Network of European Research Infrastructures for Earthquake Risk Assessment and Mitigation

Report

D10.2 Dissemination plan

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Summary

The task of the NA10 is a dissemination strategy within the NERA project that will ensure maximum impact of the project during its life span and benefits to the community and its stakeholders after the project is ended. The document describes the activities to be carried out in the framework of a dissemination strategy, results of such activities and the on-going evaluation of the progress. The NA10 also outlines a basic concept for communication within the NERA project as well as between project participants and the broader European and international community. The dissemination plan is a working tool that reflects the approach and activities of all participants in the project. This report and the final report will specify actions carried out during the project life cycle.

One of the important issues in the dissemination process was creating the Database and composing details taking information about research centers and organizations in the seismic area. Interaction of scientists who work on different, complementary fields of seismology and earthquake engineering through the collected data will enable successful work on different tasks in the project.

The Database consists of a long list of research centers and organizations in seismology domain. It provides information about contact details and enables an access to institutions, which dispose with earthquake data, information about hazard and risk products and tools. The Database contains information about organizations and institutions in Europe, United States, Asia, Africa and Australia. The data is compiled from 500 institutions in earthquake engineering. The most important task of the Database is to compose details and comprehensive information that will serve the dissemination process as an important activity of the NERA project.

The results and outputs in NERA will be disseminated in Europe and worldwide with appropriate schemes. The objectives and the deliverables are focused to the needs of public and private organizations, which operate in the field of seismic hazard. Dissemination process will contribute in achievement of a measurable improvement and a long-term impact in the assessment and reduction of the vulnerability of constructions and citizens to earthquakes. NERA have to provide a high-quality service and this will be also ensured by the adequate Database.

1.Introduction

NA10 will coordinate a nationwide program of multidisciplinary team research, education and outreach activities. Research focuses on improving assessment and performance of buildings, highways and other infrastructure, and response and recovery systems. Through dissemination work process NA10 will encourage team collaboration among academic researchers, professionals in engineering, design and other related disciplines, government officials, manufacturers, and additional stakeholders in both private and public sectors. Outreach activities will include broad-based dissemination of information and technology through research reports, national and international conferences, industry partnerships, and an information service that provides convenient access to published, recorded, and online materials on engineering, geology, and social, political and economic aspects of earthquakes. The participants in NERA project will also establish cooperative research programs with institutions outside Europe to exchange findings and advance earthquake hazard mitigation.

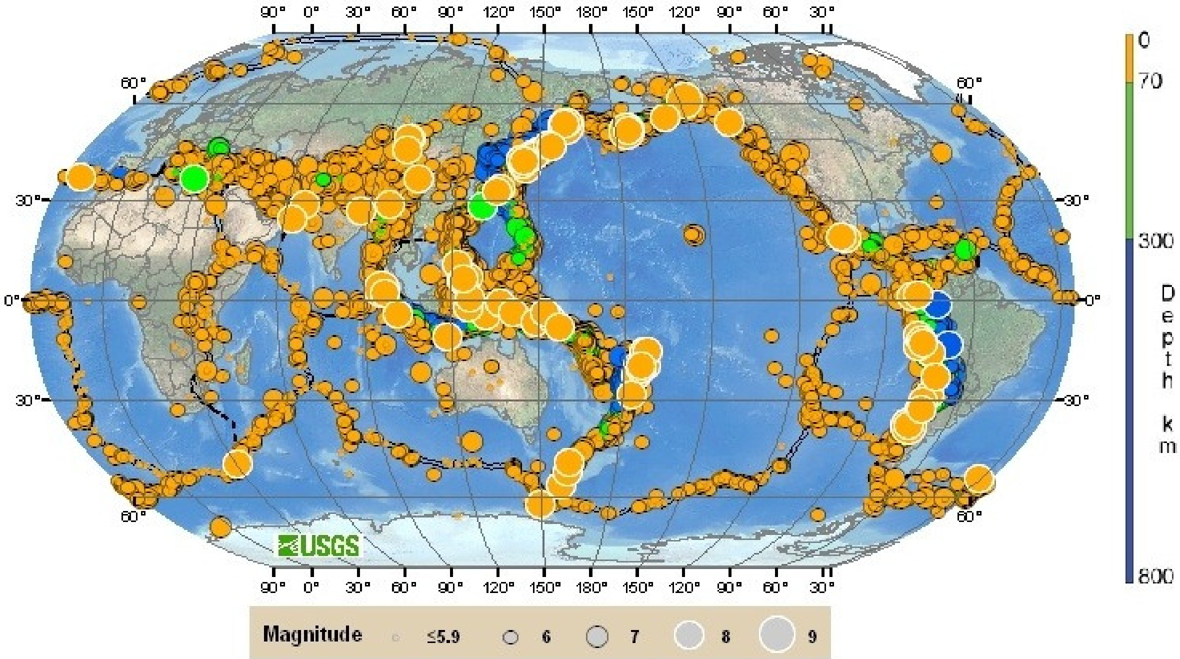

Figure 1: Global Seismicity

To achieve the goals of NA10, a Database with 500 institutions has been established serving all organizations dealing with earthquake hazards and providing information about contact details (name, town, country, address, web page of the institution, contact persons and their phone number and e-mail address).

An advanced earthquake system should consist of modern communication networks and data processing centers, which enable communication between organizations about constantly recording and analyze seismic data and provide timely and reliable information on earthquakes and other seismic disturbances. The Database will facilitate an access to various impacted economic sectors such as industry and transport. This is important in risk prevention and emergency response polices.

2.Dissemination

2.1 Issues

The general issues are

- How to optimal use the resources
- How to become noticed
- How to integrate the activities of the large group
- To provide tools for help
- To enable proper management
- To prepare for the future

In particular the following points have to be considered:

- Meta Data Format
- Training Material (Key Lectures moving People)
- Standards
- Crowd Sourcing
- Ontology
- Web 2.0 Compatibility
- IT is generally underrepresented
- Do we like USGS or NIED portals ?
- NEES
- EERI support to countries in need
- UN support to Haiti
- European harmonised Response to Disasters
- EAEE development strategy
- From SRA 2005 to Horizon 2020

The final outcome should be

- A Global Infrastructure Model
- An Easy Access to comprehensive Information
- (One Stop Shop)
- A widely accepted and used Portal
- Apps

2.2 Methodology

Communication among participants in the NERA project and research and economic organizations in Database will enable strong data acquisition and dissemination issues, advance recording and instrument technologies, improving maintenance techniques, developing data archiving and dissemination technologies, and maintaining on-going communication with strong motion data users.

The NA10 will provide the distribution and exploitation of results at all levels. NERA integrates the seismological, geotechnical and earthquake engineering infrastructures. For monitoring of dissemination, a methodology has to be planned. The methodology steps in dissemination process are illustrated in Figure 2 below.

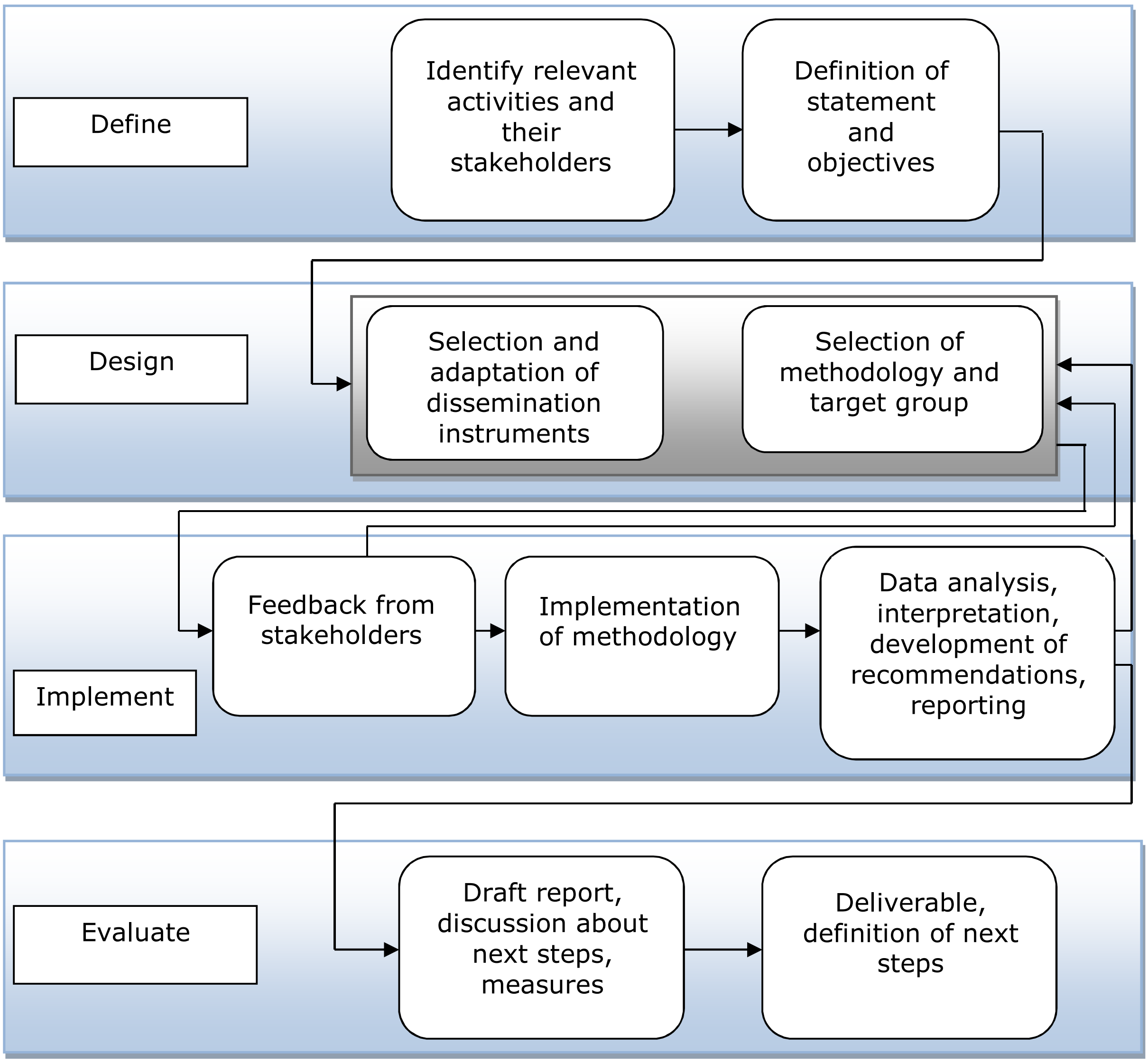

Figure 2: Dissemination methodology

The methodology consists of the steps:

2.2.1 Definition of the dissemination plan

Dissemination is an activity considerably growing during the course of a project and does not end with the end of the agreement. This dissemination plan comprises a relevant draft that has been carried over from previous projects. It is under constant development and is updated with every new knowledge or information received. The tools and measures are permanently upgraded under consideration of the feedback of the users.

In consequence this report is updated every year and will be transferred into a final dissemination plan before the end of the project. It is anticipated that the developed technologies and approaches are sufficiently attractive to justify activities beyond the end of the project. There are cycles of approximately 10 years to be expected until the next generation of development becomes relevant. This is considered in the respective strategic plans followed up by the management of the project.

2.2.1.1 Relevant activities are identified.

In preparation for the European strategic research agenda on earthquake risk prepared for submission to the European commission and the European Parliament late 2012 all relevant activities including the list of stakeholders has been re-visited and completed. Furthermore in meetings with the seismic risk community on global scale (for example at the 15th World Congress of Earthquake Engineering held in Lisbon in September 2012) the global perspective of earthquake risk research has been discussed and respective statements are developed.

2.2.1.2 Statement and objectives.

Two examples are presented here that are relevant for this work step. The overview of earthquake loss estimation and assessment tools provides a good indication to cover the consequence element of risk computation. The work document on the EU-US relevance: the future of earthquake engineering brings in the respective statement to the Trans-Atlantic coordination.

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Overview of Earthquake Loss Estimation and Assessment Tools

General

Earthquake Loss Assessments (ELAs) are produced in order to detect possible economic, infrastructure and social losses due to an earthquake. In order to produce an effective ELA, four components must be taken into account.

Seismic Loss = Exposure * Vulnerability * Hazard * Damage Loss Conversion

Exposure is defined as the amount of human activity located in the zones of seismic hazard as defined by the stock of infrastructure in that location.

Vulnerability is defined as the susceptibility of the infrastructure stock.

Hazard is defined by risk of a certain ground motion occurring at a location, which can be defined by scenario modelling via stochastic catalogues, PSHA or other methods, and can include different types of earthquake effects.

Damage Loss Conversion can be defined as the mean damage ratio (ration of replacement & demolition to repair and restoration cost, or the social cost.

Constitution of an Earthquake Loss Estimation (ELE) program

First of all there has to be a defined area of interest in which the seismic hazard should be located at every location. The vulnerability of the infrastructure stock exposed to this hazard should be convolved with this hazard and therefore a damage distribution can be established based on various classes of infrastructure damage. From this damage distribution, economic and social losses can be derived. All of these components constitute an ELE. The use of such a tool can be divided in a proactive way (pre-earthquake modelling) or a reactive way (post-earthquake fixed scenario modelling).

Exposure

Exposure is a very critical parameter in an ELE procedure. Unfortunately it is a very difficult component to collect. Data quality can vary from country to country and region to region, so it is very hard to derive an accurate infrastructure stock for any country.

There are currently many different ELE software packages and each software package requires different inputs. The inventory data includes building location, age, use, height, structural type, structural inconsistencies, construction age, number of storeys and population information.

Of course in order to do a detailed ELE, exposure needs to be undertaken on a small area level. On a city or regional level, urban characteristics are required in order to produce a suitable inventory, including location of lifelines and also building stock details. This is generally a large amount of work requiring much money and time for a certain location, but the level of detail that is able to be extracted during this part of the process determines to a great extent the accuracy of the result at the end of an earthquake loss assessment.

One of the most important aspects to be found in an exposure inventory production is that of lifelines within the region being analysed. These lifelines are intrinsically linked to the specific cost section: however, they must be identified for rapid loss estimation process in order to ensure that utility (potable water, waste water, oil, natural gas, electric power and communication) and transport systems (highway, railway, bus, port, and airport) can remain in place during a disaster. Critical Systems must also be identified for rapid response and calculation during the loss estimation module such as medical care facilities, schools and emergency services. In addition, industrial commercial and residential areas should also be identified.

Vulnerability

The principal aim of a vulnerability assessment is to derive the probability of a certain level of damage occurring to a certain infrastructure stock when subjected to a scenario earthquake.
The development of vulnerability curves is not a straightforward process. If it were possible to run a non-linear time history analysis for every single infrastructure item within the infrastructure stock and the information would be freely available, then this would be done in order to calculate the vulnerability. However, this information is not freely available for every infrastructure item and in addition it can take days to produce a single NTHA (Non-linear time history analysis) of a building when given the construction plans as a new model needs to be created for every building. Although it can be taken into account, that single (important) buildings are being computed that way.

Empirical Methods are vulnerability assessment methods on observed damage data. These methods have been employed to define the vulnerability of infrastructure stock from the 1970s. Many of these methods only use macro-seismic intensity of PGA (Peak Ground Acceleration) rather than spectral ordinates which created large scatter of results. However, these were initially the only possible methods for large scale seismic risk analysis.

> Damage Probability matrices (DPM) are methods to determine damage due to strong motion which are simply the conditional probability of obtaining a certain damage level (j) due to a certain ground motion intensity (i).
> For a given building class, subjected to a given intensity, there will be a certain percentage of buildings associated with the combination which corresponds directly to a given damage ratio, as classed within the damage state index used. Thus for this percentage of buildings, the ratio of repair to replacement cost corresponds to the values given in the DPM.

The disadvantage of using macro-seismic methods for observed damage of building stock is that the vulnerability and ground motion input are both based on observed damage due to earthquakes which is not correct. If such observed damage values are going to be used, there are also not many recordings of earthquakes with large intensities which occur close to cities. Therefore there is a lack of data in the high damage and ground motion section of the vulnerability matrix and so the statistical certainty is less towards the higher end of the spectrum. Another issue results from the fact that PGA and spectral ordinates are generally used for seismic hazard maps and these are not directly related to intensity scales which are slightly subjective in nature. PGA when derived for empirical vulnerability does not take onto account the relationship of vibration frequency content of buildings versus that of the ground motion and this is why spectral ordinates are more desirable.

Empirical Vulnerability Index Methods

These Methods are usually based on much survey data after an earthquake in order to gain information as to relationships between damage and intensity based on parameters influencing vulnerability. These methods have been used extensively throughout Italy previously using these parameters, and thus expert judgement can be used in order to calculate the vulnerability index and then produce an indirect relationship with a damage factor for a given PGA/macro-seismic intensity.
These methods have been also used as part of the RISK-UE project.
This methodology is easily adaptable to large-scale assessment of groups of buildings but still requires expert opinion. It also requires the use of extensive field surveying which not available in many regions. It is somewhat subjective and therefore is not exact, and thus surveyors may have different ideas as to define building characteristics without strict guidelines. Therefore this gives discrepancies.

Continuous Vulnerability Curves

Those methods are another empirical method which has been used for vulnerability assessment by directly utilising the probability of the damage of buildings to earthquakes. These have been produced using ISTAT data for the production of seismic risk by taking DPMs to produce vulnerability curves in terms of spectral displacement at the period of vibration.
This method was undertaken in order to overcome the inaccuracies or continuous curves based on PGA or macro-seismic intensity converted from PSI (parameterless scale of intensity).

Analytical and Hybrid Methods of Vulnerability Analysis

Analytical methods are based on structural mechanics principles and are fast becoming the preferred method of large-scale vulnerability assessment due to their proactive capacity, direct correlation with damage and non-reliance an observed damage data. Analytical methods are mainly based on non-linear analysis as this allows for stiffness degradation of existing buildings to be taken into account.

Analytically derived vulnerability and fragility curves and DPMs (Damage Probability Matrix)

Those curves can be produced by computational intensive analyses rather than observed damage data to obtain the structural performance via a given intensity measure. (Europe, Rossetto and Elnashai (2005), Dumova-Jovanovska (2004) and Masi (2004)).
Singhal and Kiremidjian (1996) derived fragility curves and DPMs from Monte Carlo simulation (random variation of material properties) for reinforced concrete frame structures using a variety of ground motions with non-linear dynamic analysis (NTHA) in order to produce the structural damage probabilities. The results for each of the nonlinear analyses was done based on the Park and Ang (1985) damage index and the statistical analysis used in order to produce the DPMs and fragility curves. The vulnerability curves were then updated with the Northridge data with an additional weighting system.

The most used damage scale for analytical fragility functions is the Park and Ang (1985) damage index.
Masi (2004) derived vulnerability curves using the EMS-98 scale, and NTHA with synthetic and real accelerograms, utilising design code and handbook derived structural models from Italian buildings from the 1970s onwards.
Rosetto and Elnashai (2005) used the damage scale derived from their 2003 paper and produced adaptive pushover curves and thus via the capacity spectrum method the performance point was defined to a damage state.
The computational time needed for analytical methods impacts upon their usefulness for countries where there are many different construction types and characteristics, and thus although not useful on their own, can be used to support empirical DPMs, fragility and vulnerability curves via their use in hybrid DPM and vulnerability curve methods, which use analytical methods to fill in the gaps and data within the damage band for certain intensity levels where there is no empirical data in that location. This is therefore faster than analytical methods.

Capacity Spectrum Method

This method is widely used within loss assessment models due to its ability to relate the crossover point of capacity via a pushover curve and demand via an ADRS (Acceleration-Displacement Response Spectrum) to a given damage state.

Essentially, the capacity spectrum method relies on an iteration method from the initial ADRS (usually set at 5%) in order to relate it directly to the pushover curve to achieve the performance point which defines the damage state taking into account both the equivalent non-linear damping and ductility (representing the horizontal displacement of the structure under increasing horizontal loading). The iteration from FEMA-440 shows the ratio beneath the capacity curve (i.e. maximum strain energy) from the performance point, to the total hysteresis loop are which is the energy dissipated by damping.
As the ground motion increases (i.e. higher ground shaking), the amount of inelastic deformation increases (i.e. larger displacements for a certain acceleration), and period lengthening occurs for the structure. More ductile structures will have larger displacement ductility associated with their capacity and stronger structures will be able to resist greater accelerations for a certain displacement.

HAZUS is a very simple hence useful and adaptive procedure. It has many simplifications as it assumes the same capacity curve for a certain location. It is also difficult to adapt the capacity curves to other locations in the world as the building classes have been derived for limited height buildings in the U.S. These buildings are also put into binned height classes and therefore the building capacity curves and vulnerability functions are approximate. Thus, in order to adapt these buildings to other locations in the world, a large amount of building information is required in order to carry out a reliable non-linear static procedure.

Giovinazzi (2005) presents a displacement-based mechanical procedure to assess masonry and RC (Reinforced concrete) frames by using s capacity cure which has been converted to a Sa-Sd plot.

Molina and Lindholm (2005) as part of their SELENA ELE software incorporate a logic tree approach within their capacity spectrum methodology in order to reduce epistemic uncertainty.

Displacement-based methods have been produced recently due to their ability to relate to damage states better than original force-based methods and proposed through Priestley (2003) as damage is strain dependent. Thus, through strains, curvatures can be derived and subsequently rotations and displacements.

Hazard

Identification of possible hazards in addition to ground shaking has been undertaken by Bird and Bommer (2004) and the impact to building damage of these potential hazards has been found to be much less than the ground shaking due to earthquakes (ground failure effects such as liquefaction, fault rupture landslide, slope stability and bearing capacity; tsunamis and seiche). However, these secondary effects cause a lot of damage to lifelines (Bommer et al, 2006).

Ground Failure

Liquefaction involves the changing of soils from slid to liquid state and is usually caused by induced cyclic shear. It is thus energy related and so is extremely complicated to incorporate into loss models. There are many uncertainties over the area and extent of liquefaction but by using simplified methods such as relationships between PGA and susceptibility liquefaction can be applied into loss models.

Bearing Capacity failures using the methods of Richards et al (1993) or Kumar et al. (2003) can be used in order to determine the damage of structures due to loss of bearing capacity, but currently there are no loss estimation models that take this into account.

Fault Rupture causes localised effects and thus is usually not incorporated into the ELE assessment.

Landslides and Slope Stability are more difficult parameters to constrain because of the need to determine the rainfall that has occurs in the area before the earthquake to have an ideas of possible landslides as they can also be rainfall-induced. Most of the analysis methods include a simple ratio between PGA and the factor of safety (FS) is based on a critical acceleration for the slide mass. Many methods have been established including a probabilistic framework by Del Gausio et al. (2003) producing damage functions for structures based on the movements and probability of slope failure. GIS evaluation models can simply identify susceptible areas to landslides, and this combined with an intensity measure approach (Wilson, 1993) may be the best method for application.

Tsunamis and Seiche (standing wave induced phenomena) have increased in importance since the Boxing Day Tsunami of 2004. Although important, this type of secondary effect should be generally applied at a rapid response level, due to the unknown nature of sea-floor bathymetry with undersea quakes and the relative lack of knowledge in the area worldwide, given the depth and uncertainty of such phenomena.

Methods of Seismic Hazard Assessment

There are two main methods of seismic hazard assessment: ones which are deterministic (DSHA) and that include a single scenario earthquake (historical, MCE or user-defined); or a probabilistic combination of earthquake scenarios in order to determine the hazard for the given area (PSHA).

A seismic hazard assessment consists of 3 components: recurrence relations (magnitude function), source zones and earthquake catalogues (historic and stochastic). The recurrence relationship comes about as a probabilistic result of the minimum and maximum earthquake possible from an earthquake catalogue for the given source to produce a probability density function giving the ARE (Annual Rate of Exceedance) of different magnitudes. Earthquake catalogues are extremely important in hazard assessment and detail the magnitude and spatial position of previous recorded earthquakes.
Source zones are the spatial regions where the future earthquakes are expected to occur, defined by tectonics, geology and and observed seismicity. Source, path and site effect calculated via GMPEs (Ground Motion Prediction Equation) and local site conditions define the ground motion field away from the sources.

