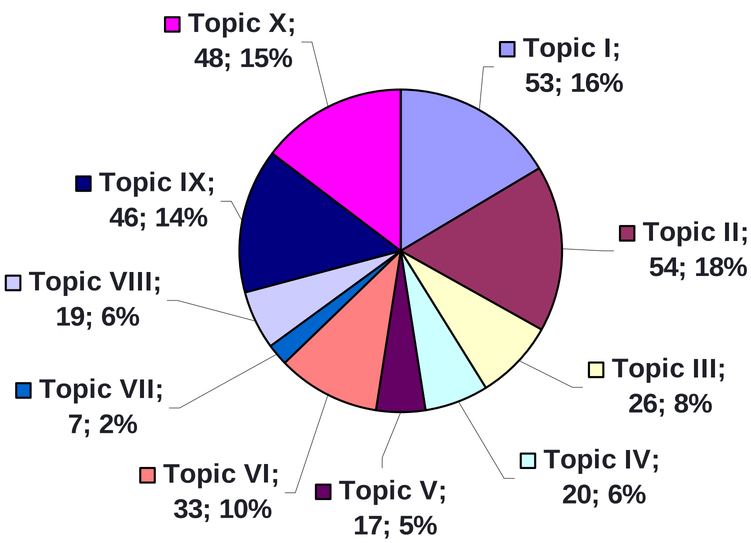



**Figure:**
**PAPERS FOR EACH TOPIC**
**(Topic i; nº papers; %papers/total)**

**Updated June 24th, 2010**

**World Congress will take place in the Magdalena's Peninsula, Santander (Spain)**

The Royal Palace of *La Magdalena* is the most emblematic building of Santander, has not a defined style though he is catalogued like "eclectic picturesque", a mixture of English and French styles with incorporation of typical elements of the highland architecture. This finds placed in the Peninsula of the same name, which has an extension of 28 hectares.

On August 4th, 1913 there took place the arrival of His Majesties, to take possession of the new palatial residence. The Kings spent the summer in Santander for 17 consecutive years until 1930. Alfonso XIII finds in our city the best place to practise his favorite sports, sailing and the hunt. Also he plays tennis and from 1915 with the inauguration of the Field of Pole, can practise this sport in La Magdalena. The Royal Caballerizas are from the same year.

The press was gathering daily the "Veraneo Regio" ("Royal Summer"), informing about the life and activities of the Royal Family who was frequenting the beaches of El Sardinero, internationally famous for the "Baños de Ola" (Bath of Waves). In this beach the Royal family installed "La Caracola" ("The Shell"), a shed where the whole family was almost daily. While in the Palace there were celebrated numerous activities of great resonance and meetings with some Ministers' Councils

In the different summer visits The Kings inaugurate different official centers, as the Municipal Library or the Mercantile Bank and they were interested in the problems of the city, where also the Spanish aristocracy used to come to spend the summer. El Sardinero and the streets of around suffer a great transformation with the construction of neighborhoods and houses for these new people. Besides the Royal Hotel, the new Great Casino of El Sardinero, one of the most ancient of Spain and Bellavista's Racetrack that will turn into the center of leisure and culture of Santander in that time.

In the decade of the twenties the International Summer Courses of Santander were created and in 1932 the International University of Santander, this one was celebrating the courses at the Auditorium that was constructed for this effect and the Caballerizas remodelled as students' residence from 1933, his first rector was Menéndez Pidal.

In the courses there took part the most prestigious figures of the Spanish intellectuality of those years and besides the Profesors and Lecturers, the guests were numerous, as Prof. Miguel Unamuno or Federico García Lorca. This last one was coming with his workshop of theatre "La Barraca" and had special resonance for his interpretations of the university theatre. These representations took place out of the Caballerizas.

After a parenthesis due to the Spanish civil war it was necessary to wait until 1949 in order that there are reinstalled in The Palace the Summer courses of the International University named from this date "Menéndez Pelayo" (UIMP).

In 1977 the City Hall of Santander by means of agreement with the Count of Barcelona recovered the Royal place of La Magdalena and from this date the park remains opened for the public, the most visited place of the city of Santander.

In 1982 the palace was declared "historical artistic monument" and in December 1993 began the works of rehabilitation of the buildings of La Magdalena. Works that were finished in 1995 and inaugurated by His Majesties Don Juan Carlos and Dona Sofía on June 14 of the same year. From this date La Magdalena is in use as Conference hall and Meetings though it continues preserving in its museum lounges and classrooms "el duende" ("the goblin") that are recognized by all those who visit them.

The Magdalena's site exhibition account on two areas, in the first of them there are three perfectly equipped rooms: Two of them have a capacity of 50 people while the third has enough space to house 70.

The Auditorium, only building of the facilities that still maintains the porpuse for wich it was built, is presented as an attractive forum for meetings wich a capacity of 328 people, to leave room for big events.