A **deterministic seismic hazard assessment** (DSHA) consists of 3 main steps and has been carried out for many locations where a complete worst case scenario or historical repetitive earthquake is waiting to be modelled:

1) Define all possible sources to cause significant hazard at a site from historic tectonic, geologic or geotechnical data.
2) Choose a fixed distance, fixed magnitude earthquake and place it on the closest position to the site on each source, defined via empirical equations on the basis of geological evidence using Wells and Coppersmith (1994) of by just adding 0.5 magnitude units to the largest historical earthquake
3) Estimate ground motions via GMPEs to determine the ground motions at the site in terms of spectral ordinates. Variability can be modelled for the ground motions within a DSHA; however a common way is to use motions which are one logarithmic standard deviation above logarithmic mean. Each of these DSHA is very useful for lifeline and critical facility locations and is increasingly being used to supplement a PSHA

A **probabilistic seismic hazard assessment** (PSHA) considers all M-D-e combinations taking into account all probabilities and scenarios possible for magnitude and distance to calculate the hazard. The steps involves are adapted from Akkar and Boore

1) Define a probability of potential rupture locations for each source.
2) Determination of the temporal distribution via recurrence relationships. The Guttenberg- Richter relationship is commonly used where Nm is the mean annual rate of exceedance of magnitude M, b is the activity parameter expressing likelihood of large and small earthquakes and , a , describes the yearly rate in logarithmic space of earthquake

$$\log(N_m) = a - bM$$

But other relationships adapt this to calculate a characteristic magnitude and thus describe truncated normal and lognormal, exponential, uniform and Qouns and Coppersmith Characteristic Equation and Delta magnitude recurrence relations.

3) GMPEs are used for the range of distances for each magnitude to produce spectral ordinates dependent on the tectonic regime with aleatory variability, σ (interevent and intraevent) of each relationship taken into account as well as the applied variability, e
4) The hazard must then be integrated by combining the effects of different size, locations, source zones and occurrence probability earthquakes in order to calculate the expected number of exceedance of ground motions due to the PDF (Probability Density Function) of magnitude, distance between source and site and also the probability calculation for spectral ordinate values away from the mean value. From this, annual rates of occurrence are derived giving a hazard curve
5) A PSHA assumption common made is the Poissonian model that takes the annual frequency of exceedance from this analysis and assumes that each earthquake is independent of other earthquake, where q(z)= is the probability of exceedance of a user-defined ground motion level for a given time, t in years, where λ(z) is the annual rate of exceedance is thus';

$$q(z) = 1 - e^{-\lambda t}$$

From this a 10% probability in 50 years gives the 1 in 475 year return period for this earthquake.

Damage Loss Conversion, Economic and Social Costs

By convolving the impacts of hazard, vulnerability and exposure, the conversion into a damage loss and specific cost in terms of economic and social cost can be applied.

There are two different scenario components for the socio-economic module that should be addressed:

a) Direct conversion of damage to fatalities, injuries, homeless and economic impact
b) Direct and Indirect socio-economic impacts and complex indicators including social and economic vulnerability

There are many different indices and databases which can be used for the evaluation of socio-economic consequence functions. Most of the historic social and economic functions have been damage-based i.e. building class related, however there is the need for pure economic and social functions which are unrelated to damage, and may be intensity-based, or based on some other parameter. Indirect social and economic functions should also be accounted for.

Social and Economic Vulnerability

Increased social vulnerability can be looked at in advance, once danger has been identified such as currently in Adelaide, Australia for a fictitious case. By using an in-depth assessment technique such as DBELA and then applying it to Adelaide, to find out which types of houses are most susceptible, people can be warned prepared and educated. In some cases the government will undertake screening methods and the retrofitting methods. Thos has been found to work in advanced nations, but in developing nations this can be a problem and so the results of ELE software need to work out some sorts of social vulnerability function based on the nation in term of building practice and not directly to damage.

It can be generally assumed that within developed countries, the seismic codes employed will be more up to date than those of developing countries. Therefore, it can be assumed that less damage will occur in these countries for an earthquake striking a high population area.

In most cases, if an earthquake strikes a location of high population density such as in the city of Kobe in Japan in 1995, it can be expected that the economic loss will be high, with a large number of death and with this value of deaths increasing with decreasing development.

It can be seen that by correlating the population growth to the locations of population density and also those of the development index, the increasing exposure of a nation to earthquake can be observed. Assuming the current population level increase, people will have to build in locations of higher risk or with increasing speed and this will cause problems in the future.

There are a number of socio-economic indices that have been established. Risk analysis when applying indicators for the socio-economic assessment on any geographical level can be undertaken using a variety of Socio-Economic Indices.

- Urban Seismic Risk Index (USRi) – Carreno et al. (2006)
- Social Vulnerability Index – Cutter et al. (2003)
- Disaster Deficit Index (DDI) – IADB
- Seismic Safety Indices
- Disaster Risk Management Index (DRMI) – IDB IDEA
- Earthquake Disaster Risk Index – Davidson (1997)
- Cities Project – Granger et al. (1999)
- Hotspots Project by the World Bank

End quote------------------

Quote----------------

EU – US relevance: The Future of Earthquake Engineering

(The US view; from NEES Vision 2020)

Earthquake engineering has matured over the past decades. This process has taken this engineering discipline from its structural engineering roots in the first lateral load code provisions made in the 1930's through an integration of earth sciences, structural and geotechnical engineering, structural mechanics, architecture, numerical and probabilistic mathematics, education and social sciences into what we today know as earthquake engineering. The focus on performance measured by the consequences of an earthquake on the function of a stricken structure and/or a stricken community is a direct result of the work of the three NSF-supported earthquake engineering research centers during the past decade. Today, the practicing community is moving towards a performance-centric approach to design through efforts like the ATC-58 Project and the development of risk targeted ground motion maps in ASCE 7-10 (ATC, 2006; ASCE 2003b).

The George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) is a major national resource that plays an essential role in the nation's strategy for reducing losses from future earthquakes (NRC, 2004; NIST, 2008). This NSF-supported network of structural, geotechnical, tsunami and field fixed and mobile laboratories provide the means to conduct complex experimental and numerical simulations of seismic response of structures and infrastructure with capabilities not available previously. The NEES network aims to provide a fertile environment for collaboration of teams capable of tackling major earthquake engineering challenges in a multidisciplinary fashion. Thus, the capabilities and continued operation of the NEES network to best address the needs of the earthquake community should be considered in parallel with any discussion of the vision for the future of the earthquake engineering disciplines.

The fortunate absence of a major damaging earthquake in the U.S. since the 2001 Nisqually earthquake has had three major effects: a dilution of focus among the research community; a divergence of priorities between the practice and research communities; and, earthquake mitigation is not keeping pace with technologies from other fields that could make radical advances toward developing resilient communities. The research talent is drawn away from earthquake engineering towards major initiatives on energy efficiency and green technologies, while the focus of the majority of the practicing community remains delivering earthquake safety at minimum cost to developers. This leads to difficulties in determining the direction of the next major earthquake engineering initiatives and in focusing the projects using the NEES network. In turn, development of the next generation of earthquake engineering researchers and practitioners is becoming constrained. Together with limited funding, the lack of a focused, community-driven vision will hinder future advances in earthquake engineering in the US.

The next 10 years are crucial for evolution of this engineering discipline. The lack of focus is also a unique opportunity to set the stage for development of areas of earthquake engineering that would not have emerged when driven by an earthquake emergency. Three principal directions are available: 1) development of new structural and infrastructure systems, which require significant time to develop and validate; 2) solutions for major community-level or industry-level earthquake-related problems, which require a multi-disciplinary approach and teams drawn from diverse but complementary backgrounds that need time to come together; and 3) introduction of global and "external" research trends, such as energy efficiency and green building technology into earthquake engineering as well as integration of earthquake engineering with major research initiatives and developments in information technology, new materials and machines, and cyber-physical systems.

Several recent reports support the need for a strong U.S. presence in earthquake engineering research. Most recently, a series of NSF workshops has focused on the major research directions moving forward in several key areas within earthquake engineering (Wight, 2010; NIST GCR 09-917-2). Furthermore, ASCE's latest infrastructure report card (ASCE, 2009) indicates that the current condition of all elements of the nation's civil infrastructure is barely passing, making it much more vulnerable to earthquakes and other hazards. In 2003 EERI proposed a comprehensive research and outreach plan focused on improving our ability to manage risk and to transfer these findings into practice (EERI, 2003). In 2004, the National Research Council went a step further by proposing a grand challenge to the earthquake engineering community including recommendations on the role of NEES and NSF as well as achievements that would be made possible by the deployment of new information and communication technologies (NRC, 2004). Furthermore, the National Academy of Engineers has identified *Restore and Improve Urban Infrastructure* as one of the 14 Grand Challenges in Engineering (http://www.engineeringchallenges.org/). EERI (2008) has also delineated the role earthquake engineering has in enhancing public safety and discussed the potential contributions of earthquake engineering to the mitigation of other hazards beyond earthquakes.

The National Earthquake Hazards Reduction Program (NEHRP) strategic plan (http://www.nehrp.gov/pdf/strategic_plan_2008.pdf) discusses the need for developing and applying knowledge generated from multidisciplinary research in earthquake resilience and includes support for operating key research and data collection facilities (i.e., ANSS, NEES). The plan links NEES to a number of strategic priorities, including advancing understanding of earthquake processes and impacts; further developing performance-based seismic design; improving techniques for evaluating and rehabilitating existing buildings; improving understanding of the social, behavioral, and economic factors related to implementing mitigation strategies; developing advanced risk mitigation technologies and practice; and developing resilient lifeline components and systems.

The 2020 Vision workshop was organized with the goal to formulate a vision of where earthquake engineering research in the U.S. needs to be in 2020 going forward through direct engagement of a large portion of the earthquake engineering community. The objectives of the workshop were: 1) to chart the principal new directions in earthquake engineering research, practice, education and outreach to be adopted by the earthquake engineering community in the next 10 years, and to postulate the principal goals for earthquake engineering beyond 2020; and 2) to reflect on the role of the current NSF NEES facilities in meeting the research needs of the earthquake community and to elucidate what new facilities would facilitate rapid progress along these new directions.

The outcomes of this workshop are presented in this report. The participants of the workshop unanimously identified resilient and sustainable communities as the overarching long-term goal to achieve in earthquake engineering. While the overarching theme was consistent with the goal of the new National Earthquake Hazards Reduction Program (NEHRP) plan for achieving resilient and sustainable communities, the participants recognized that work on achieving this goal could take the research community beyond 2020. The participants proceeded to identify seven principal directions in earthquake engineering research where significant progress needs to be made by 2020 to attain the resilient and sustainable community goal. These research directions are: 1) metrics to quantify resilience; 2) means for hazard awareness and risk communication; 3) challenge posed by existing structures and infrastructure; 4) opportunities to use new materials, elements and systems; 5) methods for monitoring and assessment of resilience; 6) means to simulate resilience of systems; and 7) methods for implementation and technology transfer. A description of each research direction is provided herein, along with the intellectual merit and broader impacts. Furthermore, the workshop participants considered the enabling technologies and fundamental capabilities needed to make substantial and rapid research progress.

Workshop participants also reflected on the role that the NEES network is playing in making progress toward achieving the vision of resilient and sustainable communities. To date, NEES has gained worldwide recognition in advancing our ability to conduct earthquake engineering simulation. NEES will also play a crucial role in meeting the unprecedented need to rehabilitate the vast stock of existing U.S. civil infrastructure. Furthermore, NEES is well positioned to provide the proof of concept testing necessary for emerging technology and substantiating evidence for its implementation. In addition, the NEES network will impact a broad cross section of society by generating opportunities for training the next generation of researchers, creating linkages to practitioners and policy makers to facilitate adoption and implementation of new technologies, providing educational materials and a strong public outreach component.

Working towards the *2020 Vision* of resilient and sustainable communities will revolutionize the discipline of earthquake engineering. The development of resilient and sustainable communities requires understanding and simulation of both the physical systems and the human systems within the communities. Thus, crossing the traditional boundaries between engineering and social science will generate necessary fundamental knowledge and enabling technologies. Such a transformation of earthquake engineering will serve to improve the disaster resilience of communities, and demonstrate that investments in earthquake safety can reduce losses from other hazards and improve lifecycle performance, while also developing the nation's human resource base in the earthquake safety field.

Wenzel, June 2011

End quote------------------

2.2.2 Design of the dissemination plan

2.2.2.1 Selection of dissemination instruments.

A portfolio of dissemination instruments is tried and used. Besides the newsletter (refer to a separate chapter) and the webpage (refer also to a separate chapter) a deep study in existing seismic portals has been performed. This exercise is necessary to sharpen the affectivity of the NERA-Portal to be created. The creation of the portal is consequently in progress and waiting to be fed with results from the project due in the coming periods.

Quote-----------------

Comparison of existing Seismic Portals

Introduction

Within the framework of the NERA project, several already existing web-portals which offer informational services concerning seismology, shall be surveyed and inspected with respect to a certain number of different characteristics and metrics in terms of usability and usefulness. This document aims to examine four rather comprehensive seismology web-portals and focuses on positive as well as neutral and negative aspects regarding the following criteria:

- Usability
- Informational services
- Security
- Availability and accessibility of seismologic data
- Integration of semantic technologies

Not every criterion can be evaluated and reviewed on every web-portal, hence the following simple assessment is reflected in point-by-point lists.

Portals

The web-portals in question which have been reviewed are:

- Observatories and research facilities for European seismology (ORFEUS), http://www.orfeus-eu.org
- European Plate Observing System (EPOS), http://www.epos-eu.org
- Centre sismologique Euro-Méditerranéen / European-Mediterranean Seismological Centre (CSEM-EMSC), http://www.emsc-csim.org
- Network of Research Infrastructures for European Seismology (NERIES), http://www.neries-eu.org and its corresponding earthquake data portal http://www.seismicportal.eu

ORFEUS

- **Pro:** Freely available, very large amounts of data, provided in SEED format. The available data-sets are clearly distinguished whether they have been quality-checked or not.
- **Pro:** Up-to-date list of recent earthquakes
- **Pro:** Real-time earthquake monitoring
- **Pro:** Seamless Google-Maps integration
- **Pro:** List of stations, including detailed information concerning their instrumentation which was used and is currently available in order to collect data
- **Con:** No SSL accessibility by default
- **Neutral**: SSL would be enabled, but is followed by an HTPASSWD authentication requests, and therefore reasonably not usable by visitors.
- **Con:** Data is primarily accessible through legacy methods, namely FTP and HTTP servers. The main FTP server in use is running vsFTPd v2.0.5, which is vulnerable to a Denial-Of-Service attach which is easily exploitable (see CVE-2007-5962)
- **Con**: Seemingly no integration of semantic technologies

EPOS

- **Neutral**: The project and therefore its corresponding web-portal are in a rather early stage of development (as stated on the web-site, the current progress is in *Preparatory phase* which is scheduled from 2010-2014).

- **Con:** Poor informational content, looks like marketing-text for the project
- **Con**: No SSL accessibility by default
- **Con**: SSL available, but leads to legacy install script of CMS on server and hence offers potentially dangerous attack vectors.
- **Con/Neutral:** Absolutely no data available. "Data products" menu item is basically empty at this time.
- **Con**: No obvious availability of informational web-services at all

EMSC-CSIM

- **Pro**: Detailed list of recent earthquakes
- **Pro**: Seamless Google Maps integration (however, its interface is not as advanced as seismicportal.eu)
- **Neutral**: The earthquakes which are shown on the map can be regulated by adjusting a time-frame; however, this time-frame appears to be too statically defined.
- **Pro**: Freely available RSS feed
- **Pro**: Cellphone/SMS/PDA realtime information services
- **Pro:** Seismological activity map widget available
- **Pro:** Automatic propagation of earthquakes via twitter
- **Pro**: Considerable list of freely available publications
- **Neutral**: Login available, but what for?

NERIS/Seismicportal

Neries:

- **Pro**: SSL available
- **Neutral**: However, SSL is not available by default, and the encrypted connection uses self-signed CA certificates, which may lead to confusion.
- **Pro:** Detailed information concerning cookies used by the web-site and stored on the client
- **Neutral:** The NERIES project is already done, and refers to NERA as follow-up project.
- **Pro:** All project reports, deliverables and documents are freely and publicly available
- **Neutral:** For data products, NERIES refers to seismicportal.eu

Seismicportal:

- **Pro:** Authentication is required in order to log in (signing up for an account is mandatory)
- **Con:** However, account details are seemingly not validated (e.g. no captcha to prevent abuse, no e-mail verification, no sign-up acknowledgement by email)
- **Con:** No SSL at all
- **Pro:** Very well done seismological "Explorers" for different kinds of data
- **Pro:** Good handling of seismological events, including RDF
- **Pro:** Very good integration of Google Maps *and* Google Earth
- **Pro:** Highly configurable, utilization of modern and state-of-the-art web-technologies ("Web 2.0")
- **Pro:** Open REST, SOAP, and WSDL web-services providing QuakeML and JSON format
- **Pro:** Readily available clients to use the interface

Erik Sonnleitner, JKU, May, 2011

2.2.2.2 Methodology selection.

One of the successful instruments for dissemination have been workshops in previous projects (i.e) NERIES. For this purpose a budget has been allocated and rules and condition for support to be given to such workshops elaborated.

Support for Workshops and Dissemination Events

1. Introduction

Results of the NERA project and the entire community shall be made available for the entire sector on global scale. It is therefore intended to support dissemination activities as specified below.

2. Objectives

NA10 only supports meetings or workshops (events) that are unambiguous aimed at:

a) Organise the integration mechanisms within the NERA project on order to facilitate knowledge transfer between the consortium partnerships
b) Transfer and integrate technical developments and achievements of NERA on a wider European and global scale
c) Promote sustainable, durable implementation of NERA achievements by specific dissemination tools
d) Link NERA's technological developments with other related research fields.

More specific definitions of dissemination goals and methodologies can be found in the respective publications of the European Commission and related strategy papers.

3. Application

Procedure:
Activity coordinator (or anyone in the NERA project) can make a proposal and apply for a cross-NERA workshop/meeting or NERA outreach workshop/meeting with the MC (see template). Direct communication with MC members before the application is encouraged to facilitate the planning.
WP10 contact: Helmut Wenzel wenzel@vce.at

Practicalities:
Alternative additional funding recommended:
It is recommended that events are co-funded from other resources as well as those extra funds can help cover EC non-eligible costs (see Annex II.19 on the next page). Costs can only be made on the basis of original receipts and must be eligible to the EC rules (VAT, for example, is not eligible! For details please see appendix)

Organisation:
- Each event will have a local organizer who is responsible for organizing the event and making the financial arrangements.
- The NERA Project Office provides assistance with announcing the event and other organizational practicalities as agreed on in the agreement.

Responsibilities:
The local organizer is responsible for the following:
- The organizer is responsible to report and justify the received funds to the EC.

- Minutes and signed participants lists are submitted to the Project Office as part of the reporting procedure. (Please update these to the Meetings Material folder on the NERA Project Portal).

Payment modalities:

- Prior to the event the organizer and the Project Office make a clear agreement on the payment modalities.
- Once the final costs are clear and accepted by the MC the Project Office will transfer the agreed funds from WP10 activity to the organizers budget.
- The Project Office retains the right to refuse payment of costs that are not clearly related to the intended workshop or ineligible towards the EC.

4. Available Funds

For these activities a total of € 100.000 is available for support. It shall be divided between the seismologist and earthquake engineers in the fraction of 2:1.

5. Documentation

Documentation shall follow the rules set for the 7th framework program. The same rules like for the partnership apply.
In addition to the cost documentation a minutes of meeting shall be produced to inform about timing, participation and subjects. Eventual material presented or papers provided shall be made available to the entire Consortium (data base). A short summary report on this activity shall be submitted by the person that issued the invitation.

Wenzel, Vienna, November 2011

NERA workshops and meetings; NERA WP10

Application template

Title *(info used for announcement)*:
Place *(info used for announcement)*:
Time *(info used for announcement)*:
Responsible organizer and contact *(info used for announcement)***:**

Short description of the [workshop / meeting] *(info used for announcement)*
(max 10 lines; include goal of the event and the target audience)

Motivation and expected outcome
(max 5 lines; indicate that it meets the objectives of WP10)

Expected number of participants

Specified workshop budget
(outline of the expenses, available additional funds and a plan on how to cover non-eligible (towards the EC) items, like VAT)

Additional comments
(Special conditions etc; like travels outside Europe, which need prior EC-officer permission, coordination with other initiatives, …)

The organizer is aware of, and will adhere to, the funding conditions as specified in the (attached) 'NERA workshops and meetings guidelines':

Signed,

Date:
Place

Annex II – General Conditions
II.19 - Eligible costs of the *project*

1. Eligible costs incurred for the implementation of the *project* must fulfill all of the following conditions:
a) they must be actual, economic and necessary for the implementation of the *project*; and
b) they must be determined in accordance with the usual accounting principles of the *contractor*; and
c) they must be incurred during the duration of the *project* as identified in Article 4.2 except for the costs incurred in drawing up the final reports referred to in Article II 7.4, which may be incurred during the period of up to 45 days after the end of the *project* or the date of termination whichever is earlier; and
d) they must be recorded in the accounts of the *contractor* that incurred them, no later than at the date of the establishment of the audit certificate referred to in Article II.26. The accounting procedures used in the recording of costs and *receipts* shall respect the accounting rules of the State in which the *contractor* is established as well as permit the direct reconciliation between the costs and *receipts* incurred for the implementation of the *project* and the overall statement of accounts relating to the overall business activity of the *contractor*; and
e) in the case of contributions made by third parties established on the basis of an agreement between the *contractor* and the third party existing prior to its contribution to the *project*, and for which the tasks and their execution by such a third party are clearly identified in Annex I, the costs must :
i) be incurred in accordance with the usual accounting principles of such third parties and the principles set out in paragraph d) above;
ii) meet the other provisions of this Article and this Annex; and
iii) be recorded in the accounts of the third party no later than the date of the establishment of the audit certificate referred to in Article II.26.

2. The following **non-eligible costs** may not be charged to the *project* :
a) any identifiable indirect taxes, including VAT or duties;
b) interest owed;
c) provisions for possible future losses or charges;
d) exchange losses;
e) costs declared, incurred or reimbursed in respect of another *Community* project;
f) costs related to return on capital;
g) debt and debt service charges;
h) excessive or reckless expenditure;
i) any cost which does not meet the conditions established in Article II.19.1.

For detailed information on the above stated, we refer to page 24 and further of the "Financial Guidelines".

II.20 – Direct costs
1 - Direct costs are all those costs which meet the criteria established in Article II.19 above, can be identified by the *contractor* in accordance with its accounting system, and can be attributed directly to the *project*.

2.2.3 Implementation of the dissemination plan

2.2.3.1 Feedback from stakeholders.

The outcomes should be presented to stakeholders for a feedback. This occurs once the design of the dissemination process is finalized in terms of instruments defined and methodology chosen (for example, this can be approved by the organizers of an event or learning activity in advance of a feedback).

2.2.3.2 Methodology implementation.

The implementation of the methodology is due in the third year of the contract meaning the coming period. A detailed discussion has been performed in the project meeting in Pavia in April 2012 where the joint strategy for the earthquake engineering and seismology community has been discussed and agreed. The decision that the NERA-Portal shall be the sustainable one for the future has been made, where all relevant results of other projects (i.e. SHARE, SYNER-G, SERIES, etc.) will be hosted. Progress is to be reported in the next period.

The subsequent items are activities that will be started in the coming period after which a report will follow.

2.2.3.3 Data analysis, reporting.

Data needs to be analyzed and summarized to a report.

2.2.4 Evaluation of the dissemination plan

2.2.4.1 Draft reporting.

Outcomes of NERA need to be measured. Feedback from the stakeholders needs to be taken.

2.2.4.2 Deliverables, next steps.

A special emphasis should be put on recommendations and the definition of next steps.

2.3 Implementation Plan

Early demonstration enables the raising of the awareness of the coming new technologies and prepare the field for their implementation. The second step of demonstration already uses the newly developed technology and can therefore be directly implemented into the operations.

Besides the direct implementation into the partner's networks a dissemination implementation campaign will be organised in the project. It is expected that the development is attractive to a huge number of stakeholders who are supplied with the methodology and services. A task force is organised prior the end of the project to promote this line of interest.

Dissemination is considered to be one of the most important activities of this project. This activity foresees the following tasks:

- Organise end **user networks** within and across the case studies and clarification tests. These will involve the respective Consortial partner, the coordinator and appropriate institutions at the European, regional and local level as well as industries and public participation
- Develop generic and **comparative dissemination material** in different formats and for different media to reach the intended target audiences
- Implement and maintain a **project web server** and document exchange platform for global dissemination and in support of the local and regional dissemination strategies in each case.
- Foster long term **networks of collaboration** with interested parties across the applications. This includes the identification of representatives or licensees in the target regions.
- Develop **strategies to implement** and institutionalise the methods developed in each case for continuing use, based on the feedback from the local networking and dissemination activities. The feedback from the various contacts shall be centrally collected and assessed.
- Obtain and **analyse feedback** from the targeted end users, industries and services. Summarise the dissemination results and lessons learned and implement them into the methodology.
- Develop an **exploitation plan** for individual and collective exploitation of the project results by each project partner. Identification and finding of new end users based on the experience from the dissemination activities.

The dissemination activities are closely linked with the global networking activities and end user involvement in the project. The dissemination activities will be ongoing during the entire project duration with increasing effort. Accordingly the dissemination plan will have to be adapted.

2.4 Dissemination Instruments

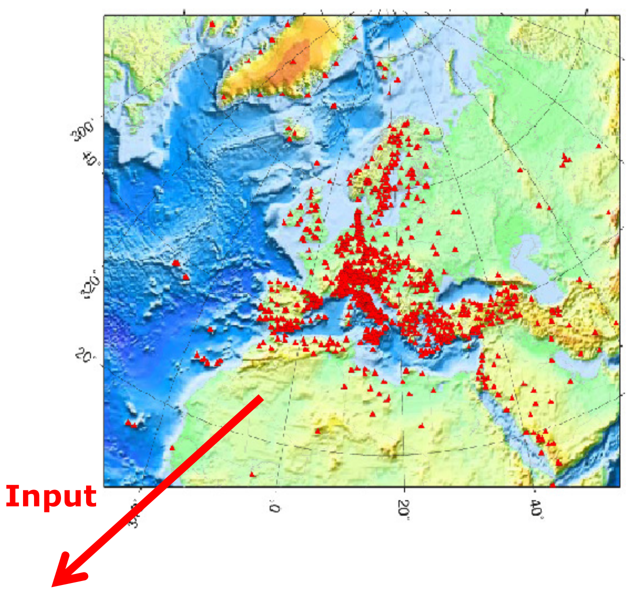
Dissemination is an important process and has important role in lifelong learning and personal development to both, to those who undertake the project and those whom the project aims to support. It influences decision-makers and serves as a base for their decisions. Dissemination generates interest in transnational cooperation but also raise awareness of cultural diversity and similarity.

Methods that can be used in dissemination process are different depending on target group. These are:

- briefings, seminars, workshops, conferences, exhibitions that provide opportunities to inform and discuss
- printed materials, e.g. reports
- websites
- links from websites
- attending conferences and seminars presenting the results
- networking
- e-mail lists for mass mailing a newsletter – continuous dissemination of process results
- press releases

2.5 From Project Objectives to a Business Process Model

Current practice is that the interest of the results from earthquake risk research is widespread. The main objective of the dissemination therefore is to develop a solution where all interested parties have access. The schematic plan is roughly shown in the next figure. A more detailed planning per sector and market players follows.



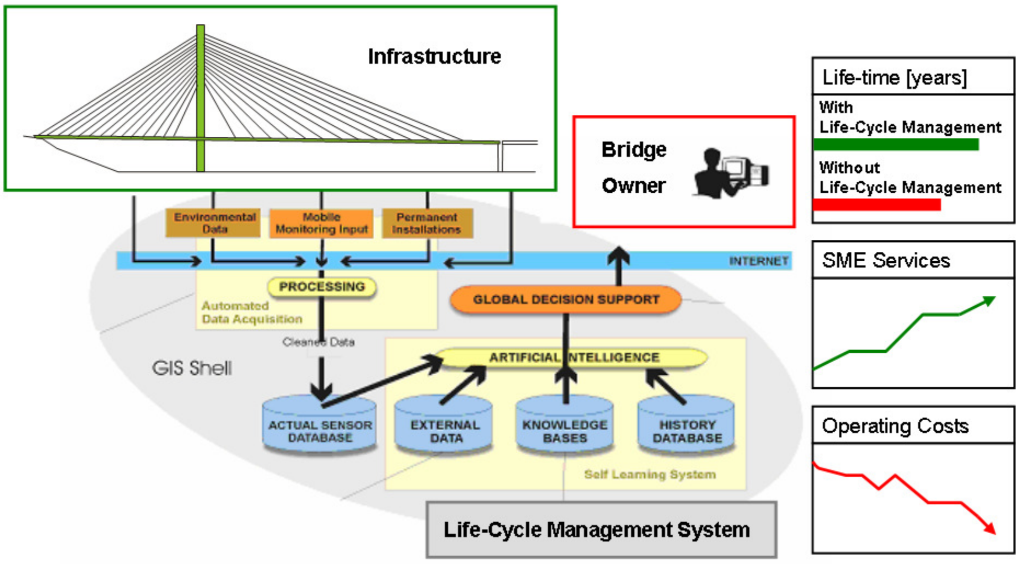


Figure 3: Example of the impact on the infrastructure sector

A crisis management and also a serviceable Life-Cycle Management System needs reliable predictions and serious input data for coordination and design. Some data are already available and seem to wait to be appropriately applied. The NERA project will mature the technologies, close the remaining S/T gaps and develop an Integrated System.

2.6 Economic Benefits for the Project Partners

The motivation of the partners to the proposed project to invest into collaborative research is carried by the identified need which can be converted into economic success.

Benefit for SMEs: The engaged SMEs will improve their already strong position in the global market. The innovated knowledge-based products and services will enable them to issue more competitive offers in this rapidly growing market. The development further opens the opportunity to conquer market segments not yet approached. So far every successful development in a European project has doubled in the turn-over and in the number of jobs at these partners.

Benefit for the industry: Industry will directly benefit from the knowledge on the knowledge for the seismic risk on the site.

Benefits for the research community: The proposed work plan will open new lines of research for the scientific community. It will improve the qualification and support the extension into new research fields. A major number of Phd programmes will be enabled.

2.7 Facts

Since 500 Mio people live in Europe the results of NERA should be ready for them. The level of information is different to End user networks have shown to be very useful connections for dissemination activities. Since the level of information is not equal for each user a strategy that uses Open Access for individual depth of information might be useful and target-oriented. Parts of our research have to be presented in a public way, but there will also be (partly) restricted access for special users with the best use of already existing tools of other projects (NERIES, IRIS, …).

2.8 Outreach

The NERA Consortium already contains a large number of participants (70 Kick Off). Other groups will be contacted which are:

- 1.000 Seismologists
- 10.000 Decision makers
- 200.000 Structural Specialists
- 2.000.000 Civil Engineers
- 25.000.000 Employees in Construction
- 500.000.000 European Population

These groups are all interested in the outcome of the NERA project. Therefore a good exploitation strategy is necessary to meet the different levels of interest.
A detailed list of networks and useful contacts is attached in Annex D.

2.9 Conferences and Presentations

A list of conferences is given in Annex B, whereas a list of publications is given in Annex C.

2.10 Local Workshops and Seminars

If appropriate a local workshop or seminar will be organised with a targeted audience, which will be invited for a presentation with discussion of the methodology and the potential. Workshops for technology transfer and the developed tools and products have to be promoted, that they can reach the practitioners and end-users. An exchange with global activities is also important. Strategies have to be harmonized wherever possible.

In most cases there will be an early meeting to get the local actors involved and to provide input to the scenario definition. After the workshops feedback will be collected and processed.

2.11 Dissemination Material

The primary dissemination material at this stage is the multimedia content of the project web server. In parallel, following a decision at the steering committee meeting a project folder will be prepared showing the potential and features of the development. Inputs from all partners will be incorporated.

2.12 Management of Intellectual Property

The responsible body for the management of intellectual property is the Project Management Board (PMB), which is dominated by industry. The subject of pre-existing knowledge will be handled as well as all other intellectual property rights questions. It is expected that a major number of patents will result from the project. To avoid mistakes in the procedure or publications without consent a clear approval procedure is implemented. IPR issues will be a fixed topic for each Project Management Board Meeting.

A comprehensive section of the Consortium Agreement (which already exists) is devoted to this subject, with well proven procedures specified.

2.12.1 NERA public website

The NERA public website www.nera-eu.org will be actively used for dissemination purposes and continuously improved during the project life cycle. The successful dissemination and integration program will be the measure of sustainability of NERA dissemination work after the end of the project.

2.12.2 Briefings

A briefing is a partway between a newsletter and a catalogue. It summaries the specific work of activity. In the NERA briefings partners should try to answer the following questions:

- What are they currently working on? (This implies a list of statements related to specific activities/tasks. These should be formulated in a way that can be understood by people who are not involved in NERA)
- Approximately completion rates (just started, ongoing, nearly completion, completed)
- Which NERA outcome is related to this information?
- Any scheduled events coming up?
- Maintain and update list of NERA outcomes

2.12.3 Other dissemination instruments

A first version of a NERA leaflet has been produced and it will be updated. The leaflets will be made available to be handed out in relevant meetings, workshops and conferences.

Publications (papers, articles, etc.) are also output that will be disseminated within the NA10. Abstracts of all scientific publications of the participants will be provided via the NERA website.

Workshops, conferences, presentations. Each workshop, meeting and conference is encouraged to return a response that will have information on the participants, conclusions and the impact on NA10 work as a feedback mechanism.

3. Dissemination strategy principles

Dissemination is a tool to connect people to subjects and activities of the network. The main principle in communication and dissemination strategy is to support and strengthen networks of people that are connected by shared objects through activities.

Defining strategy is important in coordination, dissemination and integration both within the consortium and between the consortium and the broader European and international community.
Figure 4 shows the distribution of countries in the Database according to its spatial origin. Dissemination of NERA products will be carried out through organizing integration meetings and workshops, activities in transfer of new knowledge and research products (such as software, tools, solutions), demonstration activities, involvement of stakeholders and user communities, international events with all relevant communities involved. The long-term impact of NERA will be result of technology transfer and the use of the NERA products and tools by the wider community of practitioners and end-users.

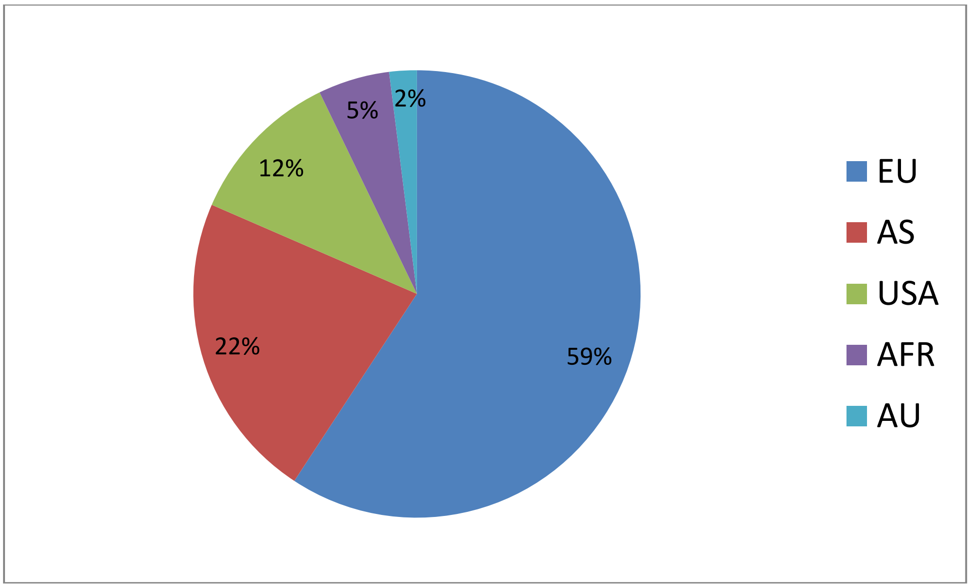


Figure 4: Percentage of countries in the Database according to its spatial origin

Dissemination is a continuous process of providing information on the quality, relevance and effectiveness of the results of project and of informing others on activities. There are three different levels in dissemination strategy: dissemination for awareness, for understanding and for actions.

The achievement of dissemination process is raising **awareness** in the attended target group. Awareness can be useful for those target audience that do not require a detailed knowledge of the project, but would benefit from an awareness of activities and project outcomes. Dissemination can also contribute to change in ways of thinking and bring new patterns of conduct in the target group.

It is important to generate **understanding** of issues and results for a number of target groups invited to engage in work within the project as well as to obtain the support of others in disseminating information. These are the groups that it is thought will benefit from the results of NERA and therefore need a deeper understanding of projects work. In order to facilitate this understanding it is necessary to make sure that communication is consistent.

Action refers to a change of practice resulting from the adoption of ideas, approaches and outcomes offered by NERA. The groups/audiences that are target are those in a position to influence and bring the change within their organizations. Therefore they need to be provided with the right skills, knowledge and understanding of projects work in order to achieve the change.

4. Products in dissemination process

4.1 The newsletter

In order to keep every partner of the consortium updated about the activities in NERA, a newsletter was created. The newsletter has various sections.

- A section called **"Comments of the coordinator"**. This box should contain a brief comment on the project itself. It will reflect the coordinators point of view on the project. It will also serve as a motivation for all the partners.
- The **NEWS** section. The news section will describe the latest news of the project and also some news not directly related to the project.
- A **"What´s happening"** section. On the left side of the newsletter certain links will be placed. These links should serve as a very quick overview of the latest news on the project.
- **Next Appointments**. This section will contain the next meetings and other opportunities, like conferences, etc. and the respective dates and links.
- The website of the project is displayed on the upper side of the newsletter. The contact details of the project management as well as the overall details of the project will be mentioned in the last section of the newsletter.

The first version of the newsletter will be distributed in October/November 2012. It was anticipated that in the second half of the project, a newsletter will be much more efficient, than in the first half of the project. Together with the database of European institutions in seismology and earth science, the newsletter serves as a very powerful tool to disseminate the important massages that the NERA project wants to communicate.

www.nera-eu.org

NERA

Network of European Research Infrastructures for Earthquake Risk Assessment and Mitigation

NERA NEWSLETTER 2012/01

Comments of the coordinator

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet.

Dr. Helmut Wenzel
VCE Holding GmbH
Vienna, Austria

WHAT'S HAPPENING

"SEISMOLOGY@SCHOOL"
European Summer School Workshop
4–8 June 2012, Naples, Italy

WP13 meeting (JRA3)
4–5 June 2012, Ankara, Istanbul

EUROSOIL 2012
2–6 July 2012, Bari, Italy

NEXT APPOINTMENTS

ESC
19–24 August 2012, Moscow, Russia

11th CST2012
4–7 September 2012, Dubrovnik, Croatia

15th World Conference on Earthquake Engineering
24–28 September 2012, Lisbon, Portugal

NEWS

Ongoing mission in northern Italy

An ongoing rapid-response mission followed the May 20 Ml 5.9 and the May 29 Ml 5.8 earthquakes close to Ferrara in Northern Italy. Under the leadership of the INGV-group, 16 stations of the ERN-INGV-modules were installed within the first 48 hours.

The first station was working in real-time after only few hours. 10 stations are now contributing to the identification of new seismic events for Civil protection purposes.

Job offer 1:
ORFEUS

The European organization for coordinating and promoting broadband seismology in Europe is looking for a Software developer. For further information visit the NERA website.

Job offer 2:
Postdoc researcher in ground-motion variability, ISTerre/INGV

EDF will support on postdoc researcher located at ISTerre (Grenoble, France) and/or INGV Milano (Italy) to foster further research and developments related to ground-motion variability. For further information visit the NERA website. (posted 30-05-2012).

Job offer 3:
Researcher in Seismology, University of Naples

The University of Naples is looking for a researcher in Seismology. For further information visit the NERA website (posted 04-04-2012).

The first year of work

- The main objective was to obtain an actual state-of-the-art overview of the integrated research infrastructure. This document led to a better planning of the project work.
- Three new channels have been set-up to distribute rapid earthquake information based on eyewitnesses feedbacks: a website dedicated to mobile devices (beta version), RICHTER, an Android application for collecting geo-located pictures of earthquake damage, and accounts on the main social networks.
- In terms of access, the number of loaded pages on www.emsc-csem.org has jumped from 4 to 12 million a month, the number of monthly visitors reaching an average of 1.5 million during the CS1. The number of subscribers to the Earthquake Notification Service (ENS) increased by 25% to reach 9 500 subscribers.
- In 2011 more than 13 TB of waveform data was requested from ORFEUS. This is the first time that the amount of data exported from the archive exceeds the amount of data inside the archive (about 11 TB).
- All milestones have been achieved. 17 out of 21 deliverables have been submitted on-time. Four deliverables are delayed.
- The financial status of the project is well on track. Slightly less than 25% of the total requested EC funding has been spent during the first year. According to the project priorities, the coordination is with 26% slightly ahead. Notably the transnational access (TA) activities are lacking behind with only 13% of the total requested EC funding.

Project Coordinator: Prof. Domenico Giardini, ETHZ/ORFEUS
Project Manager: Dr. Torild van Eck, ORFEUS/KNMI

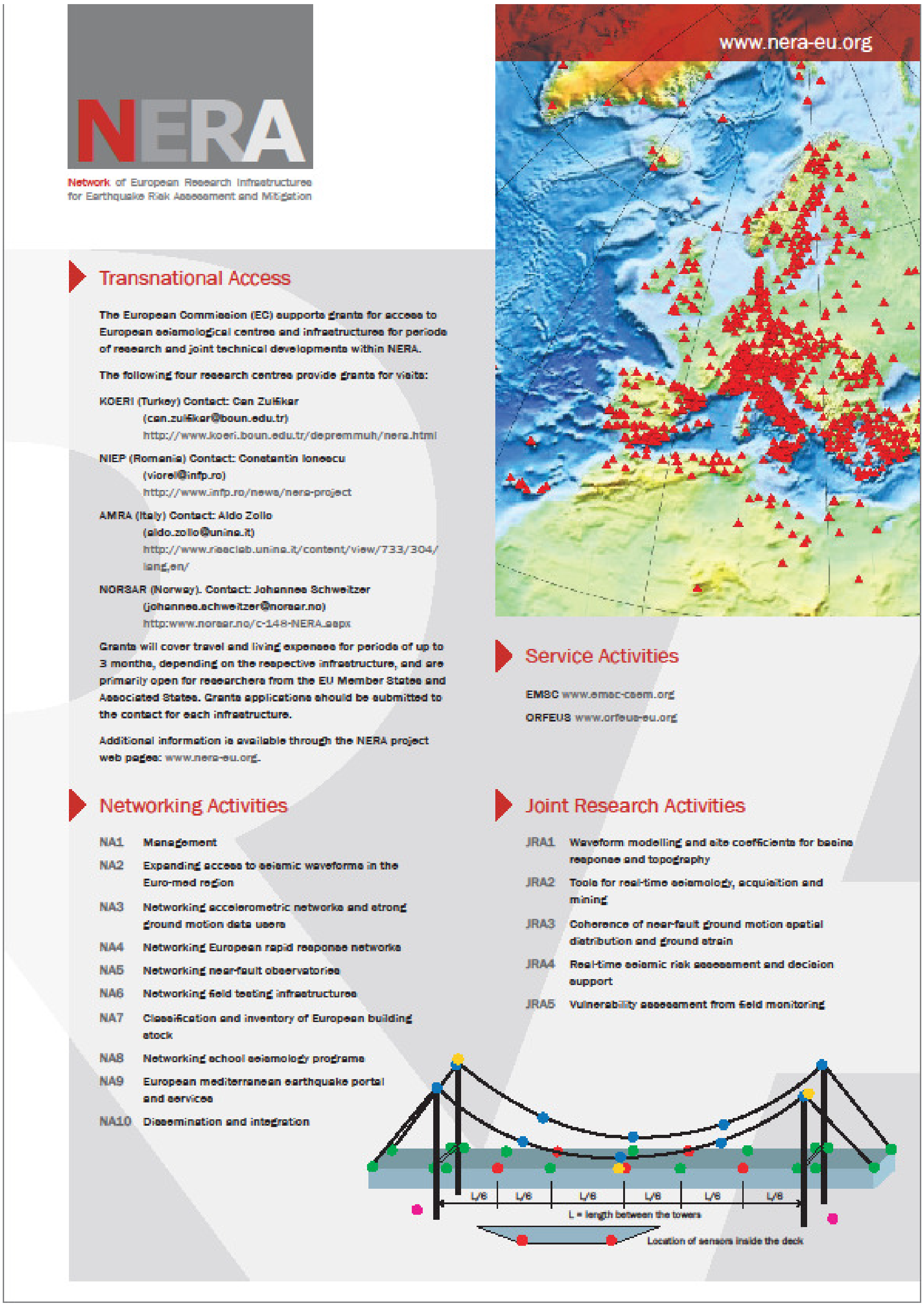
NERA Project Office: Wilhelminalaan 10, 3732 GK De Bilt, The Netherlands
T. +31 (0) 30 2206 334
E. nera@knmi.nl

Figure 5: A first draft of the newsletter.

4.2 The NERA Flyer

The idea of the NERA flyer is to have something to print out in a nice format, which contains a brief overview about the participants of the project and the overall goals of the project. It also contains a number of links that bring you to the relevant pages. This flyer was sent out to all project partners for their own use. The idea is to have a very rough understanding of what the project aims to do.

Figure 6: First page of the NERA Flyer


NERA

Network of European Research Infrastructures for Earthquake Risk Assessment and Mitigation

www.nera-eu.org

Transnational Access

The European Commission (EC) supports grants for access to European seismological centres and infrastructures for periods of research and joint technical developments within NERA.

The following four research centres provide grants for visits:

KOERI (Turkey) Contact: Can Zulfikar
(can.zulfikar@boun.edu.tr)
http://www.koeri.boun.edu.tr/depremmuh/nera.html

NIEP (Romania) Contact: Constantin Ionescu
(viorel@infp.ro)
http://www.infp.ro/news/nera-project

AMRA (Italy) Contact: Aldo Zollo
(aldo.zollo@unina.it)
http://www.rissclab.unina.it/content/view/733/304/lang,en/

NORSAR (Norway). Contact: Johannes Schweitzer
(johannes.schweitzer@norsar.no)
http:www.norsar.no/c-148-NERA.aspx

Grants will cover travel and living expenses for periods of up to 3 months, depending on the respective infrastructure, and are primarily open for researchers from the EU Member States and Associated States. Grants applications should be submitted to the contact for each infrastructure.

Additional information is available through the NERA project web pages: www.nera-eu.org.

Service Activities

EMSC www.emsc-csem.org

ORFEUS www.orfeus-eu.org

Networking Activities

NA1 Management

NA2 Expanding access to seismic waveforms in the Euro-med region

NA3 Networking accelerometric networks and strong ground motion data users

NA4 Networking European rapid response networks

NA5 Networking near-fault observatories

NA6 Networking field testing infrastructures

NA7 Classification and inventory of European building stock

NA8 Networking school seismology programs

NA9 European mediterranean earthquake portal and services

NA10 Dissemination and integration

Joint Research Activities

JRA1 Waveform modelling and site coefficients for basins response and topography

JRA2 Tools for real-time seismology, acquisition and mining

JRA3 Coherence of near-fault ground motion spatial distribution and ground strain

JRA4 Real-time seismic risk assessment and decision support

JRA5 Vulnerability assessment from field monitoring

Figure 7: Second page of the NERA Flyer

4.3 Connecting to the wider community

NA10 provides also the plan for the dissemination and technology transfer to the wider community of engineering practitioners and end-users. For this purpose the Database is created the that will enable not only the internal dissemination and integration within the NERA consortium but also the dissemination of results to a technical and scientific community not participating in NERA as well as to a wider community of practitioners and end-users outside of NERA, what is shown in the Figure 8. According to a huge demand for integration and communication tools in Europe NA10 will develop a concept, which allows to a large number of partners in the community to benefit from the NERA development and at the same time their contribution with their own experience and results. Activities in the dissemination process will include dissemination events, tutorials and training activities, public events, implementation to the industry, support and interface development for all types of users, as well as information distribution through publication of leaflets with news about results and products. This includes also organization of sessions at international conferences and congresses dedicated to seismic hazard and risk assessment.