# 10. CONGRESS SCHEDULE

| Day / Hour | Tuesday October 26 | Wednesday October 27 | Thursday October 28 | Friday October 29 |
|---|---|---|---|---|
| 8h00–8h30 | Distribution of documentation | | | |
| 8h30–10h00 | **Plenary sessions (Auditorium)** | **Plenary sessions (Auditorium)** | **Plenary sessions (Auditorium)** | **Post-congress trip (Optional)** |
| 10h00–11h15 | Coffe Break<br>**OPENING (Auditorium)** | Coffe Break | Coffe Break | |
| 11h15–13h15 | Auditorium (Topic 10)<br>Room 1 (Topic 2)<br>Room 2 (Topic 3)<br>Room 3 (Topic 8) | Auditorium (Topic 9)<br>Room 1 (Topic 1)<br>Room 2 (Topic 2)<br>Room 3 (Topic 6) | Auditorium (Topic 10)<br>Room 1 (Topic 1)<br>Room 2 (Topic 9)<br>Room 3 (Topic 5) | |
| 13h15–15h15 | Lunch | Lunch | Lunch | |
| 15h15–16h30 | Auditorium (Topic 10)<br>Room 1 (Topic 2)<br>Room 2 (Topic 3)<br>Room 3 (Topic 4) | Auditorium (Topic 9)<br>Room 1 (Topic 1)<br>Room 2 (Topic 2)<br>Room 3 (Topic 6) | Auditorium (Topic 10)<br>Room 1 (Topic 1)<br>Room 2 (Topic 9)<br>Room 3 (Topic 5) | |
| 16h30–16h45 | Coffe Break | Coffe Break | Coffe Break | |
| 16h45–18h15 | Auditorium (Topic 10)<br>Room 1 (Topic 2)<br>Room 2 (Topic 3 y 1)<br>Room 3 (Topics 4 y 7) | Auditorium (Topic 9)<br>Room 1 (Topic 1)<br>Room 2 (Topic 2 y 8)<br>Room 3 (Topics 6) | Auditorium (Topic 10)<br>Room 1 (Topics 1)<br>Room 2 (Topics 7)<br>Room 3 (Topics 5 y 10) | |
| 18h45–19h30 | **Reception cocktail** by the Mayor of Santander | Reception by the Minister of Tourism of the of the Cantabria Government<br>(**Music recital**) | **CLOSSING (Auditorium)** | |
| 21h00 | | | **GALA DINNER** | |

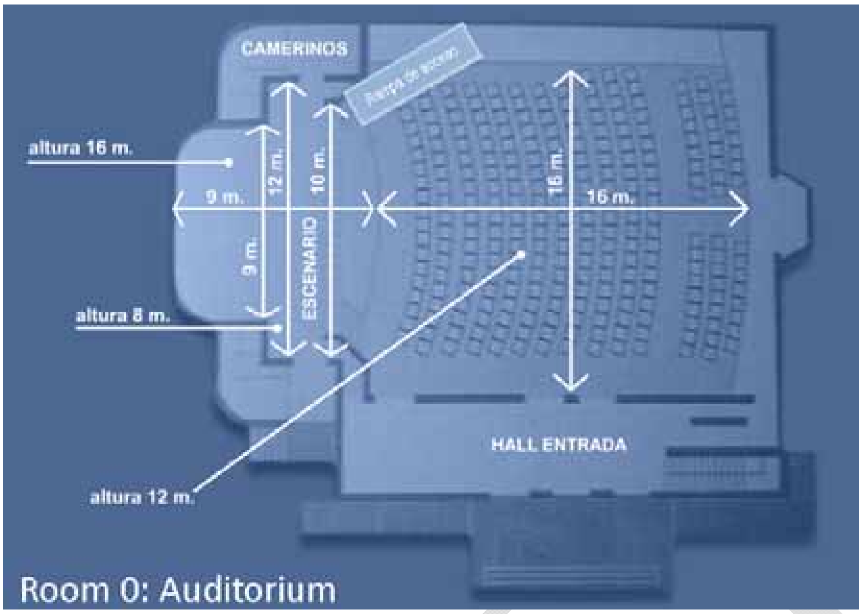
# 11. CONFERENCE ROOMS

The Congress will be held in the Magdalena's Peninsula in Santander city.


The building complex is near to the Magdalena's beach, which was rehabilitated and equipped to develop academic events (of the UIMP and of the University of Cantabria), as a students' residence, and to enjoy other activities of the Santander city (Davis Cup of tennis, recitals, etc.).

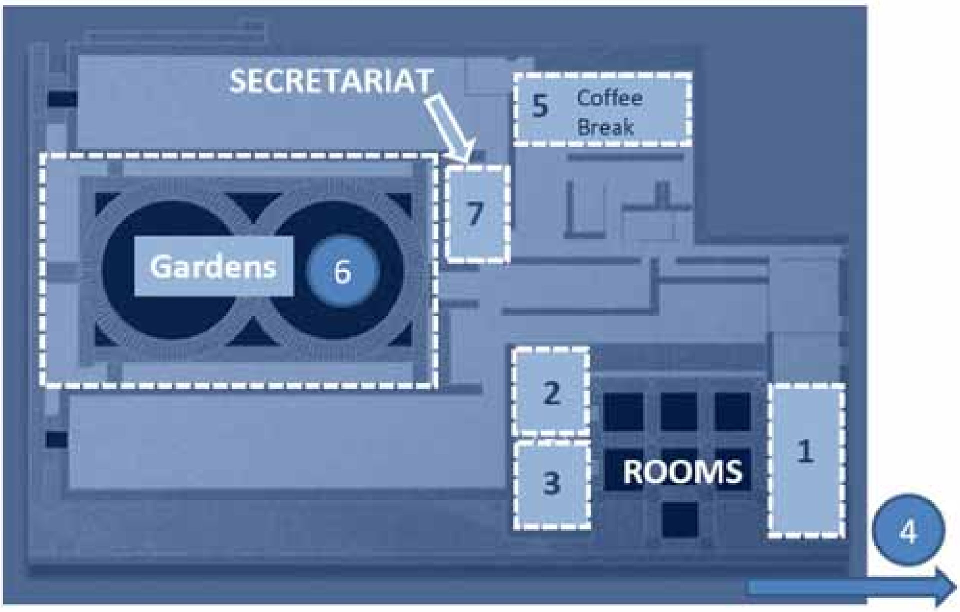
In the Congress will be used the Auditorium (that is an attractive forum for meetings with 328 seats of capacity to accommodate large events, in this case the plenary sessions) and 4 conference rooms (3 in the building complex of the Magdalena's site exhibition and another one, very close to them, in the International Center for Technology and Port Authority).