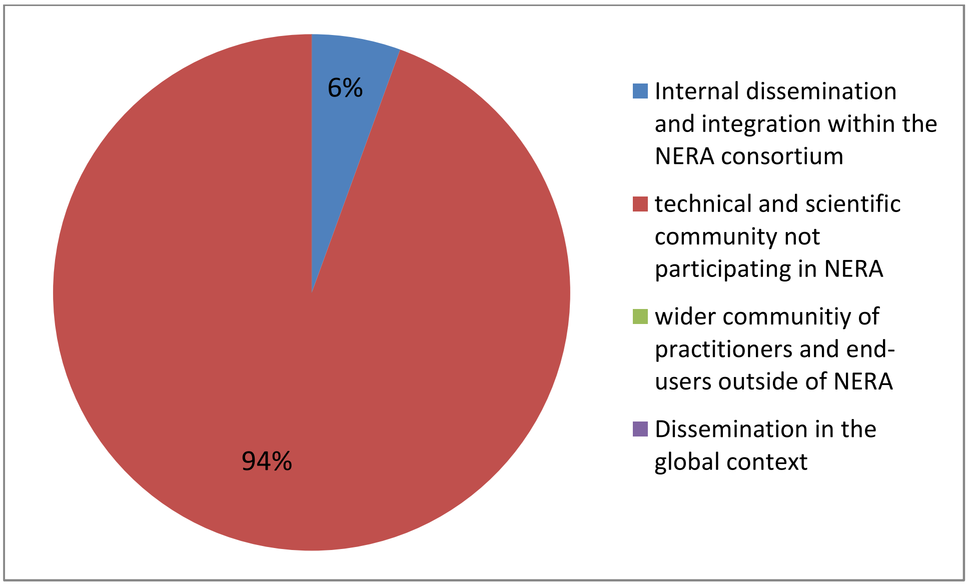


Figure 8: Percentage of institutions in the Database

Dissemination process should give answers to next questions: ***what*** will be disseminated, to ***whom*** will be results of NERA disseminated and ***where*** this will be done?

What: Research products such as software, tools, reports, solutions, good practice will be disseminated through dissemination portal by the responsible institution. Experience leads to messages about findings, recommendations, warnings. All data and tools will be presented through communication allowed by various systems. The portal should provide all necessary features to operate the systems.

There is an enormous demand for integration and communication tools for isolated approaches in Europe. The NERA project will therefore develop a conception, which allows a huge number of partners in the community to maintain their own database and engineering practice. The portal will be a good basis for a broad set of services for the seismological, seismic hazard and risk communities and it will be developed through organizing a set of integrated and interoperable web services. This will enable the access to a comprehensive set of data and resources. Implementation of this task requires a strategy by which the service providers can develop their services for use. It means developing plan for interoperability and implementations requested by users to enable long-term project sustainability i.e. efficient maintenance and use of results/information. This work implies: providing an integrated data portal that enables access to seismological and engineering data sets as well as to services with NERA products, development of an access portlet for experimental data, analysis of user requirements and interaction needs, synchronization of web services. It is important that the communication among service providers is strong and permanent and that all data within the portal both graphically and computational is maintained.

To whom: Policymakers and stakeholders present an important group, which could use results of NERA. Their access to NERA products will be done through their participation in plenary and/or WP meetings, production of reports or brochures that are appropriate to this type of audience, organization of targeted workshops as well as through the direct involvement of public authorities in specific NERA activities.

General public belongs to a group, which is not always aware of the level of seismic risk to which it might be exposed to and of the commitment of scientific/professional communities, policymaking bodies, European Commission etc. in mitigating earthquake-related risks. To this purpose material adequate for distribution will be published.

Where: Conferences, dissemination events, tutorials and training activities will be organized to inform the entire community of the current practice and the features of the developed tools.

The coordination of events and deliverables plays a major role in a practice network. A good viable solution to this issue can be the use of calendar system with events relevant for the NERA project. This scheduling can be established in internet and enable the use of event data. This could be of a great interest to the community to register its participation in events. Table 1 shows an example of calendar events that could be used for disseminating results and products of NERA.

Table 1: Relevant events - example

Event Name	Target Group	Objective	Action	Date and Location	Outcomes	Partner
15th World Conference on Earthquake Engineering				24-28 September 2012 Lisbon, Portugal		
9th International Conference on Urban Earthquake Engineering				6-8 March 2012 Tokyo, Japan		
2nd European Conference on Earthquake Engineering				24-29 August 2014 Istanbul, Turkey		

and Seismology						

Seminars will be organized to inform researches, practicing engineers and scientists about new developments and achievements in NERA project. Seminars will give a broad perspective concerning major issues. Special themes may be selected and the lectures may be related to the selected theme. Seminars will be devoted to invited lectures with additional time allocated for short presentations by researchers.

Workshops will be also organized as well as discussion sessions where users can discuss some topics and NERA results. The main aim of workshops is to bring together the NERA participants' working on related issues to discuss visionary and practical goals and directions. This includes: exchange information and coordinating various initiatives; discussing and exchanges ideas seismologists, computer scientists and outside experts to investigate innovative and relevant technological developments and directions; engaging the seismological and science community; investigating relevant options that broaden seismological analysis within earthquake engineering environment.

NA10 will make efforts to disseminate and circulate the results of the project via the publication of press articles written by various partners. These articles give information referring to activities of project partners and the quality of work completed. The purpose of articles is to inform the public at the local level about NERA. Information about a collection of selected press articles and publications are presented in Annex C.

5.Results

One of products within the NERA work is the Database, which is available in internet and serves to public and private organizations, which operate in the field of seismic hazard and seismological and earthquake engineering. It allows automatic access to the institutions worldwide contained in the Database and therefore insight into the contact details allowing a communication between them.

Contact and coordination among organizations in the Database facilitate their communication and contribution on: progression of measures, development of guidelines and standards and development and management of a strong data archiving and dissemination infrastructure. Coordination will be facilitated through on-going communication among representatives, active work groups and meetings. The goal of such communication is to make strong data and tools that can serve as an effective resource for earthquake safety practitioners as well as for emergency response and recovery following damaging earthquakes. This can enable making the database archives of institutions and can hold data from observation networks that do not maintain database archives, directly in the server. This organization scheme permits efficient dissemination of data through the internet. Data users throughout the world can access the data through the internet.

This way of communication aims: identifying new ways of research that can solve earthquake problems by collecting and synthesizing information and making it easily accessible, establishing national and international hazard research relationships, performing earthquake engineering and related research, managing research associations and cooperative programs, educating experts, practitioners and the public. It improves engineering, pre-earthquake planning and post-earthquake recovery strategies.

Dissemination of results enables many positive effects such as: feedback during the project, increased visibility of organizations in the community, promotion of innovation in local communities, promotion of innovation in society.

The aim of dissemination process is integrating the project results within education and methodological systems at local, national and European level.

Table 2: Example of Australian Database

Nm	Institution	City /Country	Internet Homepage	Contact person	Contact details	Project	Role
	Geoscience Australia	Australia	http://www.ga.gov.au/		naturalhazards@ga.gov.au earthquakes@ga.gov.au		Tech.
	Seismology Research Centre (SRC)	Melbourne Australia	http://www.seis.com.au/		61 (0)3 8420 8999		Tech.
	RMIT University Seismology Research	Australia	http://www.seis.com.au/AusSeis.html	Dr. G. Gibson	gary@rmit.edu.au gary@seis.com.au		Tech.
	Geosciences Australia (GA)	Canberra Australia	http://www.ga.gov.au/hazards/earthquakes.html	Dr. Ned Stolz	61 2 6249 9763 ned.stolz@ga.gov.au		Glob.
	Queensland University (ESSCC)	Brisbane Australia	http://www.uq.edu.au/esscc/ http://www.eait.uq.edu.au/	Prof. Graham Schaffer Dr. Robert Day*	61 7 3365 3896* r.day@uq.edu.au*		Tech.
	Primary Industries & Resources SA (PIRSA)	Adelaide Australia	http://www.pir.sa.gov.au/minerals/earthquakes		61 8 8463 3000 PIRSA.minerals@sa.gov.au PIRSA.customerservices@sa.gov.au		Tech.
	Primary Industries & Resources SA (PIRSA)	Adelaide Australia	http://www.pir.sa.gov.au/minerals/earthquakes		61 8 8463 3000 PIRSA.minerals@sa.gov.au PIRSA.customerservices@sa.gov.au		Tech.
	The Australian Earthquake Engineering Society	Australia	http://www.aees.org.au/	Paul Somerville *	61 2 9850 4416* psomervi@els.mq.edu.au		Scien

	University of Western Australia (School of Earth and Environment)	*Australia*	*http://www.seismicity.see.uwa.edu.au/ http://www.see.uwa.edu.au/*	*Prof. Matthew Tonts (Head of School) Prof. Thomas Angerer*	*6488 2683 matthew.tonts@uwa.edu.au 6488 7150 thomas.angerer@uwa.edu.au*		*Tech.*
	IASPEI, Research School of Earth Sciences	*Canberra Australia*	*http://rses.anu.edu.au/*	*Prof. Ian Jackson*	*61 2 6125 2498 jan.jackson@anu.edu.au*		*Tech.*
	Research School of Earth Sciences, Australian National University	*Canberra Australia*	*http://rses.anu.edu.au/research/ep/*	*Prof. Malcolm Sambridge * Prof. Phil Cumminsº*	*61 (0)2 612 54557* malcolm.sambridge@anu.edu.a* phil.cummins@anu.edu.auº*		*Tech.*

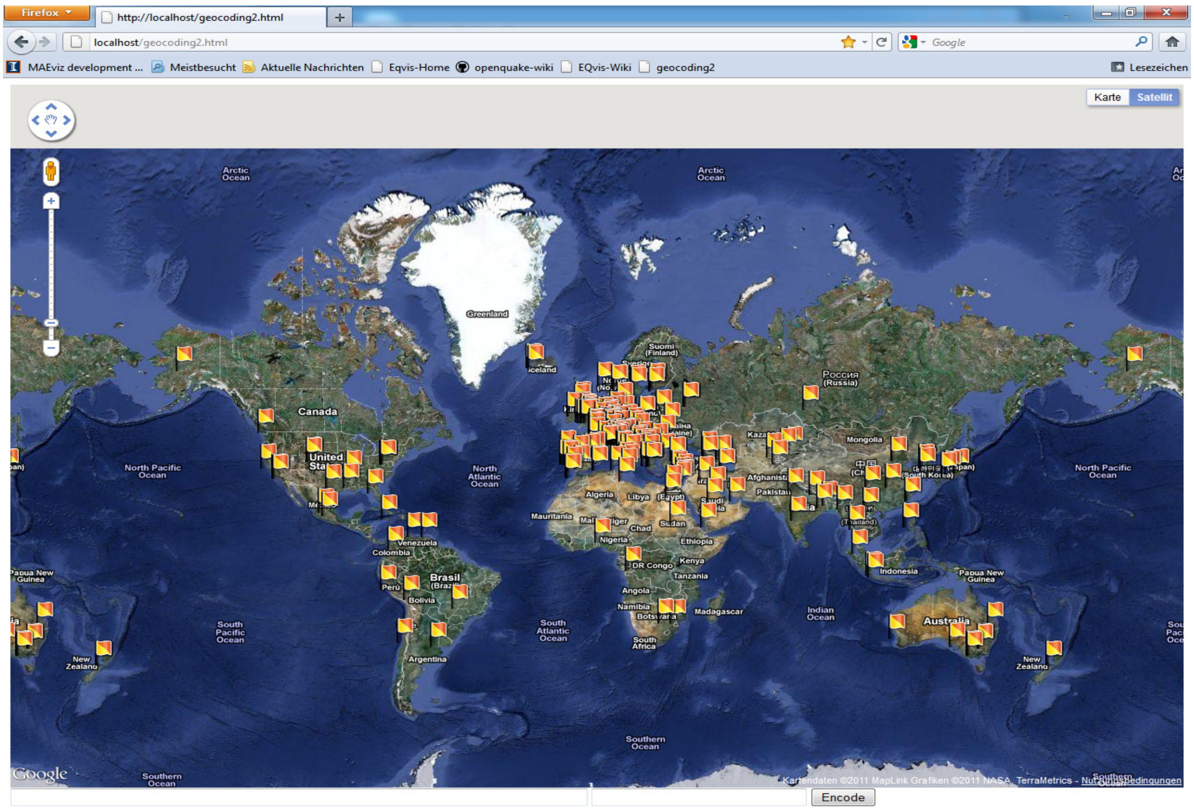


Figure 9: Database

The project NERA will provide the distribution and exploitation of results at all levels. The results and outputs in the project will be disseminated in Europe and worldwide with appropriate schemes. Products of NERA (tools, software and reports) will be available in various conferences, seminars and workshops. These will be the subject of dissemination process.

6. Conclusions

Na10 has produced the Database, which is established in the NERA public website and will be updated in later stages of the project. The Database facilitates communication and contributes to dissemination infrastructure. Such communication plays an important role in the creation of tools in implementation of dissemination methodology.

NA10 will provide tools needed for the use of data and products in the NERA project as well as the mechanisms to ensure the target groups involvement in the development of NERA activities. This should be built in the real needs and requirements of learning communities. Towards this goal the NA10 will provide specific input to be used for dialogues with target groups during the different virtual meetings, face-to-face events (seminars, workshops, etc.) as well as through the use of social networking tools. The main goal of these activities is to express ideas as possible in order to gain a clear overview of the different interests and actions of target groups. The results of these dialogues will be feedback to both NERA and the target groups in order to be able to focus on outcomes and specific activities that will be negotiated and adopted by the community.

Na10 will be responsible for organizing the feedback in the form of specific reports motivating the participants to provide information actively. The next task tasks also is maintaining and updating information.

Effectively dissemination of information about: products and outcomes of activities, stakeholders and what is offered to them (target groups, benefits for users), time schedule, disseminating tools and methods and evaluation and success criteria, will be organized using the tables presented in this document and via specific web forms.

Within the dissemination plan it will be defined a way that determine target groups. For this purpose the existing Database will be used. This activity will give information about: organizations, their members in terms of people (professional role, work place relations, etc. – contained in Database), key messages (what are the key messages related to NERA outcomes that will motivate the target groups to engage in communication with NERA) and the objective of the dissemination effort related to the particular target group.

7.List of figures

8.List of Tables

9.References

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3. Earthquake Hazards Program, http://neic.usgs.gov/neis/bulletin/symbols.html
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9. European GEOSCIENCE University Departments, http://www.uni-mainz.de/FB/Geo/Geologie/GeoInst/Europa.html
10. EUR-OPA Major Hazards Agreement, Network of specialized Euro-Mediterranean Centres, *Council of Europe,* http://www.coe.int/t/dg4/majorhazards/centres/default_en.asp
11. Federation of Digital Seismograph Networks - FDSN, http://www.fdsn.org/FDSNmem.htm
12. GEOCHANGE, http://geochange-report.org/index.php?option=com_content&view=article&id=64:members-of-committee-board-&catid=43:committee-board&Itemid=100
13. GEOCHANGE, *International Committee on issues of Global Changes of the Geological Environment,* http://www.geochange-report.org/index.php?option=com_content&view=article&id=78&Itemid=109
14. Geowissenschaften in Deutschland – Universitäten und Hochschulen, http://www.uni-mainz.de/FB/Geo/Geologie/GeoInst/UD.html
15. Global Earthquake Model-GEM, http://globalquakemodel.org/participants_public
16. International Association of Seismology and Physics of the Earth's Interior, http://www.iaspei.org/national_reps.html
17. International Seismological Centre, http://www.isc.ac.uk/help/search/agency.txt
18. International Seismological Centre ISC, Member Institutions, http://www.isc.ac.uk/doc/intro/isc_members.html
19. MTNet, http://mtnet.dias.ie/main/email.html
20. NASA centres, http://adsabs.harvard.edu/mirrors.html
21. National See Level Contacts, http://www.psmsl.org/links/sea_level_contacts/
22. NIKER Project, New Integrated Knowledge Based Approaches to the Protection of Cultural Heritage from Earthquake/Induced Risk, http://www.niker.eu/participants/
23. Northern Africa – Middle East Europe – Regional Centre, http://www.bsc.es/sds-was/node/9
24. ORFEUS Project, Observatories and Research Facilities for European Seismology, http://www.orfeus-eu.org/Organization/participation.html
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26. Public Seismic Network in USA, http://psn.quake.net/
27. World Data Centre System, http://www.ngdc.noaa.gov/wdc/contact.shtml
28. ZAMG – Internationale und internationale Organisationen aus dem Fachbereich Geophysik, http://www.zamg.ac.at/wir_ueber_uns/kooperation-international/
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Annex A. Derivation of the "Real-Time Fragility Curves" based on the Recorded In-Site Data of Fendigasse Building

Report#2: Outlines of the Analytical Procedures and the Obtained Results

1. Introduction

The mostly unpredictable and random characteristics of ground motions regarding their intensity features as well as the frequency of occurrence have secured a great challenge in the seismic design and performance evaluation of the infrastructures, exposed to such sources of excitation. However, the analysis of the past earthquakes and their devastating impacts over tens of years, taking place in various places of the world has provided the investigators and the engineers of the field with an undeniably enriched source of remarks and precious lessons, on which the theoretical, analytical and eventually statistical procedures have resulted into notable improvements towards the seismic design and protection of structures. In the light of such a view and with the aim of improving the seismic safety of the structures, several large scale research programs on the concepts of seismic risk assessment, mitigation and managements have been defined of which the focus is on the estimation of the future earthquake hazards, the consequent structural damage states and the plausible retrofitting and safety enhancement methods. Consequently and aligned with the defined expectations of the modern structural and earthquake engineering fields, this document is to present the analytical procedures, recommended to derive the "Real Time Fragility Curves" of a typical masonry residential building based on the "In-Site" measured dynamic records of the structures.

As long as the specific derived graphs in this document correspond to the recorded data of "Fendigasse" building, the specific characteristics of the measured dynamic histories of the structure and specially the existence of a great number of "white noise" records could have had its own effects on the obtained final results, though a huge amount of efforts had been dedicated to the purification of the measured data and the selection of the best possible recorded sets. Nevertheless, in case of any unforeseen but possible future modifications on the numerical results, the introduced analytical steps in this document will hold the applicability without the loss of the theoretical generality.

2. Fragility Curves Derivation

As previously introduced and based on the definitions, "fragility curves" are to represent the probability of the occurrence of a specific damage state to a structure, under a certain level of ground motion shaking[1],[2],[3],[4],[5]. As a result, any phenomena, such as degrading of the structural material properties due to aging or probable damages by various events during the lifetime of the structure could inherently influence the extent of response of the building to any arbitrary excitations in comparison to the original intact state. This is to imply that the "fragility curves" of a specific structure might not potentially hold their initial configuration and could need an upgrade to the "real time" condition.

Accordingly, the procedures described below have been followed to derive the "fragility curves" of the specific masonry structure located at "Fendigasse 20/1050Wien/Austria" based on the latest dynamic characteristics, measured in-site. Hence, the input data are assumed to reflect the most updated condition of the building in comparison to the nominal theoretically derived models.

2.1. Structural Response Evaluation

Since the exact evaluation of the response of the structures to any arbitrary time history excitation in a linear scheme requires the solution of the "Duhamel Integral", as represented in equation (1) below, the accuracy of the eigenfrequencies and mode shapes of the building as well as the modal participation factors and damping coefficients are of undeniable importance[6]. Consequently, application of the measured "real time" modal parameters can be the best way to reflect the "as-of-the-date" dynamic performance of the structure.

$$y_i(t) = \frac{P_i}{\omega_i} \int_0^t \ddot{U}_g(\tau) e^{-\xi_i \omega_i (t-\tau)} \sin(\omega_{Di}(t-\tau))\, d\tau \qquad (1)$$

$$P_i = \frac{\overline{k_i}}{M_i} \qquad (2)$$

$$\overline{k_i} = \{\phi\}_i{}^T [M]\{l\} \qquad (3)$$

$$M_i = \{\phi\}_i{}^T [M]\{\phi\}_i \qquad (4)$$

$$\omega_{Di} = \omega_i \sqrt{1 - \xi^2{}_i} \qquad (5)$$

In the equations introduced above, $y_i(t)$ is the time dependent response of a single degree of freedom (SDOF) oscillator to the ground acceleration, $\ddot{U}(t)_g$, with the structural natural and damped angular frequencies, ω_i and ω_{Di}, mass, M_i, and the critical damping ratio, ξ_i. Furthermore, the term P_i refers to the modal participation factor defined per equation (2) belonging to the i^{th} mode of vibration of the real multi degree of freedom (MDOF) system with the corresponding mode shape vectors, $\{\phi\}_i$ and the mass participation factor, $\overline{k_i}$. In addition, $\{l\}$ is the global influence vector and t and τ are the time parameters of the convolution equation (1). Eventually, the index *i* in all the terms defined in the equations above specifies the corresponding mode of response.
Consequently, once the time dependent part of the response of the original MDOF system, $y_i(t)$, is derived, the total response of the structure in a linear elastic situation, $\{x(t)\}$, can be obtained applying equation (6) to combine the effects of all the modes, equal to the total number of the degrees of freedom, *n*, as given below.

$$\{x(t)\} = \sum_{i=1}^{n} \{\phi\}_i \, y_i(t) \qquad (6)$$

Hence, as long as the main objective is to derive the response of the structure under certain different levels of ground motion hazard and the estimation of the exceedance probability based on specific damage state thresholds as closely as possible to the real-time condition of the building, the following dynamic characteristics can be directly obtained from the "In-Site" measurements and used in equations (1) through (6) to eventually assess the response of the structure under the selected excitation.

2.1.1. EigenAngular Frequencies $\boldsymbol{\omega_i}$

Once the "In-Sight" ambient and/or the properly forced excitation amplitudes of the building have been recorded and processed, the derivation of the Fast Fourier Transform (FFT) diagrams will result into the modal frequencies of the structure. Since the peaks of the FFT curves in a real scale structural measurements might not be ideally and sufficiently decomposed and obvious at the first glance, an estimation of the expected frequencies as *a priori* could serve to be a great bonus at the expense of the calculation time. However, based on the existing scientific literature at hand, some approaches such as the FDD is already capable of decomposing the modes in ambient vibration measurements[4]. Nevertheless, some issues with the actual recorded data at "Fendigasse" building and the existence of various noises within the records prevented the author of this document from applying the aforementioned method. Hence, the sub-steps defined below were followed to eventually derive the eigenfrequencies of the structure from the ambient recorded data.
- Calculation of the mass of the structure
For this purpose, the mass of the floors were estimated based on the existing drawings of the building in the "4-story" configuration, using the dead weight of the structure as shown per Table (1). Since the measurements were recorded at a time where most of the residential units were evacuated for the rehabilitation procedures, the live load effects on the building mass were assumed to be negligible. Furthermore, as long as the "Keller" floor, located below the zero datum ground level possesses both the thickest bearing walls as shown per the configurations in Appendix (I) and surrounded by the soil, a comparison procedures between the approximate "5"

degree of freedom (DOF) model and a "6" one was made of which the outcome was convincing enough to handle the rest of the analytical procedures with the "5" DOF model. The mass per unit area of the floors and the specific weight of the walls were assumed to be $175\ kg/m^2$ and $18\ kN/m^3$, in the order of appearance in this entire draft [7].

Table (1). The lumped masses of the floors- left: 5DOF- right: 6DOF

Story	Lumped Mass (ton)
1	449,64
2	380,06
3	361,67
4	359,15
Roof	183,93

Story	Lumped Mass (ton)
Erdg	518,63
1	449,64
2	380,06
3	361,67
4	359,15
Roof	183,93

- Estimation of the stiffness of the structure

Referring to the attached maps in the Appendix (I), the lateral bearing system of this building is composed of unreinforced masonry walls. Although the actual performance of the building will involve the torsional behaviors as well as the lateral motions, the level of accuracy of the aimed "fragility curves" at the defined "Phase 0" would accommodate the negligence of the torsional modes of response.
Moreover and in the absence of the required detailed information on the condition of the bearing wall-ceiling connections, the equivalent stiffness of the lateral bearing system was estimated by the application of the well-known equation of structural mechanics (7), assuming full-fixity of the wall-ceiling joints. The material mechanical properties of the building, mostly obtained from references [7],[8] are summarized per Table (2).

$$K_e = \left(\frac{h^3}{\beta E I_e} + \frac{\kappa h}{G A_w}\right)^{-1} \quad (7)$$

In equation (7), K_e is the equivalent stiffness of the masonry bearing wall with the rectangular section and fully fixed conditions at the both end supports, $\kappa = 1.5$ and $\beta = 12$. A_w also refers to the effective shear resistance area of the wall section, as a function of the nominal section area, A_n, per equation (7). In addition, G is the shear modulus of the material and all the other terms hold their definitions as clarified elsewhere.

$$A_w = \frac{A_n}{\kappa} \quad (8)$$

Table (2). The experimentally reported material properties of Fendigasse masonry building[7],[8]

Young Modulus	Shear Modulus	Poisson's Ratio
(Pa)	(Pa)	-
1,80E+09	512820513	0.17

Furthermore, it needs to be reminded that as long as there are some non-negligible openings in the continuous bearing walls as schematically shown in Fig. (1), the lateral stiffens of these elements have been approximated using the equivalent moment of inertia, I_e, per equation (9)[9].

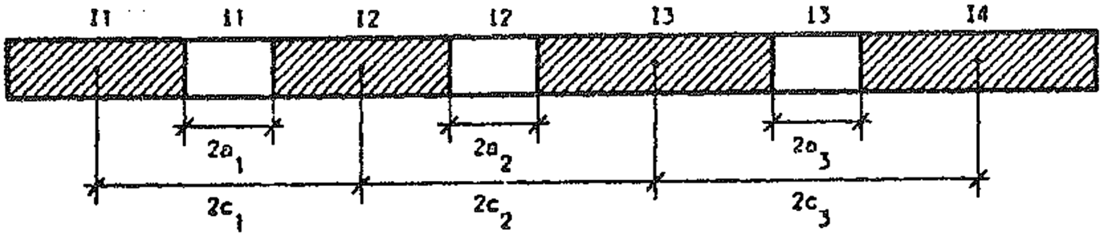

Fig (1). Schematic continuous bearing wall with openings[9]

$$I_e = \frac{I}{1+\frac{8I\psi}{(I_1+I_2+I_3+\cdots)\alpha^2}} \tag{9}$$

$$\alpha = \omega \mathrm{H} \tag{10}$$

$$\omega^2 = \frac{6\acute{E}}{Eh(I_1+I_2+I_3+\cdots)}\left(\frac{i_1c_1^2}{a_1^3}+\frac{i_2c_2^2}{a_2^3}+\cdots\right) \tag{11}$$

In equations (9) to (11), I is the moment of inertia of the whole wall should it contain no openings, I_i refers to the moment of inertia of the partially continuous parts of the wall and i_i is the moment of inertia of the openings, taken to be positive rather than negative. a_i and c_i also define half of the width of the openings and the center to center distance between the adjacent partially continuous walls, in the order of appearance and as sketched in Fig. (1). In all the introduced notations, the index *i,* acts as the number identifier in the original equations. The parameter ψ, considering both the geometrical and material properties of the bearing walls with openings, is derived from the empirical curves, schematically shown per Fig. (2). As noticed, such curves are a function of the terms α and ω by equations (10) and (11) and the term J_l as the ratio of the length of the wall to the height of the structure. Moreover, the terms H, h, $\acute{E}$ and E in equations (10) and (11) are to represent the total height of the building, the center to center distance between the two consequent openings along the height of the structure, the modulus of elasticity of the connecting beam at the top of the opening and of the wall itself, respectively. The final lumped lateral stiffness of the building in both the *X* and *Y* directions and for the two "5DOF" and "6DOF" models are presented in Tables (3) and (4), in the order of appearance. Once again, it needs to be emphasized that these equivalent spring stiffness values do not reflect either the torsional properties of the building or the soil-structure interaction at the supports, but the existence of the openings within the walls. In addition, the effects of the adjacent buildings on the dynamic properties of the structure have not been directly included into the stiffness approximation.

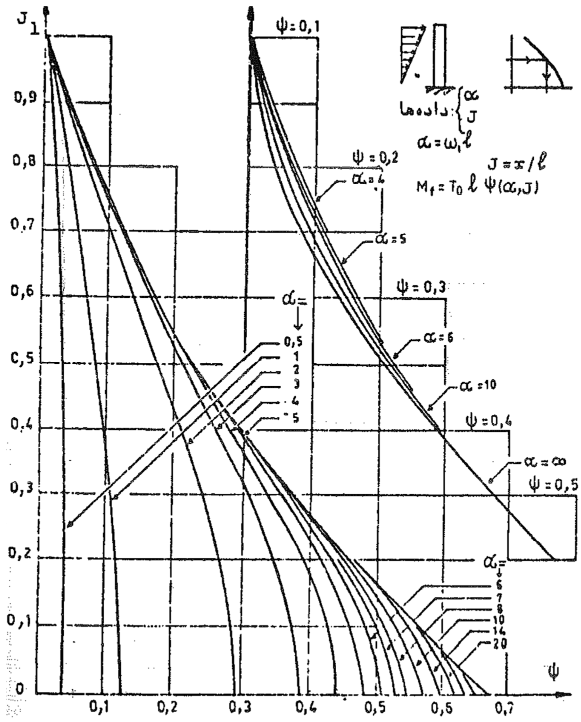

Fig (2). Graphs of the parameter ψ of the building based on α and J_l [9]

Table (3). Approximate lumped stiffness of the 5DOF model

Story	Lumped Stiffness X (kN/m)	Lumped Stiffness Y (kN/m)
1	1993664,62	2439224,719
2	1963019,98	2006311,141
3	1723771,35	1831176,268
4	1739337,35	1847591,053
Roof	1683446,62	1789144,371

Table (4). Approximate lumped stiffness of the 6DOF model

Story	Lumped Stiffness X (kN/m)	Lumped Stiffness Y (kN/m)
Erdg	2871113,65	3972161,192
1	1993664,62	2439224,719
2	1963019,98	2006311,141
3	1723771,35	1831176,268
4	1739337,35	1847591,053
Roof	1683446,62	1789144,371

- Approximation of the eigenfrequencies

As well specified and known in the technical literature, the eigenvalues of the mass and stiffness matrices of the defined linear elastic mass-spring system will yield the eigenangular frequencies of the structure[6],[10]. Hence, once the mass and stiffness of the structure have been estimated through the procedures explained above, solution to equation (12) will provide the analytically expected values of the eigenfrequencies

$$|[K - M\omega^2]| = 0 \qquad (12)$$

where $[K]$ and $[M]$ respectively refer to the stiffness and mass matrices of the defined system, where the mass matrix remains the same though the stiffness matrix varies for the two orthogonal horizontal directions, *X* and *Y*.
Once the analytical eigenfrequencies have been derived, the corresponding peaks detected in the measured FFT curves will provide the real time modal frequencies of the structure to be applied to the fundamental equation (1). Samples of such a spectrum are represented per Fig. (3).
The following Tables (5) and (6) represent the analytically approximated and the averaged measured frequencies of the system in each direction and for the two defined DOF classes. As noticed per the numerically represented data, the difference between the calculated eigenfrequencies of the 5DOF and 6DOF mass-spring systems are sufficiently small in the accuracy scale of the defined "Phase 0" stage to continue with just the 5DOF model for the rest of the calculations. Moreover and clearly, the following relationship between the linear frequency and the angular one has been consistently used for the entire calculations.

$$\omega_i = 2\pi f_i \tag{13}$$

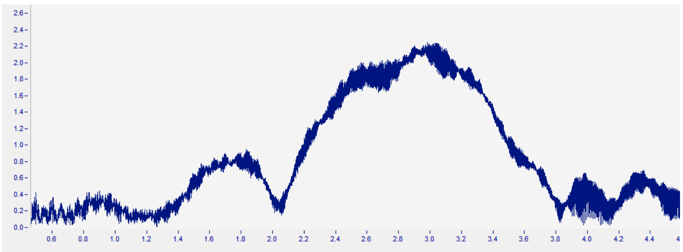

Fig (3). Sample FFT spectral analysis for the eigenfrequency determination[11]

Table (5). The approximated analytical eigenfrequencies- left: 5DOF- right: 6DOF

Mode X #	Freq (Hz)	Mode Y #	Freq (Hz)
1	3,67	1	3,76
2	9,82	2	10,38
3	15,28	3	15,89
4	19,39	4	19,94
5	21,6	5	22,25

Mode X #	Freq (Hz)	Mode Y #	Freq (Hz)
1	3,24	1	3,4
2	8,49	2	9,14
3	13,51	3	14,28
4	17,11	4	18,38
5	19,9	5	21,05
6	21,64	6	22,37

Table (6). The averaged measured eigenfrequencies for the 5DOF model

Mode X #	Freq (Hz)	Mode Y #	Freq (Hz)
1	3,18	1	2,86
2	9,41	2	10,80
3	15,60	3	15,35
4	20,23	4	19,85
5	23,23	5	23,03

2.1.2. Mode Shapes

As sufficiently well-known from the principles of dynamics of structures, once the eigenfrequencies of the system are known, the solution to equation (14) will result into the analytical mode shapes of the structure[10]

$$[K - M{\omega_i}^2]\{\phi\}_i = 0 \tag{14}$$

where all the terms have been previously defined. However, as long as the main motivation of this current research program is to obtain the so-called real dynamic properties of the building by the in-site measurement

methods, a well-equipped recording set up where each degree of freedom possesses at least one accelerometer unit must provide the eigenvectors of the system along with the eigenfrequencies at the same time.
Nevertheless, in the absence of such measurement set up, the following analytical procedures will theoretically result into the real-time mode shapes of the structure using a single story recorded data set.
Referring to the sub-steps taken to derive the analytical eigenfrequencies of the structure by the application of equation (12), the actual stiffness of the structure can be back calculated by the same methodology, should the actual stiffness matrix $[K]$ be taken as the unknown and the real-time measured frequencies of the system, ω_i, be back substituted as the known elements. The solution to the derived nonlinear system of *n* equations will result into the elements of the actual stiffness matrix of the structure. Hence, in a subsequent step, the "real-time" mode shapes of the structure could be derived, applying equation (14), in which all the engaged terms $[K]$, $[M]$ and ω_i are updated for the actual condition. It could also be expected that by such a back calculation methodology, the derived actual stiffness matrix could reflect the effects of the adjacent structures, the torsional movements and to some extents the soil-structure interactions brought up by the application of the measured eigenfrequencies. As a result, once the first bracket in equation (14) is updated, its analytical solution will end up with the "real-time" lateral mode shapes of the structure.
Despite the fact that all the detailed required steps described to first derive the actual stiffness matrix of the structure and consequently calculate the mode shapes have been followed for the specific case at "Fendigasse" where all the sensors were placed at one level, the derivation of the correct solution to the system of nonlinear equations could not be completed due to a lack of the required sufficiently strong mathematical tools to handle the equations. However, skipping the procedure to update the stiffness matrix and applying the same approximately calculated analytical one, equation (14) was solved by the combination of the measured eigenfrequencies with all the other terms for the unknown eigenvectors of the building in the two orthogonal directions. The values of the mode shapes for "Fendigasse" are summarized in Tables (7) to (11), as well as the Fig. (4).

Table (7). First mode shape of the building in the X and Y directions

Mode X #1	Mode Shape	Mode Y # 1	Mode Shape
5	1	5	1
4	0,8473	4	0,8636
3	0,6299	3	0,6773
2	0,3578	2	0,4463
1	0,18589	1	0,2082

Table (8). Second mode shape of the building in the X and Y directions

Mode X #2	Mode Shape	Mode Y #2	Mode Shape
5	1	5	1
4	-0,219	4	0,7107
3	-1,2403	3	-0,204
2	-1,363	2	-0,942
1	-1,1207	1	-0,794

Table (9). Third mode shape of the building in the X and Y directions

Mode X #3	Mode Shape	Mode Y #3	Mode Shape
5	1	5	1
4	0,3154	4	-0,298
3	-0,972	3	-1,016
2	-0,3142	2	0,1254
1	1,7262	1	0,9467

Table (10). Fourth mode shape of the building in the X and Y directions

Mode X #4	Mode Shape	Mode Y #4	Mode Shape
5	1	5	1
4	1,115	4	-0,678
3	-2,4868	3	-0,253
2	2,2939	2	0,9538
1	-1,3667	1	-0,752

Table (11). Fifth mode shape of the building in the X and Y directions

Mode X #5	Mode Shape	Mode Y #5	Mode Shape
5	1	5	1
4	-0,502	4	-0,665
3	0,25	3	0,428
2	-0,106	2	-0,237
1	0,0372	1	0,0959

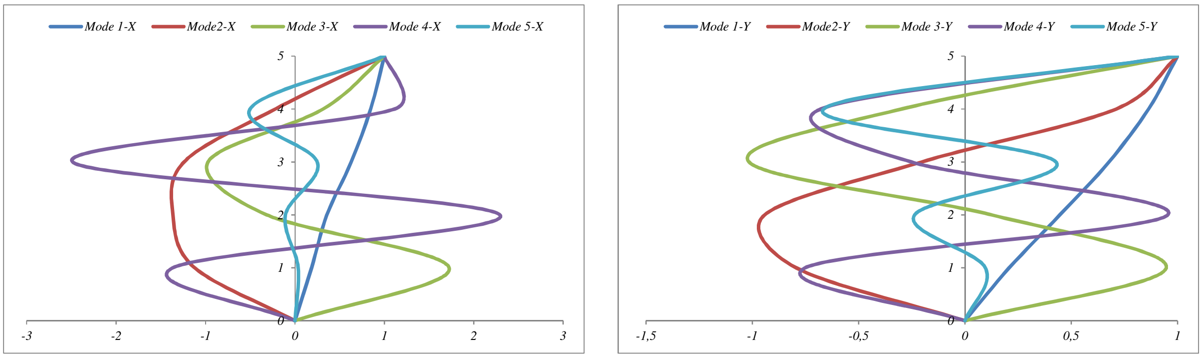

Fig (4). Mode shapes of the structure- left: X direction- right: Y direction

2.1.3. Modal Damping Coefficients

In the preceding parts, all the required structural characteristics in the fundamental equation (1) were determined besides the modal damping coefficient values. Hence, the following is to represent one of the practical methods to estimate the aforementioned quantities from the measured data.

- Application of the half-power band width method

According to the theories of dynamics of structures, the maximum amplitude of the steady-state response of an oscillator, X, and static stiffness K, to a harmonic excitation with the amplitude F_0 and angular frequency ω can be estimated by the following relationship[6].

$$X = \frac{F_0/K}{\sqrt{\left[1-\left(\frac{\omega}{\omega_n}\right)^2\right]^2+\left(2\xi\frac{\omega}{\omega_n}\right)^2}} \qquad (15)$$

In equation (15), ω_n and ξ are the angular natural frequencies and damping coefficients of the SDOF oscillator, in the order of appearance. As noticed per equation (15), the oscillator will reach its maximum range when the frequency of excitation falls close enough to the vicinity of the natural frequency of the dynamic system, as shown by equation (16) below[6].

$$X_{max} = \frac{F_0/K}{2\xi} \quad (16)$$

As long as equation (15) holds for any arbitrary maximum amplitude of vibration a certain dynamic system may undergo, the so-called “half-power band width” method essentially tries to derive a relationship between Lehr’s critical damping coefficient, ξ, and the eigenfrequency of the system when the maximum amplitude of vibration is equal to $X_{max}/\sqrt{2}$. Hence, multiplying equation (16) by $1/\sqrt{2}$ and equating it with the right hand side of equation (15) and further simplifying the relationship for small values of Lehr’s damping coefficient, the following expression enables the engineers to approximate the damping properties of the system, using the experimental displacement spectrum in the frequency domain by the following expression

$$\xi = \frac{\omega_2 - \omega_1}{\omega_n} = \frac{f_2 - f_1}{f_2 + f_1} \quad (17)$$

where ω_2 and ω_1 are the angular frequencies corresponding to the amplitude values in the spectrum equal to $X_{max}/\sqrt{2}$[6].
Application of the aforementioned procedures to the measured data in a real scale structure subjected to a series of artificially induced harmonic excitations under controlled conditions may result into a sufficiently smooth FFT spectrum which will be turned into the displacement amplitudes, dividing the recorded accelerations by the corresponding squared angular frequencies at each and every point. Derivation of such a displacement spectrum will consequently serve as the base for the application of equation (17). However, in the absence of the well recorded sets of data where the harmonic frequency of excitation was swept through a reasonably wide range to capture all the modal frequencies of the structure, the best set of data obtained from the ambient vibrations first needs to be recognized and subsequently smoothed out to reflect the desirable amplitude peaks in the FFT spectrum. Nevertheless, since the measured vibrations in the real condition is usually accompanied by inevitable noises from the surrounding environments, the corresponding modal peaks and frequencies might not be eventually reflected into the obtained FFT diagrams with the expected resolutions. That is to say that should the quality of the recorded data allow for the application of the aforementioned procedures, the modal damping coefficients will be estimated using equation (17).
However, it has to be declared that neither of the measured histories at “Fendigasse” building as of July 2011 resulted into a sufficiently smooth FFT curve and the numerical results obtained by the application of equation (17) were not in the expected range of civil engineering applications. Hence, a conservative value $\xi = 0$ for all the modes of the structure was assumed in the derivation of the “Phase 0” fragility curves.
Based on the calculations, undertaken in sub-sections (2.1.1) through (2.1.3), the required dynamic structural characteristics of the system for the derivation of the response of the structure applying equation (1) have already been derived. Consequently, the selection of the proper earthquakes, $\ddot{U}(t)_g$, for the structural response derivation will be brushed up as follows.

2.2. Ground Motion Hazard Level Selection

As declared earlier, the determination of the “fragility curves” requires the estimation of the response of the structure under certain various hazard levels and further relating the obtained results to the specified damage states in a probabilistic scheme. Since the fundamentals of the structural response derivation by the application of a time history analysis as the most exact method were sufficiently entailed in the preceding section, the major outlines of the selection of the appropriate ground motions as the second essential step will be briefly reviewed as follows.
According to the outlines mentioned in reference [1], there are certain challenges to be conquered in the selection of the proper group of earthquakes, representing each level of the ground motion hazard[1]. Based on the numerous recent investigations on the probable parameters affecting the devastating characteristics of an earthquake, “the demand intensity of the earthquake on the structures generally is not quantitatively unique, as the same value of peak ground acceleration (PGA) as a common representation of the seismic demand does not guarantee the similarity of the structural responses by any ways. Hence, in order to classify the ground motions, representing the same level of hazard, the localized special effects such as the faulting mechanism, the path of the seismic wave, the directivity and fling-step effects in addition to the soil amplifications and its interactions with

the structure foundation have to be reflected into the derived fragility curves, as affecting the longitudinal axes of the graph, potentially noticeably"[1],[5],[12],[13],.
In addition, "scaling the set of the ground motions representing the certain hazard level to the current code-based spectra might serve as an ad-hock solution, however, in more advanced cases and special structures and lifelines, special seismic hazard analysis has to specify and describe the seismicity of the area"[1].
Moreover, "based on the widely available research results on the damage indices and measurements, this is a difficulty to find the most appropriate quantitative representation of the seismic demand, as it is usually coupled with the specific structural behavior. In the other word, although some analytical researches have shown the sensitivity of specific types of the structures to certain ground motion parameters, derivation of a general conclusion might not be applicable as long as some other types of structures may show different degrees of sensitivity to other characteristics parameters of the ground-motion"[1],[12].
Although the aforementioned issues have already been detected and clarified, the solution to such matters, sourcing from the unknown random nature of the earthquakes cannot be deterministically found. Hence, as long as the order of accuracy of the "Phase 0" curves could leave some rooms for further possible future modifications regarding the by-the-time detected shortcomings, the following major characteristics were taken as the appropriate base to detect and selelct the earthquake group at each hazard level.
i) Since Vienna is not potentially prone to highly destructive ground motions, the earthquakes were intensively selected in a way not to possess any obvious Near-Field characteristics, specifically high amplitude pulses in the velocity and displacement records or long period motions in the acceleration time histories[8],[15].
ii) The recording station of the seismic data has to be at least 10 *km* away from the source of faulting.
iii) In order to keep the smoothness of the final fragility curves for all the defined hazard levels, in this research project only one set of earthquakes, satisfying the two above conditions was selected and consequently linearly scaled to different hazard levels. In the other word, the basic earthquake group remained the same while the amplitudes of the acceleration data were multiplied by a factor, representing the hazard level of interest.
Once the proper group of earthquakes was selected of which the characteristics are summarized in Table (12), the acceleration records have been first normalized for the unit of ground motion accelerations in the *g* scale and consequently modified for the PGA in the range of 0.05*g* to 1.5*g*, with a 0.05*g* acceleration increments. That is to say that the structure has been subjected to 30 defined hazard levels based on the PGA classifications where each hazard level contains 8 ground motions. Moreover, in Table (12), the terms PGV and PGD refer to the peak ground velocity and peak ground displacement, in the order of appearance. All the recorded time histories are retrieved from Peer Berkeley Strong Ground Motion Database[14].

Table (12). As recorded characteristics of the selected earthquakes[14]

Earhtquake	Recording Station	Array	PGA (g)	PGV (cm/s)	PGD (cm)	Energy Density (cm^2/s)
Imperial Valley 1979	Elcentro Calipatra Fire Station	225	0.128	15.37	11.3	653.5
Imperial Valley 1979	Elcentro Calipatra Fire Station	315	0.078	13.62	13.85	445.069
Imperial Valley 1979	Elcentro 13	140	0.117	14.67	8.05	453.18
Imperial Valley 1979	Elcentro 13	230	0.139	13	5.94	422.33
Imperial Valley 1979	Elcentro Coachella Canal	4045	0.115	12.46	2.51	106.85
Imperial Valley 1979	Elcentro Coachella Canal	4135	0.128	15.61	3.1	152.853
Imperial Valley 1979	Elcentro Delta	262	0.238	26.015	12.79	4942.61
Imperial Valley 1979	Elcentro Delta	352	0.351	35	347.2	7791.2

2.3. Numerical Evaluations and Arithmetic Statistics

The procedures entailed in the preceding sub-sections suffice the numerical evaluation of the structural response by the application of the fundamental equations (1) and (6) in a time history scheme, using the scaled ground motion records referred in Table (12). Hence, the proceeding parts are to summarize the obtained numerical structural responses and the arithmetic statistical procedures accomplished to derive the "definition-based real-time" fragility curves of the specified building at "Fendigasse".

As attached per Appendix (II) to this document, a computer code in "Fortran 95" programing environment, capable of assessing the linear response time history of the structure in both the forced and free phases of vibration, was developed and the maximum inter story drifts of the one-dimensionally modeled building in the two orthogonal directions were extracted as the parameters of interest[16]. In the next step, the obtained responses of the structure in each defined hazard level were purified for the maximum three values, implying that though in each ground motion hazard state defined by the corresponding scaled PGA of the record, the structure was subjected to eight separate ground motions in the two horizontal orthogonal directions, only the three highest inter story drifts of the building were selected to represent the structural behavior for the rest of the statistical calculations.

Consequently, the mean and standard deviation of the structural response in each hazard level are evaluated and the continuous probability of exceedance of each defined damage state is calculated, applying equation (18) as follows[5],[17].

$$Fragility = P(R_s > L_{DS}|HL_G) = 1 - P(R_s < L_{DS}|HL_G) \tag{18}$$

In the equation above, P is to represent the probability calculation function, R_s, the structural response, L_{DS}, the defined damage state limit corresponding to the type of the structural response evaluated and HL_G is the ground motion hazard level. Based on the theories of probability and statistics, the notation used in equation (18) is clearly referring to a conditional probability.

Furthermore, in order to derive the fragility values as a continuous quantity for each damage state instead of a set of discrete numbers, it is a common practice to assume a normal distribution density function for the obtained structural responses in each hazard level with the specific calculated mean and standard deviation values and assess the fragility as the cumulative distributed probability function. Implementation of the described procedure into equation (18) will render the following expressions[18].

$$f(R_S; \mu, \sigma^2) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(R_S-\mu)^2}{2\sigma^2}} \tag{19}$$

$$F(L_{DS}; \mu, \sigma^2) = \phi\left(\frac{L_{DS}-\mu}{\sigma}\right) = \frac{1}{2}\left[1 + erf\left(\frac{L_{DS}-\mu}{\sigma\sqrt{2}}\right)\right] \tag{20}$$

$$erf(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-t^2} dt \tag{21}$$

$$Fragility = P(R_s > L_{DS}|HL_G) = 1 - \phi\left(\frac{L_{DS}-\mu}{\sigma}\right) \tag{22}$$

In equations (19) to (22), f and F refer to the probability density and the cumulative probability distributions in the order of appearance. In addition, μ and σ are the mean and the standard deviations of the obtained structural

responses in each defined hazard levels. Moreover, the terms ϕ and erf represent the cumulative distribution probability and error functions, respectively and t and x are the dummy variables to define the error function. All the other terms hold their definitions as stated elsewhere.
The final numerical values of the introduced terms, parameters and functions are summarized and represented per Tables (13) and (14) for the two orthogonal directions. It needs to be clarified that in this project, four different levels of the damage state, namely the slight, moderate, extensive and complete have been defined of which the numerical inter-story drift ratio limits, L_{DS}, are reproduced in an ascending order in the aforementioned tables, obtained from FEMA HAZUS[5].
In addition and as declared earlier, all the maximum structural inter-story drift ratios were assessed using a linear time history analysis. However, the obtained results have been consequently applied towards the fragility derivation in the damage state levels "moderate", "extensive" and "complete", where at least the materials plasticity will invalidate the general applicability of the linear dynamic theories. Nevertheless, this is to emphasize that as long as the monitored structural response is selected to be the inter-story drifts and not the force-based actions, assuming the equality of the linear and nonlinear inelastic displacements could sufficiently fulfill the preciseness level of the derived fragility curves in the defined "Phase 0"[6],[10]. Notwithstanding, the detailed effects of such an assumption could be further investigated in the future, should the specific data on the material plastic performance be available. The obtained definition-based real-time fragility curves of the building in the X and Y directions are shown in Figs. (5) and (6), respectively.