The Auditorium is equipped with simultaneous translation, u-matic video high and low frequency, Betacam metal tape reading, VHS supports PAL, NTSC and SECAM, closed circuit TV, air conditioning, area: 350m$^2$.




*Auditorium of the Magdalena's site exhibition*

Of the three conference rooms (in the building complex of the Magdalena's site exhibition), two of them have 50 seats capacity, and another for up to 70 seats. The rooms are equipped with the following features: Centralized simultaneous translation and portable projector fixed / portable voice and data circuit, closed circuit tv, air conditioning.




***1***. *70 seats room /* ***2***. *50 seats room /* ***3***. *50 seats rooms /* ***4***. *Conference room CITAP (Cerda's lighthouse): 35 seats /* ***5***. *Coffee break area /* ***6***. *Gardens /* ***7***. *Secretariat.*

Also, the Congress will have an extra conference room courtesy of Santander Port Authority. The conference room CITAP (International Center for Technology and Port Authority) with 35 people capacity, is fully equipped. The room is located in the Cerda's lighthouse (in the Magdalenas's Peninsula), a privileged place in Magdalena's topography.

*Sunrise on the Cerda's lighthouse (Room 4: Conference room CITAP)*

# OCTOBER 28TH, 2010

**October 28, 2010**

**11h15–13h15** *Chairperson* **Prof. D. Ural**

*AUDITORIUM*

*Topic 10*

1039 ROCK THIN-SECTIONS STUDIES: A GEOLOGIC TOOL USEFUL FOR BUILDING AND MONUMENT REHABILITATION

Sánchez, M.A., Iriarte. E. and Gutiérrez-Medina, M.

1040 A CONTRIBUTION TO TECHNICAL INSPECTION PROCESSES IN RESIDENTIAL BUILDING DIAGNOSIS

César Díaz, Còssima Cornadó, Leiris Simancas

1041 REHABILITATION OF THE HERITAGE – CASE STUDY: "JESUS' COLLEGE" IN COIMBRA

Torres, Isabel ; Silva, J. Mendes ; Carvalhal, Mário ; Cordeiro, Pedro

1042 ZINC ROOFS: ANOMALIES AND REHABILITATION

Silva, J. Mendes; Torres, Isabel; Mauricio, Carla

1044 VALUES OF RESTORATION OF HISTORICAL RESIDENTIAL ARCHITECTURE. EL PALACIO DE EQUÍSOAIN: INTERVENTION FOR SUSTAINABILITY

Joaquín Torres-Ramo, Verónica P. Quintanilla-Crespo

1045 LOGISTIC ISSUES AND PRACTICAL AND ORGANIZATIONAL SUGGESTIONS FOR WORK OUT AND INTERPRETATION OF IMPACT-ECHO TESTS.

García-Lengomín Pieiga, A. , Fernández Álvarez, J.P.

1049 QUESTIONS AND HYPOTHESIS REGARDING THE TOWER OF HERCULES EXTERIOR RAMP

Lozano Martinez-Luengas, Lozano Apolo, Gorosabel Pando, Lazcano Aretxabala, Hernández Basterra

1050 FACILITIES LAYOUT IN THE BUILDING REHABILITATION OF THE "LABORAL CITY OF CULTURE" OF GIJÓN.

Martín Rodríguez, Ángel. Suárez Domínguez, Francisco. Coz Díaz, Juan José del. Préndes Gero, María Belén

1052 PATHOLOGY AND REHABILITATION OF THE CONSTRUCTNON DESTRUCTIVE TECHNOLOGIES IN THE BUILDING INVESTIGATION.

QUALITY IN NON-DESTRUCTIVE DIAGNOSTIC PROCESS FOR ANALYZING BUILDING SEISMIC VULNERABILITY

Massimo Pitocco

1053 REHABILITATION OF BUILDINGS AND KNOWLEDGE MANAGEMENT: PROJECT HKNOW

A. Soeiro and A. Sá

**October 28, 2010**

**15h15–16h30** *Chairperson* **Prof. C. Díaz**

*AUDITORIUM*

*Topic 10*

1054 CONSERVATION OF CULTURAL HERITAGE: SYMPTOMS, INVESTIGATION AND DIAGNOSIS. CASE STUDY IN A 16TH CENTURY BUILDING.

C. Galán-Marín, C. Rivera-Gómez

1055 ASSESSMENT OF PROCESS IN THE RESTORATION OF ARCHITECTURAL HERITAGE. SPATIAL ANASTYLOSIS IN THE REFURBISHMENT OF HACIENDA LOS MOLINOS DE MAESTRE, IN THE OLIVE GROVES OF SEVILLA.