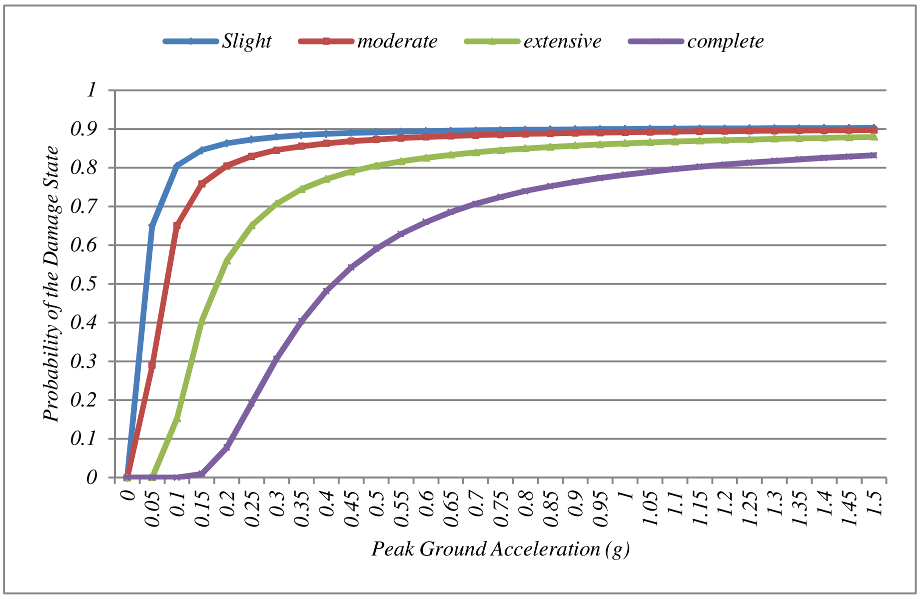

Fig (5). Definitions-based fragility curves of the building in the X direction

Table (13). The fragility calculations for different levels of damage states in the X direction

Hazard Level	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	PGA(g)	
Structural Inter-Story Drift Ratio	0	0.0021	0.0042	0.0063	0.0084	0.0105	0.0126	0.0147	0.0168	0.0189	0.0210	0.0231	0.0252	0.0461	0.0482	0.0503	0.0524	0.0545	0.0566	0.0587	0.0608	0.0629	Elcentro Calipatra Fire Station 225	Earthquake
	0	0.0040	0.0081	0.0121	0.0161	0.0202	0.0242	0.0282	0.0323	0.0363	0.0403	0.0444	0.0484	0.0887	0.0927	0.0968	0.1008	0.1048	0.1089	0.1129	0.1169	0.1210	Elcentro Calipatra Fire Station 315	
	0	0.0006	0.0013	0.0019	0.0026	0.0032	0.0039	0.0045	0.0052	0.0058	0.0065	0.0071	0.0077	0.0142	0.0148	0.0155	0.0161	0.0168	0.0174	0.0181	0.0187	0.0194	Elcentro Delta	
Mean	0	0.0023	0.0045	0.0068	0.0090	0.0113	0.0135	0.0158	0.0181	0.0203	0.0226	0.0248	0.0271	0.0497	0.0519	0.0542	0.0565	0.0587	0.0610	0.0632	0.0655	0.0677	μ	
Standard Deviation	0	0.0017	0.0034	0.0051	0.0068	0.0085	0.0102	0.0119	0.0136	0.0153	0.0170	0.0187	0.0204	0.0374	0.0391	0.0408	0.0425	0.0442	0.0459	0.0476	0.0493	0.0510	σ	
Fragility (Eq 21)	0	0.6507	0.8046	0.8449	0.8629	0.8730	0.8794	0.8838	0.8871	0.8896	0.8915	0.8931	0.8944	0.9008	0.9011	0.9014	0.9017	0.9019	0.9022	0.9024	0.9026	0.9028	L_{DS}=0.0016	Damage States
	0	0.2897	0.6507	0.7584	0.8046	0.8295	0.8449	0.8554	0.8629	0.8686	0.8730	0.8765	0.8794	0.8931	0.8938	0.8944	0.8950	0.8955	0.8960	0.8964	0.8969	0.8973	L_{DS}=0.0032	
	0	0.0004	0.1527	0.4050	0.5604	0.6507	0.7068	0.7442	0.7705	0.7898	0.8046	0.8162	0.8255	0.8675	0.8695	0.8713	0.8730	0.8745	0.8758	0.8771	0.8783	0.8794	L_{DS}=0.008	
	0	0	0.00002	0.0097	0.0775	0.1916	0.3067	0.4039	0.4814	0.5422	0.5903	0.6287	0.6597	0.7963	0.8024	0.8079	0.8129	0.8174	0.8215	0.8253	0.8288	0.8320	L_{DS}=0.0187	

≈continues≈

Table (14). The fragility calculations for different levels of damage states in the Y direction

Hazard Level	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	PGA(g)	
Structural Inter-Story Drift Ratio	0	0.0007	0.0015	0.0022	0.0030	0.0037	0.0045	0.0052	0.0059	0.0067	0.0074	0.0082	0.0089	0.0163	0.0171	0.0178	0.0185	0.0193	0.0200	0.0208	0.0215	0.0223	Elcentro Calipatra Fire Station 225	Earthquake
	0	0.0029	0.0059	0.0088	0.0117	0.0147	0.0176	0.0205	0.0235	0.0264	0.0294	0.0323	0.0352	0.0646	0.0675	0.0705	0.0734	0.0763	0.0793	0.0822	0.0851	0.0881	Elcentro Calipatra Fire Station 315	
	0	0.0012	0.0023	0.0035	0.0046	0.0058	0.0070	0.0081	0.0093	0.0105	0.0116	0.0128	0.0139	0.0255	0.0267	0.0279	0.0290	0.0302	0.0314	0.0325	0.0337	0.0348	Elcentro Delta	
Mean	0	0.0016	0.0032	0.0048	0.0065	0.0081	0.0097	0.0113	0.0129	0.0145	0.0161	0.0177	0.0194	0.0355	0.0371	0.0387	0.0403	0.0419	0.0435	0.0452	0.0468	0.0484	μ	
Standard Deviation	0	0.0012	0.0023	0.0035	0.0047	0.0058	0.0070	0.0082	0.0093	0.0105	0.0116	0.0128	0.0140	0.0256	0.0268	0.0279	0.0291	0.0303	0.0314	0.0326	0.0338	0.0349	σ	
Fragility (Eq 21)	0	0.5044	0.7574	0.8231	0.8512	0.8666	0.8762	0.8828	0.8875	0.8911	0.8939	0.8962	0.8981	0.9070	0.9075	0.9079	0.9083	0.9086	0.9089	0.9092	0.9095	0.9098	L_{DS}=0.0016	Damage States
	0	0.0864	0.5044	0.6805	0.7574	0.7983	0.8231	0.8395	0.8512	0.8599	0.8666	0.8719	0.8762	0.8962	0.8972	0.8981	0.8989	0.8996	0.9003	0.9010	0.9015	0.9021	L_{DS}=0.0032	
	0	0.0000	0.0202	0.1827	0.3698	0.5044	0.5949	0.6568	0.7007	0.7330	0.7574	0.7765	0.7918	0.8583	0.8614	0.8641	0.8666	0.8688	0.8709	0.8728	0.8746	0.8762	L_{DS}=0.008	
	0	0	0.00000	0.0000	0.0043	0.0339	0.0983	0.1817	0.2669	0.3449	0.4126	0.4702	0.5187	0.7438	0.7539	0.7630	0.7712	0.7786	0.7853	0.7915	0.7971	0.8023	L_{DS}=0.0187	

≈continues≈

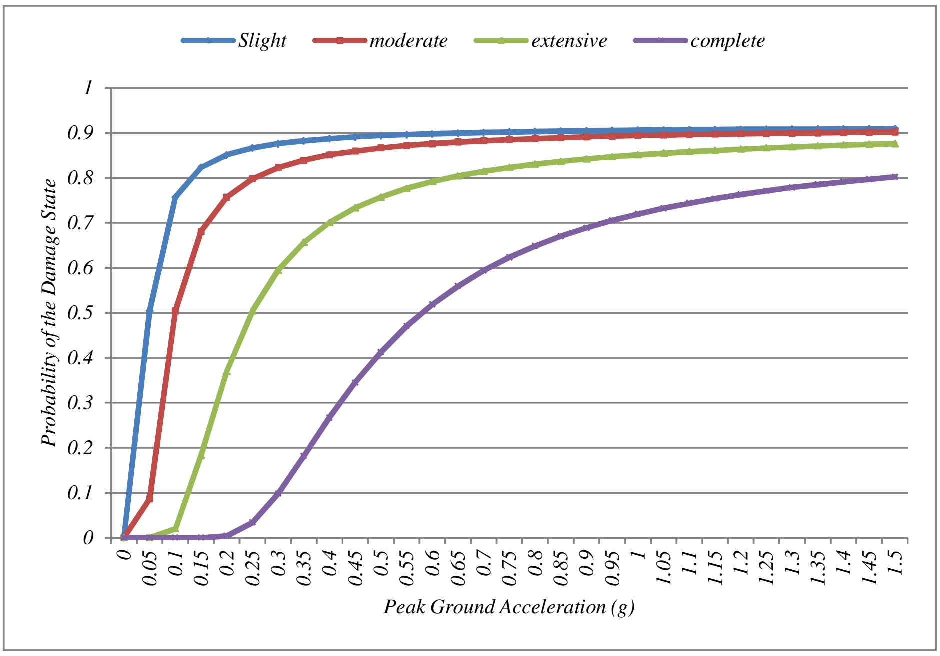

Fig (6). Definitions-based fragility curves of the building in the Y direction

3. Curve Fitting and Fragility Functions

As noticed per the configuration of the derived curves in Figs. (5) and (6), and according to the technical literature at hand, the fragility curves could be idealized and generalized by a lognormal distribution function in terms of the intensity parameter, used to define the ground motion hazard levels[2],[3],[5],[19]. In the other word, the aim of this section is to introduce the family of the lognormal distribution functions which could sufficiently exactly approximate the trend of the fragility curves, derived analytically and based on the definitions as shown in Figs. (5) and (6).
According to probability theories, a lognormal cumulative distribution function, F, is defined by equation (23), below

$$F(\ln(PGA)\,;\mu,\sigma) = \phi\left(\frac{\ln(PGA)-\mu}{\sigma}\right) = \frac{1}{2}erfc\left(-\frac{\ln(PGA)-\mu}{\sigma\sqrt{2}}\right) \qquad (23)$$

where μ and σ are known as the location and scale parameters, corresponding to the mean and standard deviation of the natural logarithm of the ground motion hazard level intensity index, here referred as PGA[20]. In addition, the term $erfc$ represents the complementary error function[21].

In compliance with the eventual objective of this section and in order to relate the derived probabilities of exceedance known as the fragilities directly to the ground motion intensity parameter, PGA, via a lognormal distribution curve fitting, the procedures described below have been followed. All the terms have been already defined in the preceding parts[22].

$$erfc\left(-\frac{\ln(PGA)-\mu}{\sigma\sqrt{2}}\right) = Fragility \times 2 \qquad (24)$$

$$erf\left(-\frac{\ln(PGA)-\mu}{\sigma\sqrt{2}}\right) = 1 - erfc\left(-\frac{\ln(PGA)-\mu}{\sigma\sqrt{2}}\right) = 1 - Fragility \times 2 = z \qquad (25)$$

$$erf^{-1}(z) = \frac{1}{2}\sqrt{\pi}\left(z + \frac{\pi}{12}z^3 + \frac{7\pi^2}{480}z^5 + \frac{127\pi^3}{40320}z^7 + \frac{4369\pi^4}{5806080}z^9 + \frac{34807\pi^5}{182476800}z^{11} + \cdots\right) \quad (26)$$

$$-\frac{\ln(PGA)-\mu}{\sigma\sqrt{2}} = erf^{-1}(z) \quad (27)$$

According to equation (27), the terms μ and σ can be derived based on the slope and the intersection of a line, connecting every two points of the pairs $\left(\ln(PGA), erf^{-1}(z)\right)$. Should the obtained definition-based fragility curves in Figs. (5) and (6) inherently follow a lognormal distribution function, equation (27) will turn out to be a unique line in terms of the $\ln(PGA)$ and $erf^{-1}(z)$ for the entire pairs of each specific damage state. However, as long as the definition-based curves schematically resemble a lognormal distribution function, though not necessarily analytically, the solution to equation (27) will not result in a single (μ, σ) pair and a couple of "statistical fragility functions", defined per equation (23) will be achieved. Consequently and in essence, the engineer in charge may select the best fitted curve for any generalization purposes.

Regarding the descriptions given above, the statistical fragility functions in this specific project could be referred as "self-induced". That is to imply that for every two points of the definition-based fragility curves at each hazard level shown per Figs. (5) and (6), a separate statistical fragility function with a specific (μ, σ) pair was first calculated, as the Figs. (7) to (14) depict the numerical convolution results, accomplished in "Fortran 95" programing media and Microsoft Excel 2010[16], [22]. As observed per the aforementioned figures, there are above four hundred possibilities of statistical lognormal fragility functions for each hazard level and the direction of interest, enveloping the real definition-based fragility curves. As long as the selection of the best statistical lognormal curve fitting the original real definition-based fragility function is greatly dependent on the type of the structure and the seismicity of the area in addition to the required degree of conservatism, the samples of the best fitting curves from this document author's point of view have been shown in Figs. (15) and (16) with the corresponding calculated mean and standard deviations, (μ, σ), despite the fact that the selection of the most appropriate statistical fragility function could not be unique. In the two latter referred figures, the analytical fragility curves are shown by continuous lines and the fitted lognormal one by the dotted line.

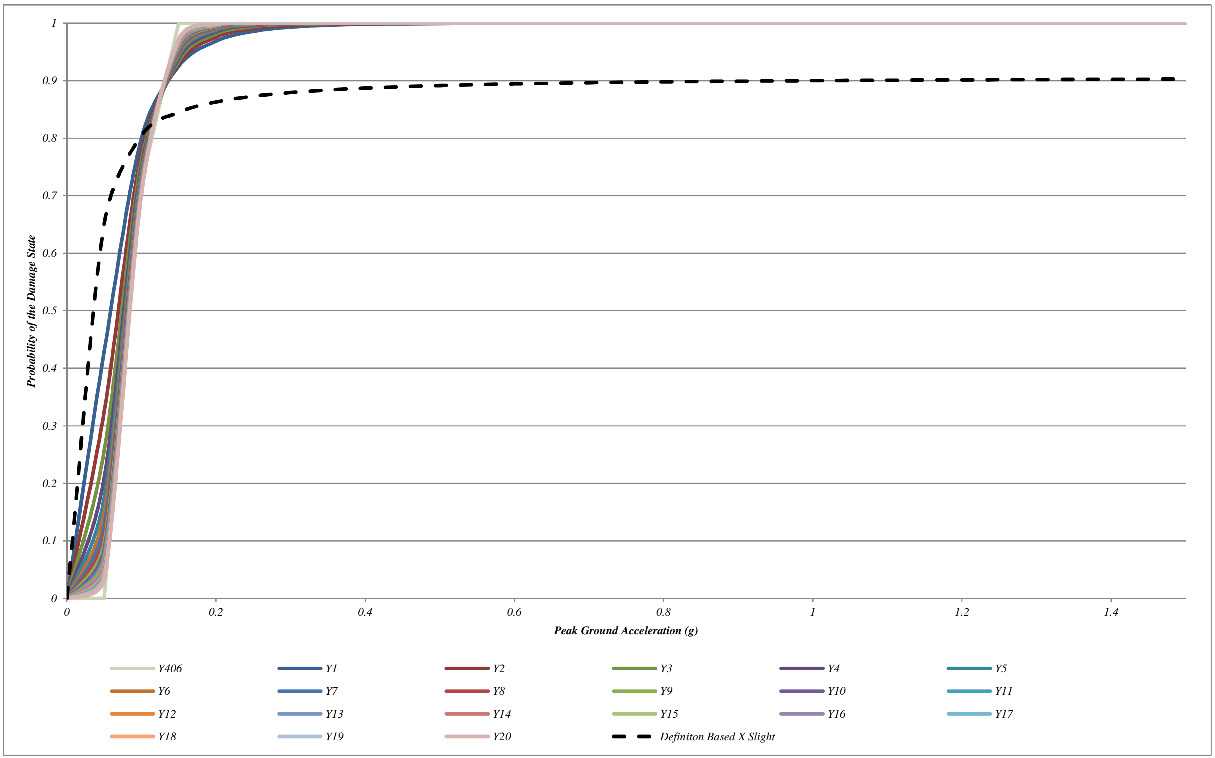

Fig (7). Statistical self-induced and definitions-based fragility curves for the slight damage state- X direction

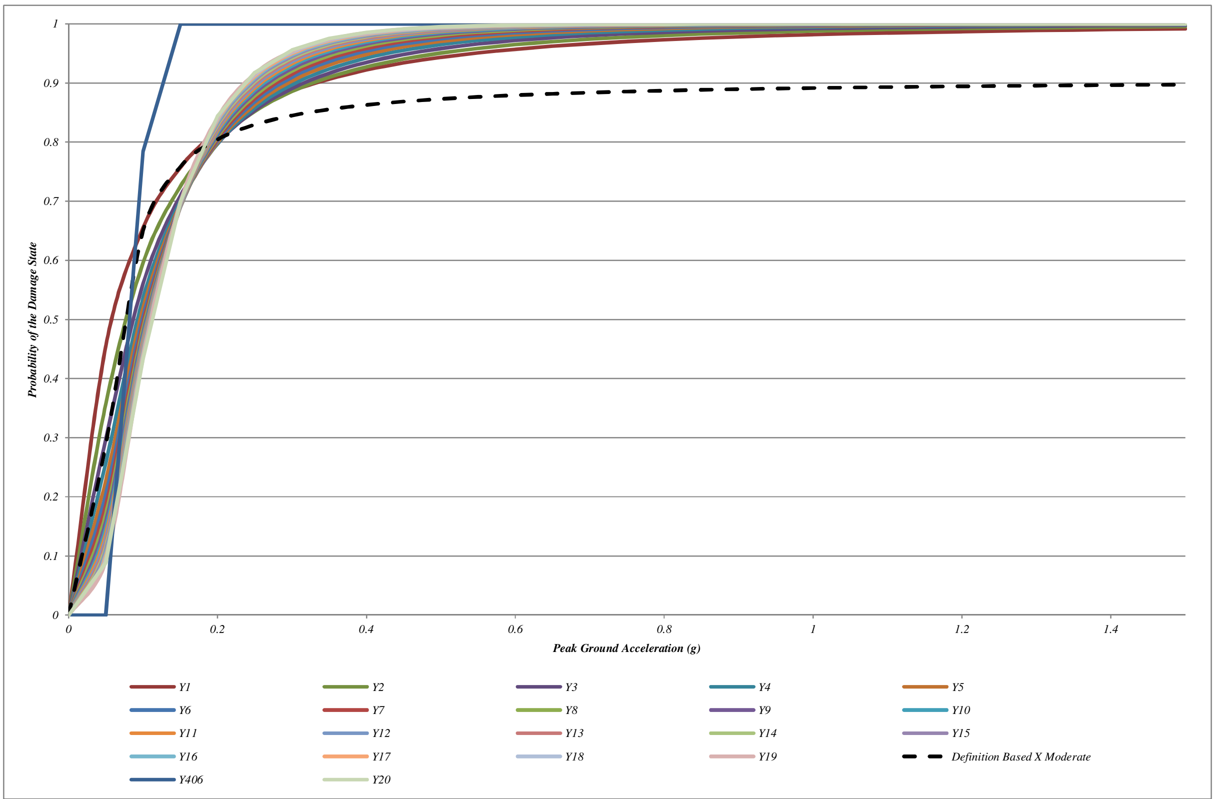

Fig (8). Statistical self-induced and definitions-based fragility curves for the moderate damage state- X direction

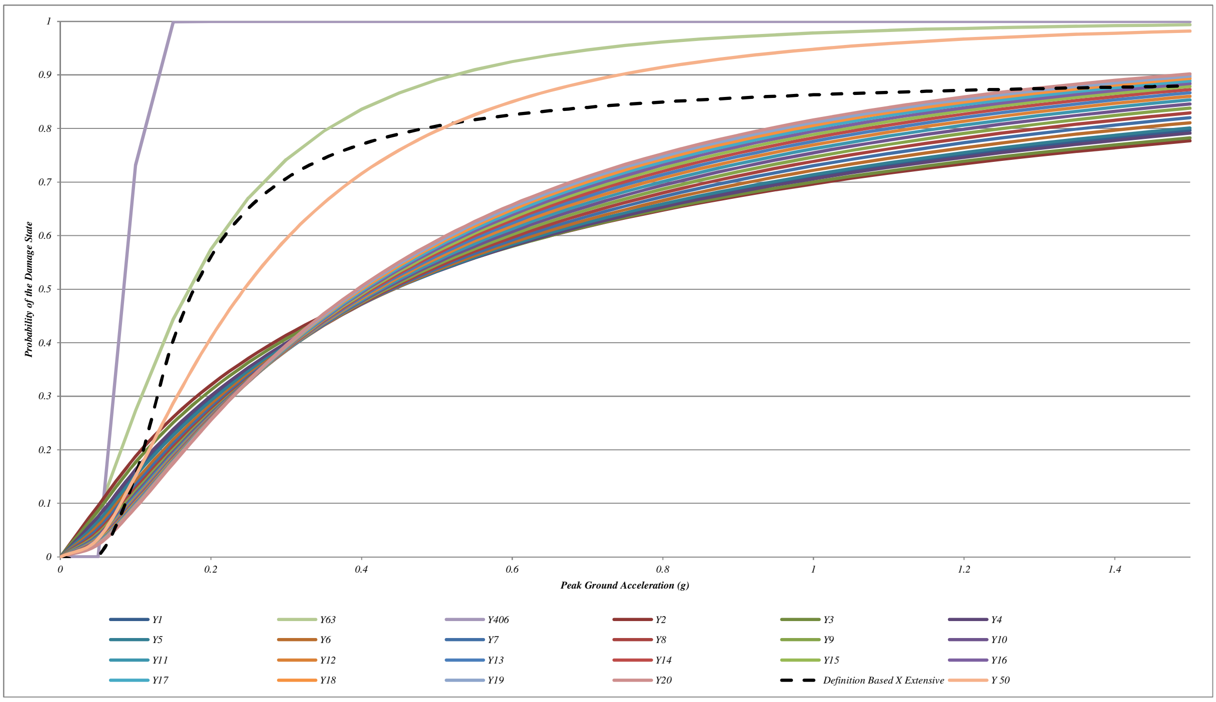

Fig (9). Statistical self-induced and definitions-based fragility curves for the extensive damage state- X direction

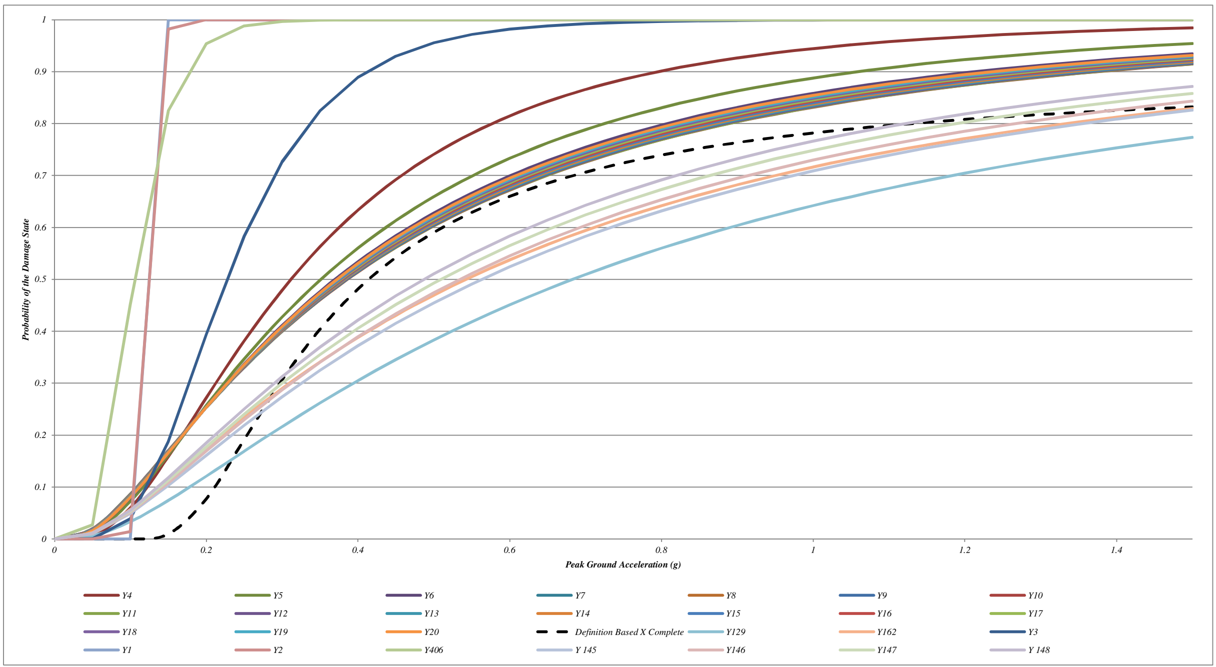

Fig (10). Statistical self-induced and definitions-based fragility curves for the complete damage state X direction

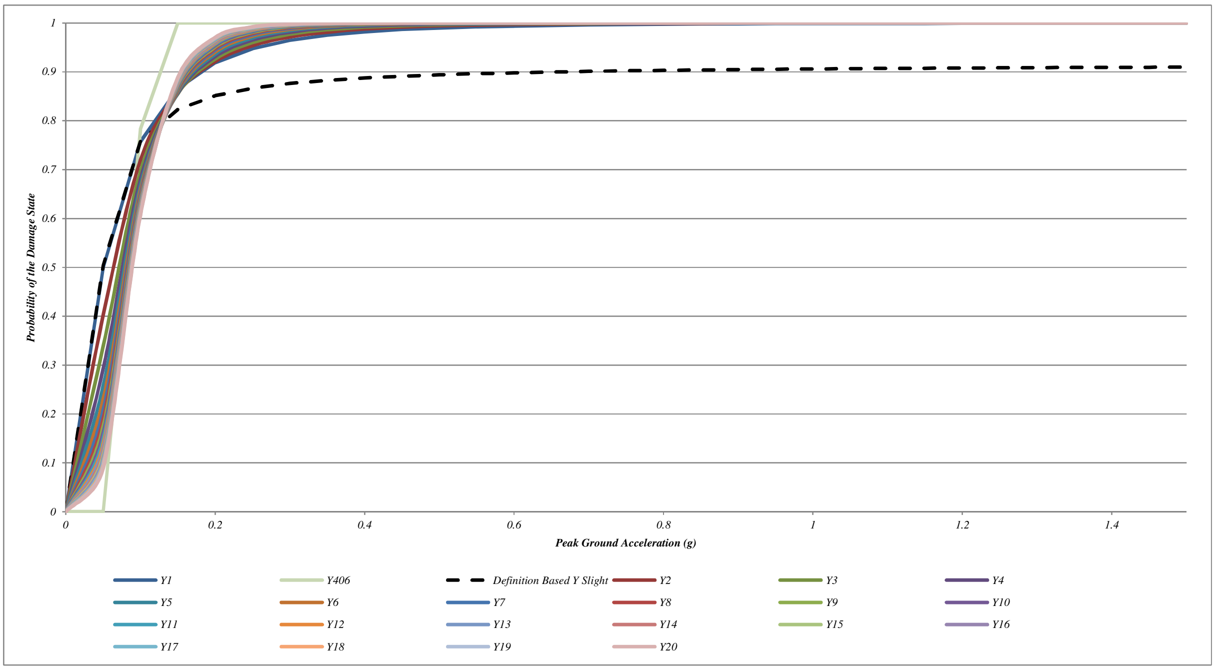

Fig (11). Statistical self-induced and definitions-based fragility curves for the slight damage state- Y direction

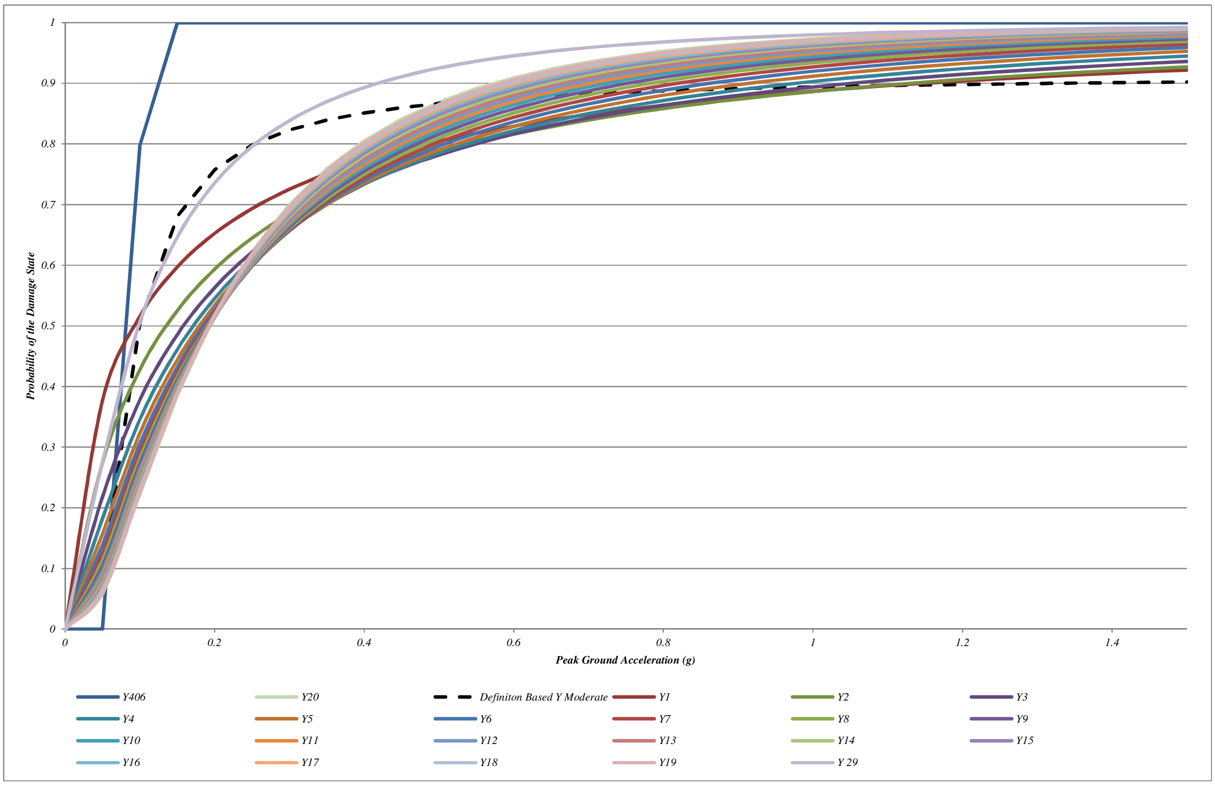

Fig (12). Statistical self-induced and definitions-based fragility curves for the moderate damage state Y direction

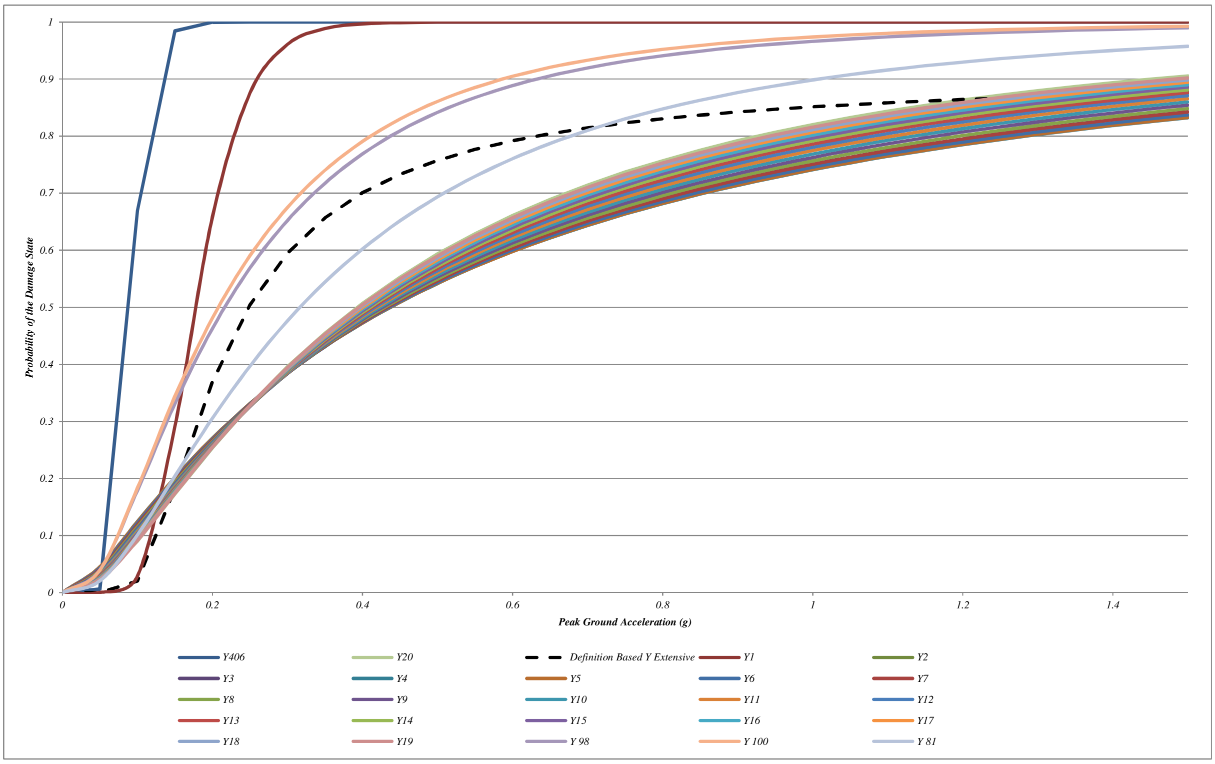

Fig (13). Statistical self-induced and definitions-based fragility curves for the extensive damage state Y direction

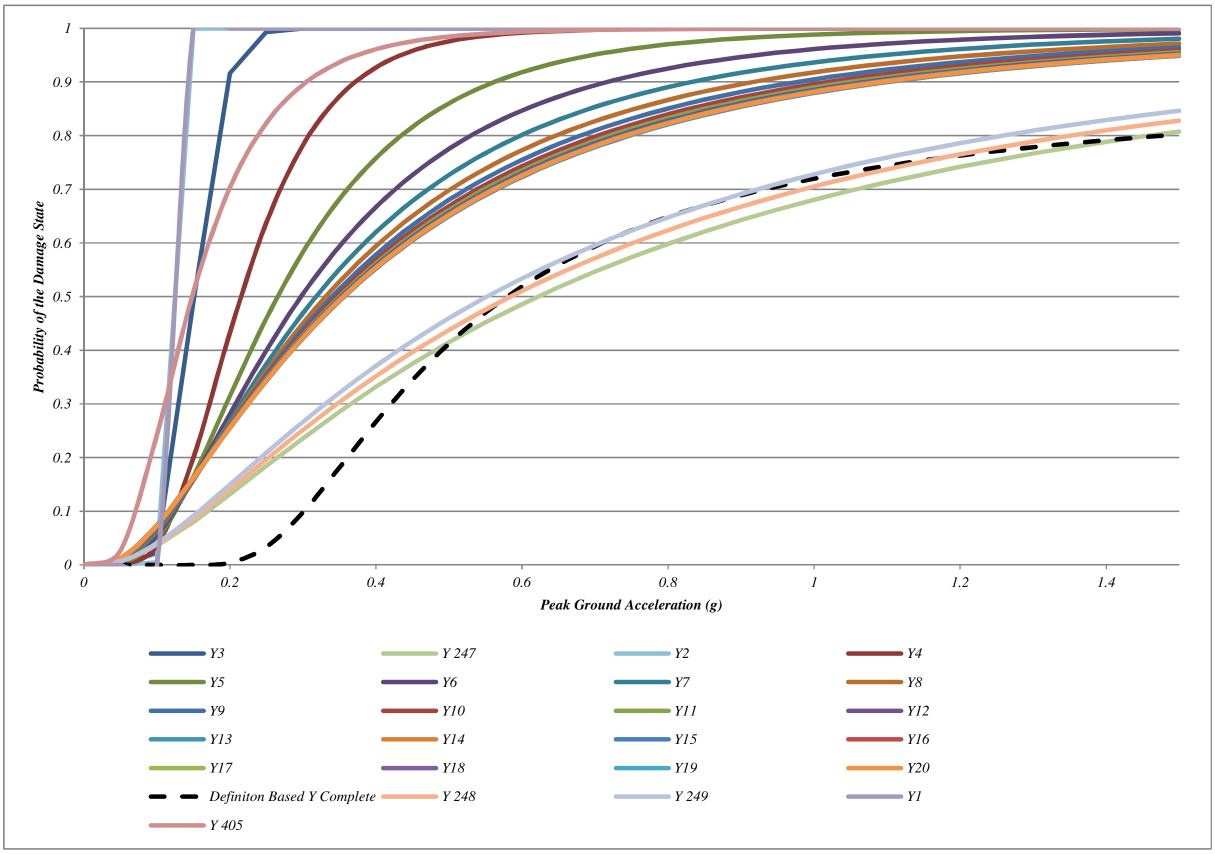

Fig (14). Statistical self-induced and definitions-based fragility curves for the complete damage state Y direction

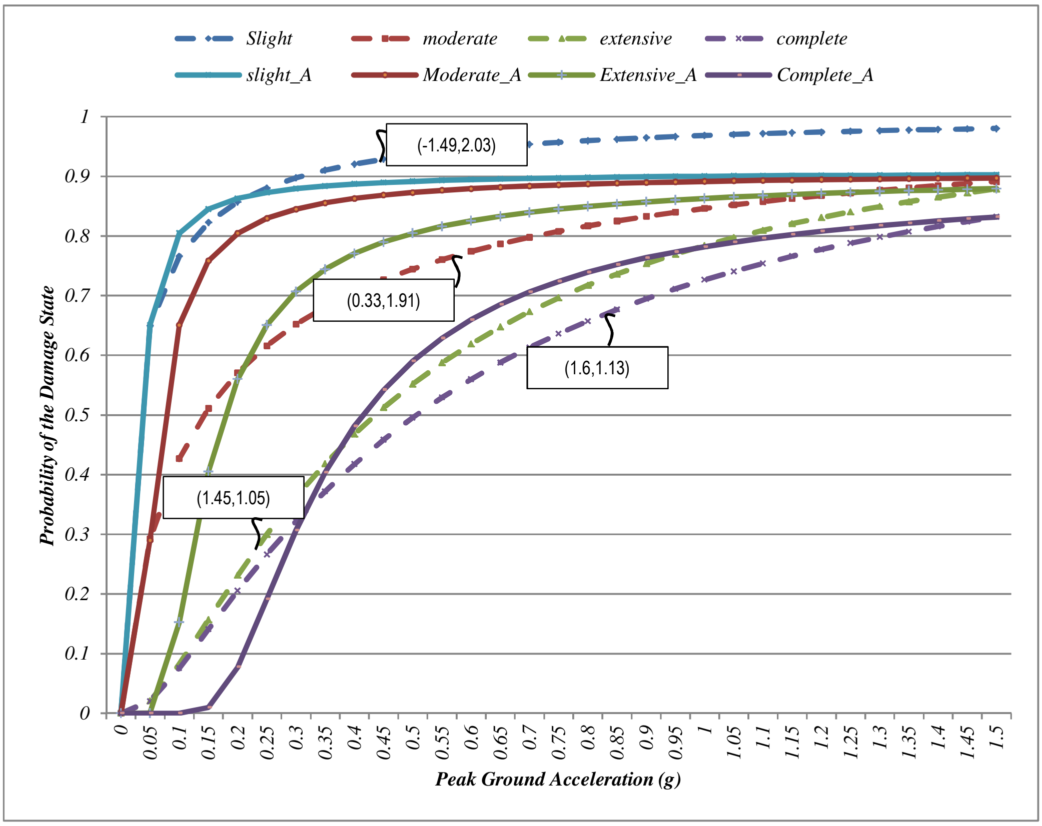

Fig (15). Comparison of the fitted Statistical self-induced (dotted) and definitions-based (continuous) fragility curves in the X direction with (μ, σ)

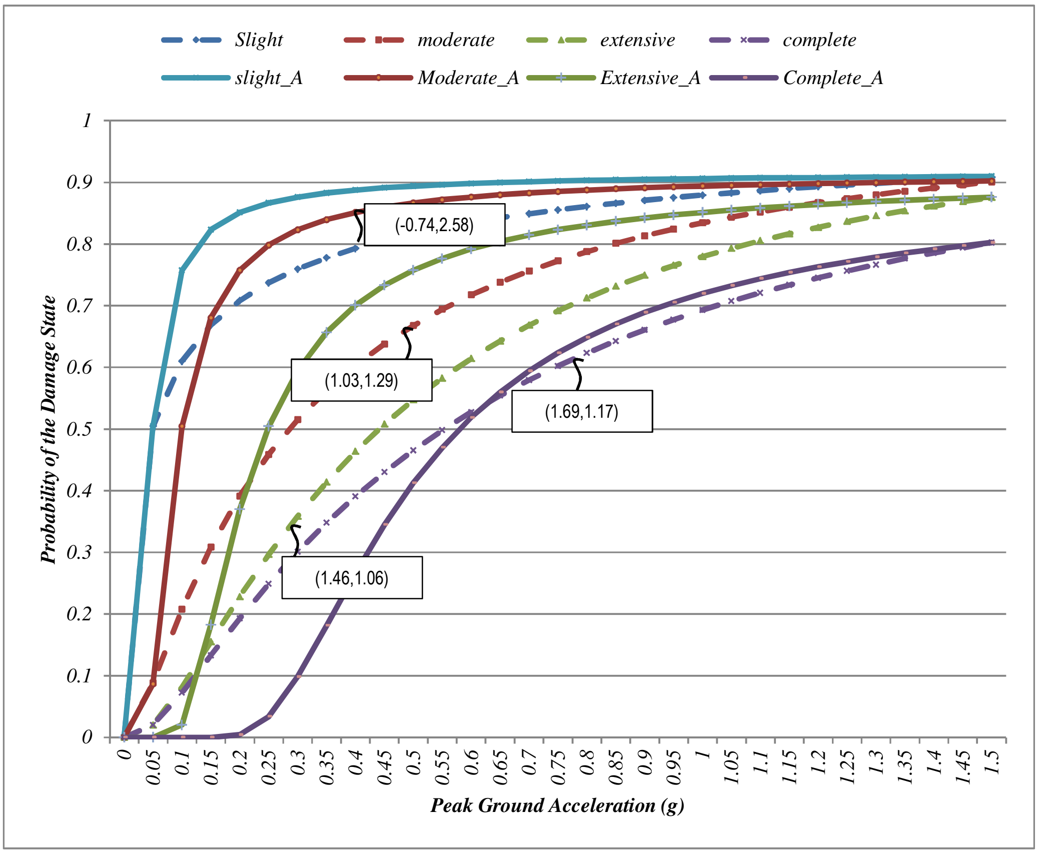

Fig (16). Comparison of the fitted Statistical self-induced (dotted) and definitions-based (continuous) fragility curves in the Y direction with (μ, σ)

4. Summary, Conclusions and Future Work

4.1. Summary and Conclusions

Since the first introduction of the concept of fragility curves in the safety assessment of nuclear power plants, there has been an ongoing effort towards the generalization of the methodology for the vulnerability and risk assessment of various structures, specially but not specifically within the Civil Engineering applications[22],[23],[24],[25].

Furthermore and based on the definition of the seismic fragility of any arbitrary object, the analytical procedures should target the evaluation of the probability of reaching or exceeding a certain damage level under a specific demand state, here taken to be the ground motion hazard level[26],[27],[28],. As abundantly declared in the preceding sections and with the aim of first deriving the "definition-based real time" fragility curves of the structure for the "as-of-the-date" condition and consequently idealizing the derived curve, serving as the exact reference, by a lognormal distributed cumulative function, the following steps were taken of which the results were carefully presented in sections (2) and (3). It needs to be reminded that all the numerical evaluations have been specifically performed, using the actual recorded data of the unreinforced masonry building at "Fendigasse" so that the derived diagrams and functions could be interpreted as the 'real-time' properties of the structure under consideration. Clearly, for any detailed information not entailed in this summary section, the reader may consult the main body of the text and/or further the referred manuscripts and technical literature.

Quoting from the structural fragility definition, the following three elements are the main components of constructing such curves by analytical approaches.

- The ground motion hazard level

Based on the vast literature at hand, the bizarre nature of the earthquakes, all categorized under the same natural hazard class though with far different characteristics might not easily allow for the determination of the best parameter to characterize the ground motion destructive potential. However, in this specific case, the PGA of the earthquakes was selected to serve as the ground motions hazard level indicators[12],[14],[15],[29],[30],[31]. The selected acceleration time histories were chosen in a way not to possess any significant Near-Field effects regarding the seismicity of the area.

- The evaluated structural response

Since the calculation of the probability of reaching or exceeding a certain damage state undeniably calls for the assessment of the structural behavior either in terms of the force-based actions or displacement-based reactions, the inter-story drift ratio of the structure derived by a direct linear time history analysis for both the forced and free phases of vibration was selected to form the base of justice for the structural dynamic performances. The two points of emphasis could be first the application of the updated frequencies, masses, mode shapes and damping coefficients of the building into the "Duhamel" integral, equation (5), according to the in-site measurements recorded by the "Vienna Consulting Engineers" staff, and second, the implementation of the linear time history analysis results towards the derivation of the fragility curves for the damage states higher than the "slight" one where the materials plasticity are playing an important role. However, this matter has been justified by the author of this draft that the similarity of the displacements in the linear and nonlinear analyses could be a sufficiently accurate assumptions for the defined level of the project, as "Phase 0". Should sufficient information regarding the inelastic behavior of the material be at hand, the latter assumption could be relaxed and be re-validated via the plastically analyzed responses[32]. As aforementioned, the linear time history analysis of the one-dimensional mass-spring modeled system in "Fortran 95" programing environment resulted into the derivation of the maximum inter-story drift of the structure under each hazard level and applied towards the derivation of probability density function of the structural response and consequently the cumulative probability distribution function of which the adjoin is taken to be the structural fragility at the defined ground motion hazard level verses different structural damage states.

- The damage state limits

The damage state thresholds in the ordinary structural applications are defined based on the evaluation of the capacity curves of the structure in a nonlinear static scheme which by and large needs the analysis of a sufficiently large group of buildings, all of the same type. Though even such detailed time consuming analysis results have been well challenged regarding the compatibility of the responses with those obtained by a dynamic time history analysis, the inter-story damage state limits defined per FEMA HAZUS and obtained by the application of the push over analysis to buildings of the same type have been used in the current project[5],[30].

Once the “definition-based real-time” fragility curves were derived using equation (22), the idealization of the obtained curves by lognormal cumulative probability functions in terms of the defined ground motion hazard level and the corresponding mean and standard deviations of the logarithmized parameter resulted into a family of statistic “self-induced” fragility functions by the application of equation (23) with the back calculated data from equation (27). As noticed per Figs. (7) to (14), the “definition-based” fragility curves do not resemble a unique lognormal cumulative probability function, hence, instead of a single pair of the mean and standard deviations, a family of such pairs have been calculated at each defined damage state and for the two horizontal orthogonal directions. Despite the fact that the selection of the best statistically fitted curve essentially requires an engineering judgment, oriented towards the specific matters of considerations in the specially defined project, the samples of the so-called best fitted curves and the statistical characteristics have been shown in Figs. (15) and (16).
Moreover, the following flow chart in Fig. (17) once again summarizes the taken steps towards the derivation of the both the “definition-based real time” fragility curves and the corresponding “self-induced” fragility functions.