Aguilar, María de la Cruz; Gómez-Stern, Bernardo

# CODE: 1052

# PATHOLOGY AND REHABILITATION OF THE CONSTRUCTNON DESTRUCTIVE TECHNOLOGIES IN THE BUILDING INVESTIGATION. QUALITY IN NON-DESTRUCTIVE DIAGNOSTIC PROCESS FOR ANALYZING BUILDING SEISMIC VULNERABILITY

**Massimo Pitocco**

DiTAC – Dipartimento di Tecnologie per l'Ambiente Costruito Facoltà di Architettura di Pescara
e-mail: labqsm@unich.it

**Key words:** procedure quality, building safety, innovative technologies, tools.

**Abstract**
Building safety in the event of natural calamities, for instance earthquakes, can be analyzed for vulnerability. This kind of analysis will include a prediction evaluation of damage that would be caused to a building by a potential earthquake of a pre-established force. In order to achieve this, a calculation model referred to structural and typological characteristics is required to define a cause-effect relationship. In addition to the calculation model, seismic vulnerability is also compared to parameters of improvement and deterioration, which depend on material quality, maintenance conditions, dimensions and building geometry. To acquire a complete knowledge of buildings to establish a proper correspondence between the model and reality, as well as to have attainable parameters, knowledge of the quality of building conditions is needed.
The data acquired from destructive evaluation have closer relationships with structural behaviour quantity parameters, while data acquired by non-destructive evaluations, i.e. through advanced technological equipment, are not directly comparable to the aforesaid parameters.
Moreover, the extensive amount of data acquired with these technologies often lacks useful and appropriate interpretation. In order to use the diagnostic technologies necessary for analysing the seismic vulnerability evaluation, it is then crucial to adopt quality systems within non-destructive diagnostic processes, so that acquired data can be usefully managed and interpreted.
Quality, intended as compliance with requirements, within a diagnostic campaign, can be defined through the set of data meeting expressed needs. In other words, the seismic vulnerability analysis diagnostic process has to be defined at every step: organization structure, responsibility, processes and resources used.

TOPIC 10 – PATHOLOGY AND REHABILITATION OF THE CONSTRUCT
Non destructive technologies in the building investigation

**Quality in non-destructive diagnostic process for analyzing building seismic vulnerability**

Massimo Pitocco
DiTAC – Dipartimento di Tecnologie per l'Ambiente Costruito
Facoltà di Architettura di Pescara
Viale Pindaro 42
65125 Pescara - Italy
labqsm@unich.it

**Key words:** procedure quality, building safety, innovative technologies, tools.

**Abstract**
Building safety in the event of natural calamities, for instance earthquakes, can be analyzed for vulnerability. This kind of analysis will include a prediction evaluation of damage that would be caused to a building by a potential earthquake of a pre-established force. In order to achieve this, a calculation model referred to structural and typological characteristics is required to define a cause-effect relationship. In addition to the calculation model, seismic vulnerability is also compared to parameters of improvement and deterioration, which depend on material quality, maintenance conditions, dimensions and building geometry. To acquire a complete knowledge of buildings to establish a proper correspondence between the model and reality, as well as to have attainable parameters, knowledge of the quality of building conditions is needed.
The data acquired from destructive evaluation have closer relationships with structural behaviour quantity parameters, while data acquired by non-destructive evaluations, i.e. through advanced technological equipment, are not directly comparable to the aforesaid parameters.
Moreover, the extensive amount of data acquired with these technologies often lacks useful and appropriate interpretation. In order to use the diagnostic technologies necessary for analysing the seismic vulnerability evaluation, it is then crucial to adopt quality systems within non-destructive diagnostic processes, so that acquired data can be usefully managed and interpreted.
Quality, intended as compliance with requirements, within a diagnostic campaign, can be defined through the set of data meeting expressed needs. In other words, the seismic vulnerability analysis diagnostic process has to be defined at every step: organization structure, responsibility, processes and resources used.

## 1 Introduction

Building safety in the event of calamities of natural origin, like earthquakes, is subject to assessment of vulnerability. This kind of assessment will include a prediction evaluation of damage that would be caused to a building by a potential earthquake of a pre-established force. In order to obtain this it is necessary to define a calculation model considering the structural and typological characteristics which defines the cause-effect relationship This is possible both by using plans and by performing diagnostic observations on buildings by means of *destructive (DT)* or *non-destructive tests (NDT).* There are also "slightly destructive" tests, including superficial penetromy and endoscopy, requiring little intervention on existing buildings.
Evaluating seismic vulnerability is, in effect, a census of existing buildings and the possible consequences of a seismic event, independently of any subsequent intervention.
In old centres found in highly seismic areas, buildings are high vulnerable to earthquakes and need planned interventions on a territorial scale. NDTs can be particularly useful to evaluate technical-financial options: they are typically extremely flexible and adaptable. Another aspect that should not be neglected is that of not inconveniencing residents or interrupting the routing of the building.
Data obtained with DTs present closer relationships with quantitative parameters of structural behaviour, while data obtained with evolved technological equipment are not directly comparable to these parameters. Moreover, despite the extensive amount of data obtained through these technologies, no useful and adequate interpretations ensue. To exploit these technologies for the analysis of seismic vulnerability evaluation, it

becomes indispensable to adopt quality systems within non-destructive diagnostic processes, to achieve useful management and interpretation of recorded data. Thus a campaign of diagnostic investigations must be planned, compliant with a Quality Assurance System, in order to acquire not only organic and systematic knowledge of buildings that offers an accurate association of the model with reality, but also reliable parameters. This will then reduce the various uncertainties and contradictions arising precisely when investigating existing buildings.
The Quality Assurance Level represents the main objective of the Quality Assurance System, and it underpins the following three factors:

- number
- organization
- execution.

The two main aspects characterizing the Quality Assurance Level and System are: *quality* in the diagnostic investigation and *assurance* of that quality.
The quality of the diagnostic investigation is represented by its compliance with requirements.
The assurance of quality is represented by two parameters: organization of the actions required to meet requirements and verification that these actions have actually been implemented..
The Quality Assurance System will be planned in relation to the Quality Assurance Level, while the latter is not regulated by any directive and is a discretionary datum for defining requirements as per need.
Once the person in charge has defined the quality of a provided service, the assurance of an implemented procedure and the required level, then the management of subsequent actions to obtain the required quality must also be defined.
Therefore Quality System Management comprises the planning of actions (intended as a set of methods and tools) within the system, in turn intended to define, obtain, prove, demonstrate and maintain that system. In order to implement system management, suitable documentation will have to be drafted, which will also be sufficient to prove that required quality has been achieved and prove procedure implementation.
The body of international regulations applied to quality of intevention establishes the basic actions for planning a Quality Assurance System as:

- planning
- organization
- control
- evaluation

In turn, control should refer to:

- existing documents
- documents obtained through investigations
- investigation
- tools and equipment
- diagnostic process
- in situ tests and trials
- laboratory tests and trials
- non uniformity
- records

The level of precision applied to the implementation of all these actions defines the Quality Assurance Level that might be obtained from the application of a predetermined Quality Assurance System.

## 2 Quality assurance level

From the preceding statements, it can be presumed that the analysis of a building's seismic vulnerability will also require that the quality of the diagnostic process be defined, primarily by the Quality Assurance Level that the person in charge of the diagnostic investigation establishes for each building, as per specific demands and after assessing various aspects, including:

- complexity of the case to assess and consequently the complexity of the ensuing investigation;
- available time and resources;
- technological tools to use in site investigation;
- technological tools to use in lab trials;
- effect of erroneous data on future project choices.

The assurance levels can be classified as:
- Level 1
- Level 2
- Level 3

Level 1
This level guarantees quality via onsite observations and diagnostic investigations carried out with simple equipment like a sclerometer, crackmeter, hygrometer, etc. During site inspections the building's construction and maintenance will require verification, as will compliance of materials and technical components with applicable standards.
This level of investigation achieves:
- documented pre-diagnosis of building conditions;
- diagnostic protocol as the basis for further in-depth investigations.

Level 2
This level guarantees Quality Assurance by means of a systematic plan of actions to be carried out while defining the investigation campaign, the procurement of instruments and the implementation of the actual investigation.
This level of investigation, characterized by three different actions classified as imperative-optional-recommendable, achieves:
- in-depth knowledge of a building, useful for developing an intervention plan;
- superficial knowledge of complex cases for organizing more in-depth investigations.

Level 3
This level guarantees Quality Assurance by means of systematic and documented planned actions, identified as imperatives. This level only becomes necessary following a court order.

## 3 Diagnostic non destructive tests on existing building asset

In order to assess safety thresholds and the future evolution of a construction, the chief necessity is planning and implementation of building component and material investigation, which can actually be performed with diagnostic non-destructive tests (NDTs).
The main aspect of a diagnostic test on existing buildings is analysis using technological equipment to acquire knowledge of material and component performance disruptions. After obtaining this information a requirement-performance methodological approach is applied to relate the building's state of preservation to the diagnostic investigation (both destructive and non-destructive types).
*NDTs can be defined as all those techniques whose application does not compromise a structure's functional integrity and, at the same time, does not imply damage or alteration to the appearance of any of their parts. There is dimensional correlation between the investigated object's size and the trace left by the investigation. These methodologies do not eliminate "destructive" tests completely, since it may be necessary to integrate this type of investigation with laboratory tests on samples taken in situ, but in these cases there is no risk that non-typical samples will be taken, since the choice is guided by data emerging from previous investigations .* [1]
Supported by recent technological equipment enhancement, the current trend is to use non-destructive investigations which may be less invasive on one hand, leaving no traces on the structures (preferable especially when dealing with buildings of historical-artistic value), on the other the result may be an unmanageable quantity of recorded data or – worse still – misinterpretations of actual data. A further inconvenience is the lack of direct correlation between data obtained through non-destructive investigations, referred to quality, and structural behaviour parameters, referred to quantity.
The advantages from this kind of investigation are fourfold:
- rapid intervention;
- building integrity is safeguarded;

- collected data is easily illustrated in graphs;
- quantity and quality data can both be obtained.

This type of investigation is chosen when:

- identifying surface deterioration;
- identifying structural elements not directly visible;
- identifying discontinuities in structural elements;
- verifying the physical and mechanical properties of materials
- quantifying damages in affected structures;
- mapping building materials and typologies in areas lacking homogeneity;
- checking the typology and quality of recovery interventions.

Figure 1: School in Via Milano, Pescara-Italy (image by author)
Combined Survey: hammer and ultrasonic method
Preliminary diagnostic investigations for the assessment of seismic vulnerability of a school building with combined structure. This test enables definition of the physical and mechanical characteristics of the materials that make up the structure, appraising the speed at which waves traverse the actual structures. For reliable results, two transducers are used simultaneously: one emitting and the other receiving, to localize with precision the section of structure under investigation.

Moreover, it will then be possible to guide any destructive testing that may be required in future, optimizing the identification of areas to locate sampling, thus avoiding the risk of investigating areas that are not representative for the diagnostic scenario envisaged.

The most appropriate distinction for NDTs, however, is based on the type of datum obtained: qualitative or quantitative.

Qualitative investigations are:

- sonic;
- ultrasonic;
- thermographic;
- radar;
- endoscopic.

Quantitative investigations are:

- dilatometric;
- penetrometric;
- flat jack.

Figure 2: School in Largo Madonna, Pescara-Italy (image by author)
Pad presence, direction and diameter of reinforcement bars before coring
Preliminary diagnostic investigations for the assessment of seismic vulnerability of a school building comprising two blocks: one with bearing walls and the other with a reinforced concrete frame. This test was performed on the reinforced concrete area of the building and part of a free section of the metal reinforcement bars was defined (lengthwise steel bars and transverse brackets) before removal of a concrete sample for laboratory analysis (coring), thereby avoiding damage to the structure being analysed.

Figure 3: School in Largo Madonna, Pescara-Italy (image by author)
Monitoring internal and external seismic vibrations
Preliminary diagnostic investigations for the assessment of seismic vulnerability of a school building comprising two blocks: one with bearing walls and the other with a reinforced concrete frame. This test was applied to horizontal structures (floors) and the land on which the school was erected, defining seismic input via the study of terrain vibrations caused by propagation of seismic waves, as well as the study of dynamic behaviour of floors in relation to ground movement.

The choice of the NDT most suitable for the needs of the technician who will have to assess the seismic vulnerability of an existing building depends on a careful examination of several criteria:

- operating methods;
- context compatibility;
- location accessibility;
- equipment availability;
- staff safety;
- user safety;

- data processing;
- compatibility of readable data and equipment use;
- equipment operating principle;
- expected result;
- total costs;
- timeframe.

If assessment of the abovementioned criteria suggest a non-destructive diagnostic test, the following will be needed:

- even just approximate information of equipment characteristics and use procedures;
- selection of collected data;
- interpretation of data by reliability;
- assessment of the building's residual performance characteristics.

Figure 4: School in Largo Madonna, Pescara-Italy (image by author)
Flat-jack test
Preliminary diagnostic investigations for the assessment of seismic vulnerability of a school building comprising two blocks: one with bearing walls and the other with a reinforced concrete frame. This test was applied to the bearing walls, defining two typical parameters of the outer bearing walls: local stress (using only a flat-jack) and deformability characteristics (using two flat-jacks).

# 4 Quality in non destructive diagnostic processes for seismic vulnerability assessment

An effective non-destructive diagnostic campaign depends mainly on accurate planning as well as the effectiveness of its implementation, so these two steps require appropriate structuring and monitoring.

Any technician assessing the seismic vulnerability of an existing building will be responsible for the diagnostic appraisal, and will decide which kind of test to carry out and the kind of Quality Assurance Level to apply.

Precisely because of the characteristics of a non-destructive test, as already described, the Quality Assurance Level relies closely on two tools:

- a Quality Assurance Plan, to be carried out by the diagnostic centre, for guaranteeing that all tests are performed pursuant to correct procedures;
- a General Quality Plan, defining the requirements of the analysis project. Requirements include reliability, accuracy and fulfilment of the technical specifications.

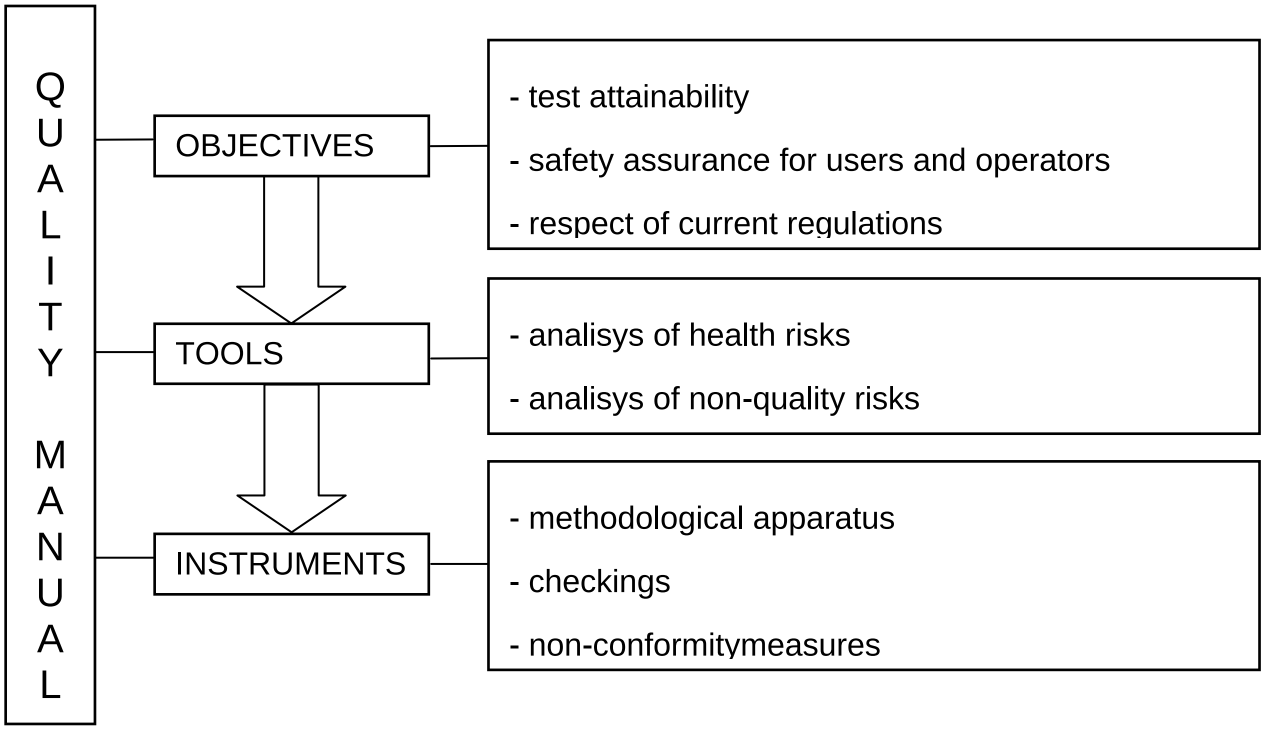
The broad definition of reliability is the level of success achieved by a device or apparatus in the task for which they were designed. In diagnostic tests, reliability represents the main aspect, since it guarantees consistency of data obtained, underpinning the seismic vulnerability evaluation. The definition of the *reliability* requirement has to be anticipated by assessing the non-quality risk. Dependability various investigation process phases is related to the reliability requirement, and it comprises: planning new tests, test implementation; data processing; return of results to the customer.

To satisfy the aforementioned requirements, the diagnostic structure must acquire and apply a Quality Assurance Plan compliant with UNI EN ISO, which identifies suitable procedures satisfying quality requirements. In alternative to the Quality Assurance Plan, it is possible to adopt a document defining procedures to follow while testing, in order to satisfy the Quality Assurance Level requirements defined by the person in charge of the investigation. The Quality Assurance Plan must include the objectives and services offered by the organization undertaking the structure, as well as its willingness to implement those objectives and services. The minimal contents must be as follow:

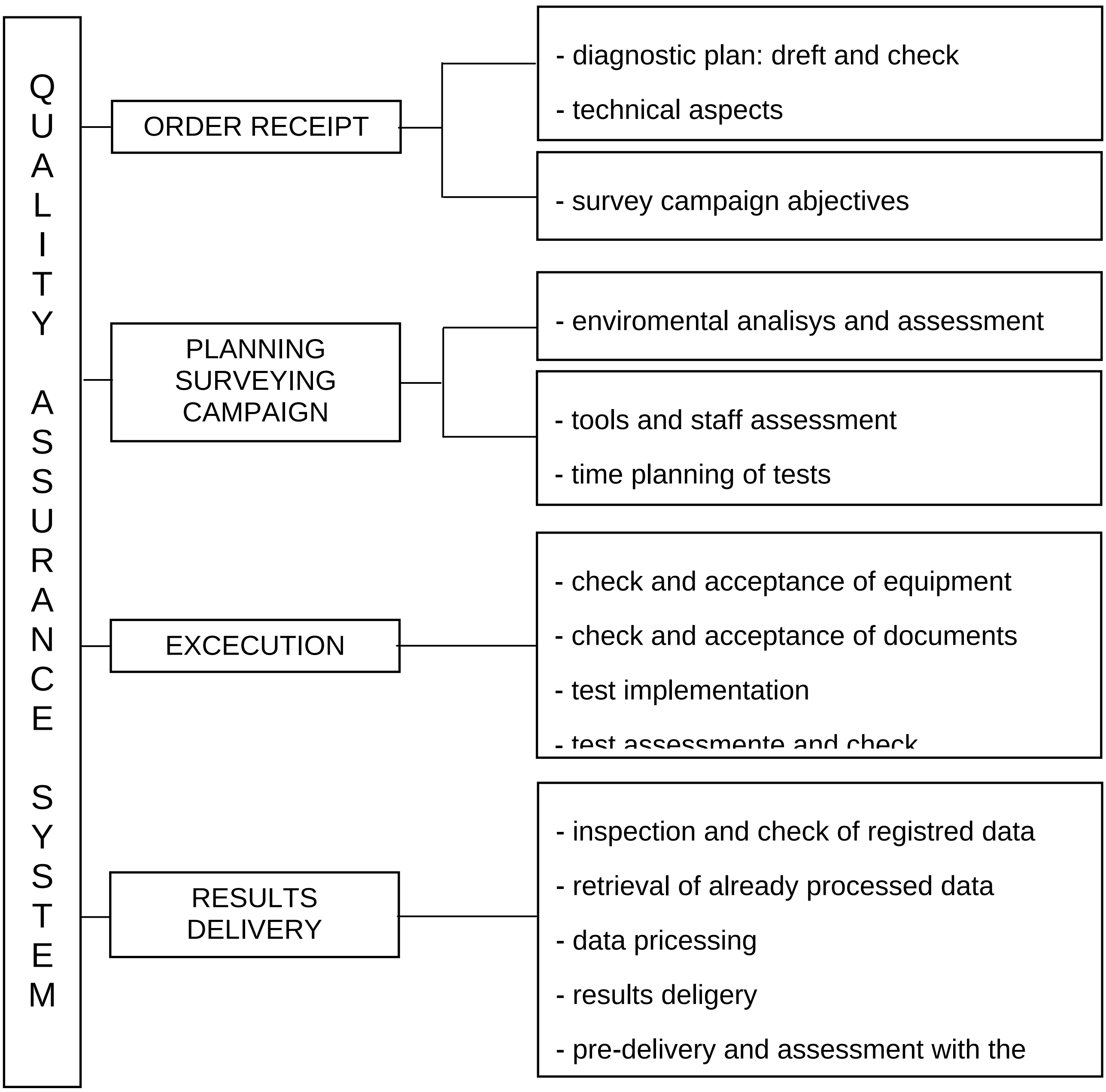
- Internal arrangements on the organization, highlighting roles and responsibility;
- Investigation objectives;
- Planning tests, checks, data storing and delivery;
- Performance of laboratory activities;
- Procedures for managing detected data;
- Definition of a reference document.

The Quality Assurance Plan will be a planning document as part of a specific diagnostic campaign complying with Quality Manual directives which, in turn, will refer to UNI EN ISO standards.

Examples of a Quality Manual and a Quality Assurance Plan are shown in the diagrams below.



QUALITY MANUAL
OBJECTIVES
- test attainability
- safety assurance for users and operators
- respect of current regulations
TOOLS
- analisys of health risks
- analisys of non-quality risks
INSTRUMENTS
- methodological apparatus
- checkings
- non-conformitymeasures

QUALITY ASSURANCE SYSTEM
ORDER RECEIPT
- diagnostic plan: dreft and check
- technical aspects
- survey campaign abjectives
PLANNING SURVEYING CAMPAIGN
- enviromental analisys and assessment
- tools and staff assessment
- time planning of tests
EXCECUTION
- check and acceptance of equipment
- check and acceptance of documents
- test implementation
- test assessmente and check
RESULTS DELIVERY
- inspection and check of registred data
- retrieval of already processed data
- data pricessing
- results deligery
- pre-delivery and assessment with the

## Conclusions

It is clear that obtaining quality data in order to assess building seismic vulnerability by non-destructive tests can be achieved by specific internal organization and accurate diagnostic campaign planning. Basically, the assessment technician and the person in charge of diagnostic investigation will have to work together on the following stages:

- auditing the organization's quality structure;
- planning a diagnostic campaign, assessing the number and position of detectable areas in relation to building characteristics and position;
- re-examining the contract and plan of the diagnostic campaign (see the UNI ISO EN 9004-2 governing re-examination procedures);
- verifying any existing data obtained through past investigations on the same building;
- consulting databanks to retrieve information on data from other destructive and non-destructive tests made on similar materials and components (it is then extremely important to process data in a very precise and systematic way);
- considering environmental and technological factors, as well as their interrelationship, which could influence the investigations and data interpretation;
- calibration of onsite tools.

The pathway must be implemented within the defined timeframe, using available resources and the assuring results reliability. In order to guarantee data reliability, a non-quality risk test must be implemented since when assessing a building's seismic vulnerability, a datum altered by technical errors – of human or procedural origin – can lead to an inaccurate assessment of building response to earthquake action, with highly dangerous consequences on the population. When planning and implementing a non-destructive diagnostic campaign, the non-quality risk can be caused by the following errors:
test design; used tools; test implementation; processing of recorded date; lack of knowledge for tools relevant to assessed structure characteristics.
Once the non-quality risk analysis has been assessed, a procedure able to eliminate such a risk will have to be adopted to reduced the risk of residual non-quality as much as possible. The procedure will be activated by the technician assessing vulnerability and by the person in charge of the diagnostic investigation, each with regard to their own operational responsibilities and requirements, in order to guarantee an adequate level of detected data, crucial for the required assessment, both for private and public clients.

## Reference


Tronconi O. (2009), "L'innovazione nella Tecnologia dell'Architettura" in *Materiali del 4° Seminario OSDOTTA*. L'innovazione nella ricerca. (Torino, 10-13 2008), a cura di O. De Paoli e E. Montacchini, Firenze University Press, p. 238.
Ceroni M., Elia G. (2008), *Diagnostica per I beni culturali*, Alinea editrice, Firenze.
Di Sivo M., Ladiana D. (2007), *Sicurezza e manutenzione dell'ambiente costruito*, Quaderno del Laboratorio QSM n. 6, Alinea, Firenze.
Minciardi R., Ugolini P. (a cura di), (2006), *La messa in sicurezza del territorio da eventi calamitosi di tipo naturale. Atti del Convegno di Lerici-12 Settembre 2005*, Alenea editrice, Firenze.
Franceschi S., Germani L., Pasquini M., Ulivi E., (2003), *Il progetto di restauro-protocolli operativi*, Alinea editrice, Firenze.
Cattanei A., Di Battista V., Jurina L. (a cura di), (2002), *Prevenzione dei rischi di crollo nell'edilizia residenziale*, Aline editrice, Firenze.
[1] Franceschi S., Germani L., Pasquini M., Ulivi E., (2003), *Il progetto di restauro-protocolli operativi*, Alinea editrice, Firenze, p. 102.