4.2. Future Work

As long as the obtained results have been derived in the absence of the torsional motions, soil-structure interactions, adjacent buildings effects on the dynamic properties of the structure as well as the nonlinear performance of the building, each of the aforementioned issues could potentially open up new gates for further investigations.
Moreover, since the derived statistical fragility functions were “self-induced” by the application of a truncated series to recover the error function in equation (26) and consequently obtain the possible family of the lognormal cumulative distribution functions resembling the real definition-based fragility curve, the comparison of this approach with those obtained by a probabilistic method using Monte Carlo simulation analysis could be a potential topic of interest without the loss of the validity of the current “self-induced” methodology[33],[34].

Ambient Data Monitoring ⟹ **Data Processing** ⟹ **Real-Time Structural Natural Frequencies, Mode Shapes and Damping** $(\boldsymbol{\omega_i}, [\boldsymbol{A}], \boldsymbol{\xi_i})$

Real-Time Mass Calculation $[\boldsymbol{M}]$ ⟹ **Back Calculation of Global Elastic Stiffness** $|\boldsymbol{K} - \boldsymbol{M}\boldsymbol{\omega}^2| = 0$

Appropriate Selection of the Ground Motion Records for Various Hazard Levels ⟹ **Duhamel Integral** $\boldsymbol{y_i(t)} = \frac{\overline{K_i}}{\omega_i}\int_0^t \ddot{\boldsymbol{u}}_g(\boldsymbol{\tau})\boldsymbol{e}^{-\xi_i\omega_i(t-\tau)}\sin(\boldsymbol{\omega_i}(\boldsymbol{t}-\boldsymbol{\tau}))\boldsymbol{d\tau}$

Structural Response $[\boldsymbol{x}(\boldsymbol{t})] = \boldsymbol{y_i}(\boldsymbol{t})[\boldsymbol{A}]$ ⟹ **Response and Limit Damge State Comparison** $\boldsymbol{x} \geq \boldsymbol{x_{DS}}$

Exceedance Probability Evaluation for the Mean Ground Motion Parameter of the Selected Hazard Level $F(XDE) = P(x \geq x_{DS}|ED)$ ⟹ **Updating the Mean and Standard Deviation Parameters**

Fig (17). Flow chart to derive the “definition-based” and “static self-induced” fragility curves using the in-site monitored data

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Appendix I

The Geometric Configuration of the Building

Fig (A.1). The monitored building at Fendigasse, courtesy of Dr. F.Kopf

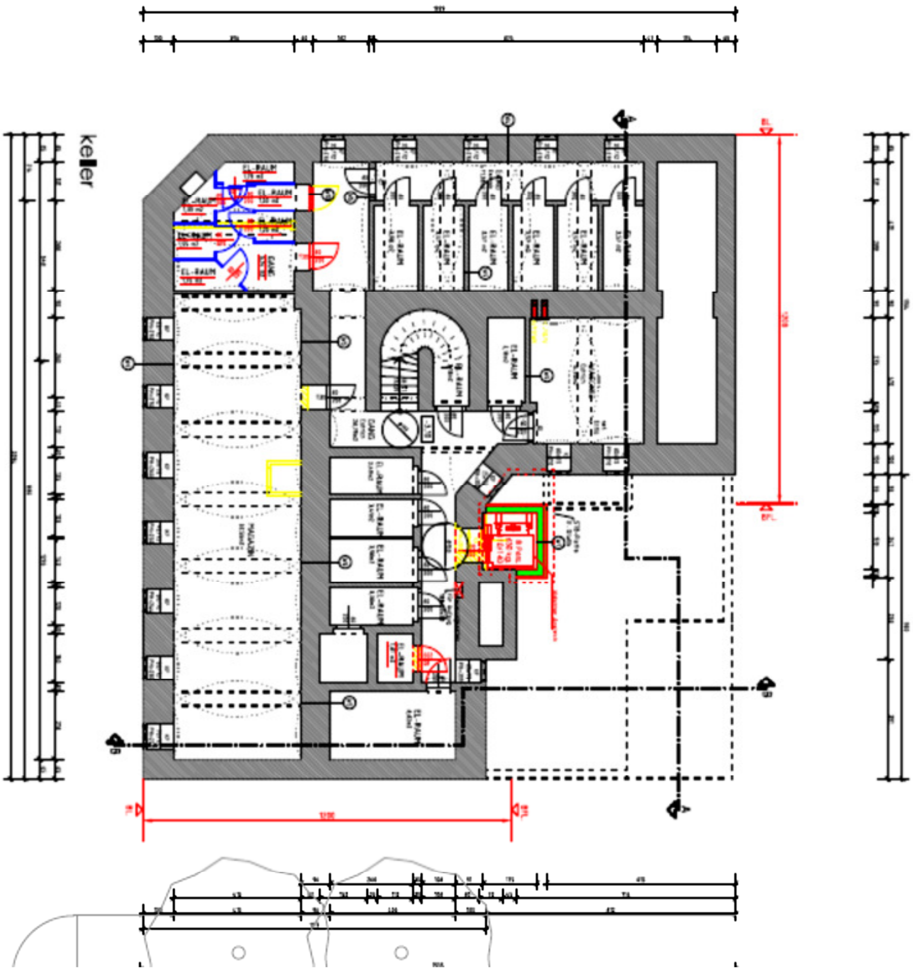


Fig (A.2). The plan of the structure at the Keller level

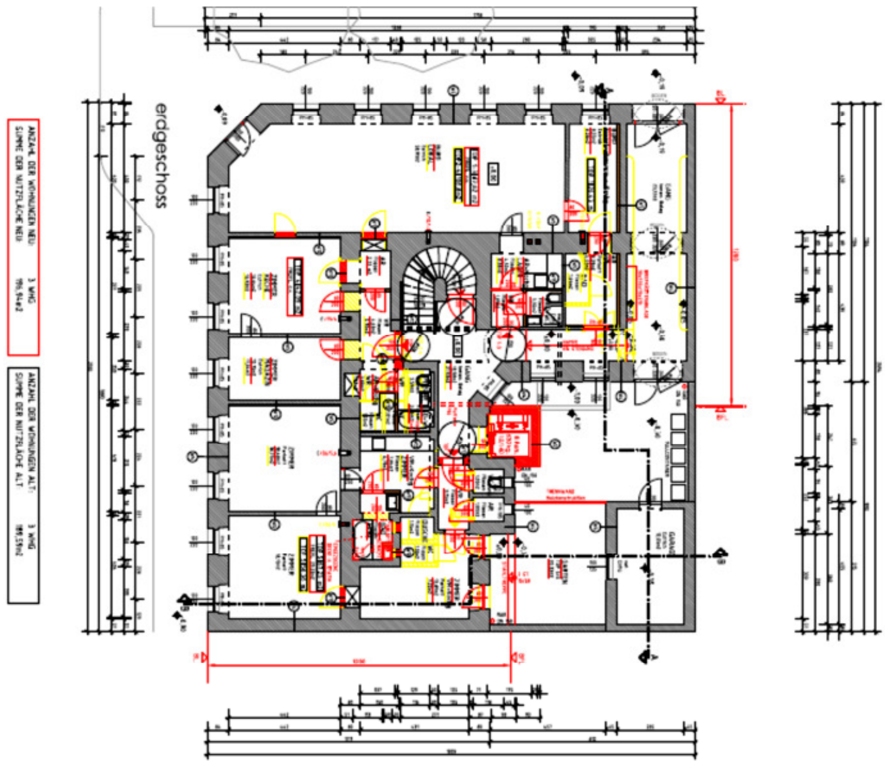


Fig (A.3). The plan of the structure at the Ground floor

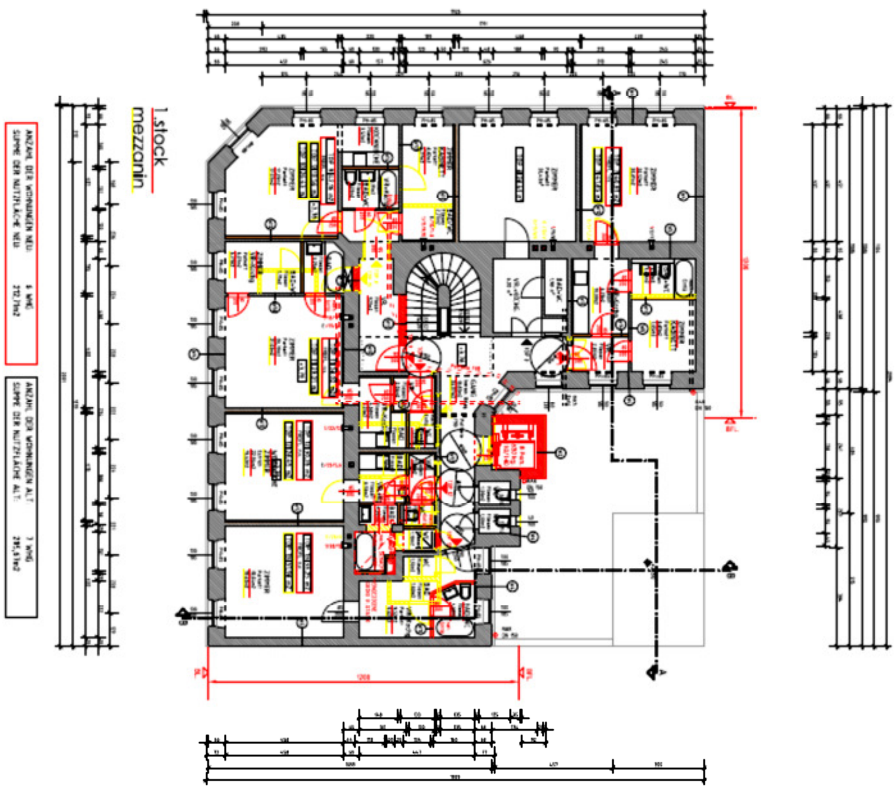


Fig (A.4). The plan of the structure at the 1st floor

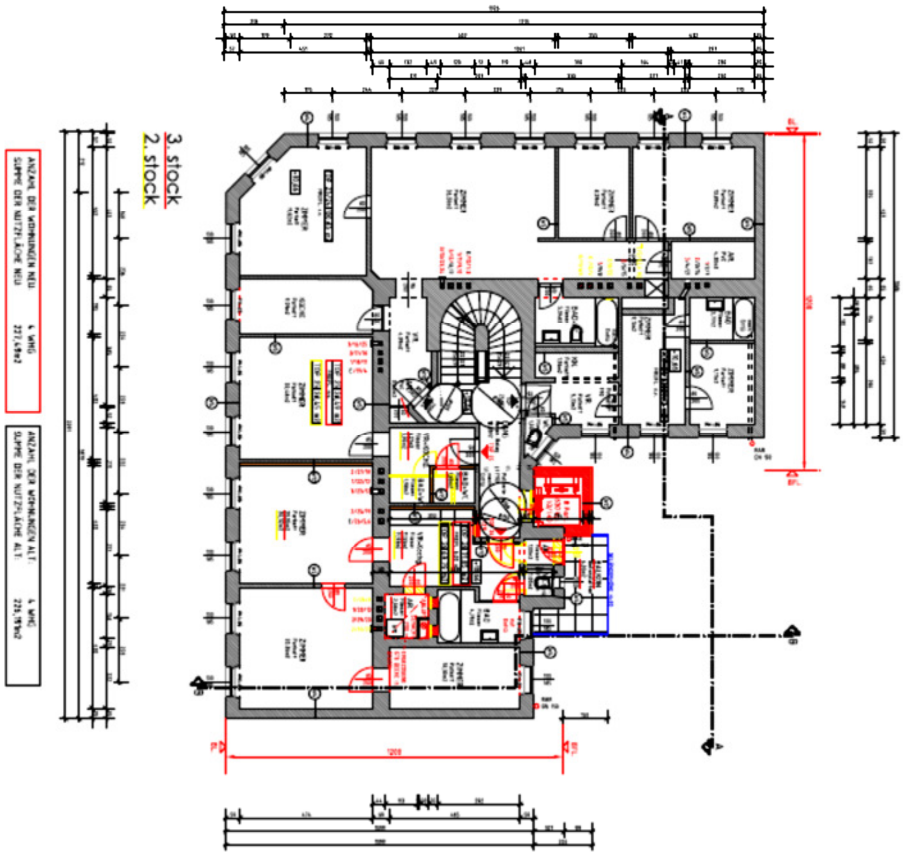


Fig (A.5). The plan of the structure at the 2nd and 3rd floors

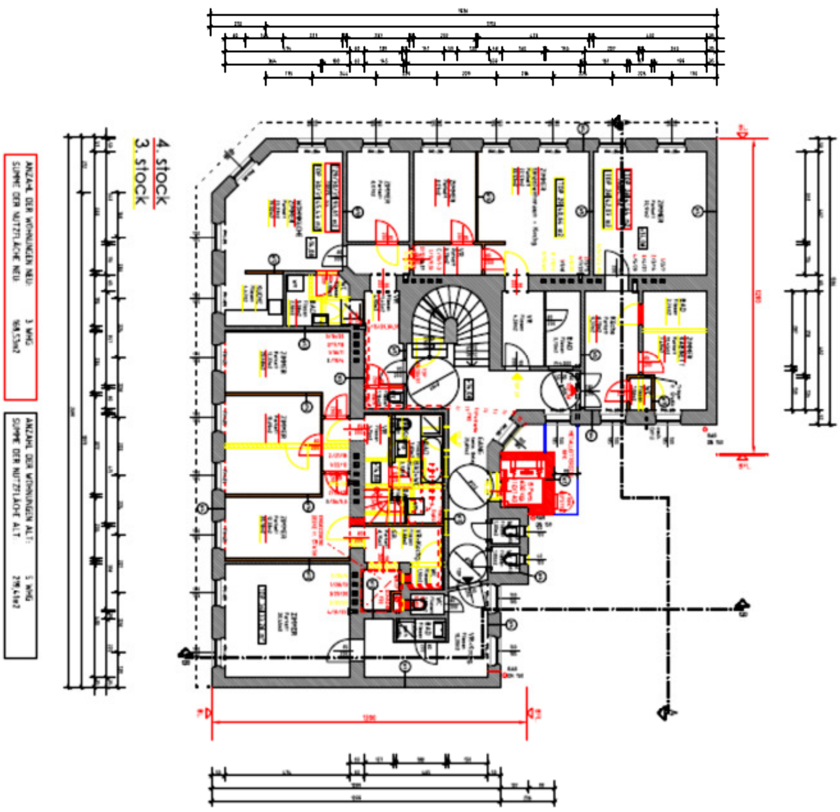
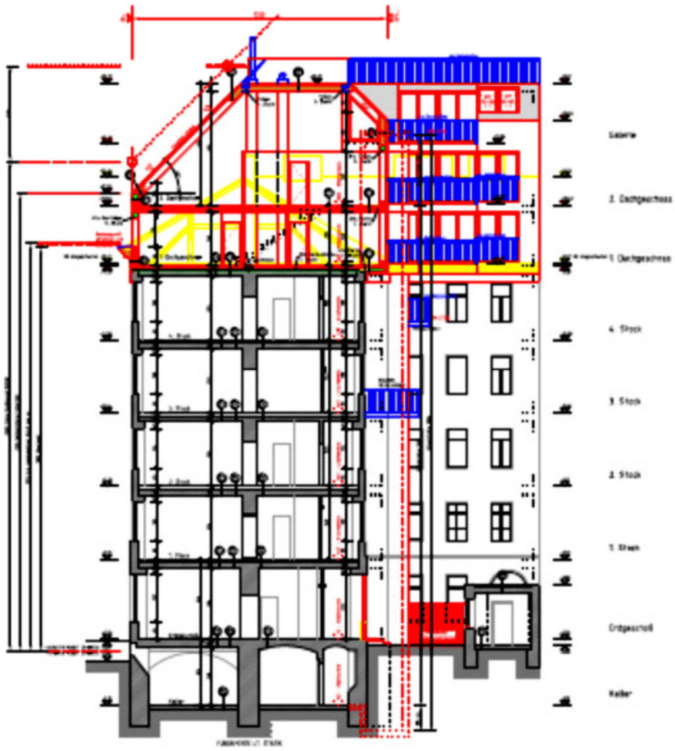


Fig (A.6). The plan of the structure at the 4th floor

SCHNITT A-A

Fig (A.7). The east-west section view of the building



SCHNITT B-B

Fig (A.8). The north-south section view of the building

Appendix II

Program Linear Time History Response Evaluation- Fortran 95

AII.1. Program Structure

```
Program Response_Evaluation

Implicit None

!! This Program is set up to calculate the linear elastic response of a one-dimensional "Mass-Spring" building model due to any arbitrary earthquake record

! for any inquiries, please refer to 'Parmida Boroumand'(Boroumand@vce.at), VCE part-time employee. (3 May 2012)

Real:: DeltaT,Freevib,t, Modalcoef,  Func, Ta, gscale,Ttotal, DEV1, DEV2, DIF1, DIF2

Real,Dimension (:), Allocatable:: MaxDrift, MaxDisp, Mbar, Kbar, Omega, Zeta, IDENV, C, D, Velzerofree, Respzerofree

Real,Dimension (:,:), Allocatable:: Conv, RespDisp, Drift, A, M, Temp1,XT, AT, earthacc

Integer::n,i,j,l,P,ForcedandFreevbsteps, Forcedvibsteps, INT1, INT2, row, column, rowi, coli

Character(20)::Earthquake

Print*, " Welcome to the program Linear Time History Analaysis"

Print*,'Please enter the name of the ground motion'

Read*, Earthquake

Print*, "How many ROWS and COLUMNS does your earthquake file have?"

Read*, Row, column

Print*, 'Please enter the total duration of the ground motion in seconds

Read*, Ttotal

Print*, 'Please enter the time steps in the the ground motion record in seconds'

Read*, DeltaT

Print*, 'The time steps are kept the same for the free and forced vibration phases'

Print*

Print*, 'Please enter the number of the stories, degrees of freedom'

Read*, n

Print*, 'Please enter the total "forced and free vibration duration" as a factor of the total ground motion duration,"n*Td"' !! a better discription, please!

Read*, Freevib

Print*, 'Please enter the scale of the acceleration record'

Read*, gscale

Print*, 'Ttotal/deltaT, Int',Ttotal/deltaT, INT(Ttotal/deltaT)

INT1=INT(Ttotal/deltaT)

INT2=INT(Freevib*Ttotal/deltaT)

DEV1=Ttotal/deltaT

DEV2=Freevib*Ttotal/deltaT
```

```
Dif1=INT1-DEV1

Dif2=INT2-DEV2

if (Dif1<0)   INT1=INT1+1

If (Dif2<0)   INT2=INT2+1

 Forcedvibsteps=INT1+1

ForcedandFreevbsteps=INT2+1

Print*, 'INT1, Forcedvibsteps', INT1, Forcedvibsteps

Print*,'INT2, ForcedandFreevbsteps', INT2, ForcedandFreevbsteps

Allocate(Omega(n))

Allocate(Zeta(n))

Allocate(IDENV(n))

Allocate (A(n,n))

Allocate (M(n,n))

Allocate (AT(n,n))

Allocate (Temp1(n,n))

Allocate (Conv(n,ForcedandFreevbsteps))

Allocate (Kbar(n))

Allocate (Mbar(n))

Allocate (C(n))

Allocate (D(n))

Allocate (RespDisp(n,ForcedandFreevbsteps))

!Allocate (Drift (n,INT(Freevib*Ttotal/deltaT+1)+1))

Allocate (Drift (n,ForcedandFreevbsteps))

Allocate (MaxDisp (n))

Allocate (MaxDrift (n))

Allocate (Respzerofree(n))

Allocate (Velzerofree(n))

Allocate (XT(1,n))
```

```
Allocate (earthacc(row,column))

Open (1,File='Input.txt')

Read (1,*) (OMEGA(i), i=1,n)

Read(1,*) (Zeta(I), I=1,n)

 Do i=1,n

  Read (1,*)(A(i,j), j=1,n)

  IDENV(i)=1

 End Do

 M(:,:)=0

 Do i=1,n

  Read (1,*)M(i,i)

 End Do

  Close (1)

 Open (3,File='Earthquake.txt')

  earthacc(:,:)=0

  Do i=1,row

  Read (3,*)(earthacc(i,j), j=1,column)

 End Do

 Close (3)

AT=TRANSPOSE(A)

Temp1=MATMUL(AT,M)

 Kbar=MATMUL(Temp1,IDENV)

 Mbar=MATMUL(MATMUL(Temp1,A),IDENV)

 !!-----------------------------------------Duhamel Integral, Forced Vib----------------------------------------------

Conv(:,:)=0

  Do l=1,n
 Modalcoef=Kbar(l)/(Mbar(l)*Omega(l)*(1-zeta(l)**2)**(1/2))
   Conv(l,:)=0
```

```
t=0
  Do I=1, Forcedvibsteps

 t=(i-1)*deltat

  Ta=0

 Func=0

  if (t<=Ttotal) then

   Do J=1,i

    Ta=(J-1)*Deltat

  rowi=INT(j/column+1)!! no need for an additional (+1) since all are integers

  if (MOD(j,column)==0) rowi=rowi-1 !May (26) TUW debugging :)

  coli=J-(rowi-1)*column
 Func=gscale*earthacc(rowi,coli)*EXP(-zeta(I)*Omega(I)*(t-Ta))*&
    &sin (Omega(I)*(1-zeta(I)**2)**(1/2)*(t-Ta))*Modalcoef

   if ((Ta==0).OR.(Ta==t)) Func=Func/2
     Conv(I,i)=Conv(I,i)+Func*DeltaT
        End Do
   End If
  End Do
 End Do

!!!!-------------------------------- Free Vib-----------------------!!!!

RespDisp(:,:)=0  !May (24-TUW)

RespDisp= MATMUL(A,Conv)
Respzerofree(:)=RespDisp(:, Forcedvibsteps)

Velzerofree(:)=(RespDisp(:, Forcedvibsteps)-RespDisp(:, Forcedvibsteps-1))/Deltat

Print*, 'Initial Disp Free Vib', Respzerofree(:)

Print*, 'Intial Vel Free Vib', Velzerofree(:)
 Do I=1,n

   XT(1,:)=A(:,I)

    C(I)= (MATMUL(MATMUL(XT,M),Respzerofree))/Mbar(I)

D(I)=(MATMUL(MATMUL(XT,M),Velzerofree)+Mbar(I)*Omega(I)*Zeta(I)*C(I))/(Mbar(I)*Omega(I))

       Do I=Forcedvibsteps+1, ForcedandFreevbsteps
```

```
        t=(i-1)*deltat

         Conv(l,i)=(C(l)*Cos (Omega(l)*(1-zeta(l)**2)**(1/2)*(t-Ttotal))+&
         &D(l)*sin (Omega(l)*(1-zeta(l)**2)**(1/2)*(t-Ttotal)))&
         &*EXP(-zeta(l)*Omega(l)*(t-Ttotal))
  End Do

   End Do

!!------------------------------- total response -----------------------------------------------

 RespDisp= MATMUL(A,Conv)

 Print*, 'That is the anwere for the 30th second response'

 Print*, 'Resp 30s',RespDisp(:, INT(30/deltaT+1)+1)

  Do P=1,n-1

   Drift(P,:)=RespDisp(P,:)-RespDisp(P+1,:)

  End Do

   Drift(n,:)=RespDisp(n,:)
 Do i=1,n
  MaxDisp(i)=RespDisp(i,1)
  MaxDrift(i)=Drift(i,1)

   Do j=1,  ForcedandFreevbsteps

    if (ABS(MaxDisp(i))< ABS(RespDisp(i,j))) MaxDisp(i)=RespDisp(i,j)

    if (ABS(MaxDrift(i))< ABS(Drift(i,j))) MaxDrift(i)=Drift(i,j)
   End Do
 End Do

   Open (2,File='5story Output Elcen Delta(352) 0.05g.txt')
   Write (2,*)'The X-Output for the Ground Motion_',Earthquake
   Write(2,*)
   Write (2,100) MaxDisp
   Write (2,*)
   Write (2,200) ABS(MaxDrift)
   100  Format("The Maximum Displacement Due to Earthquake in 'm'", F10.4)
  200  Format("The Maximum Drift Due to Earthquake in 'm'",F10.4)
   Close (2)

 End Program Response_Evaluation
```

AII.2. Program Verification

In order to verify the accuracy of the set up code in Fortran 95, a couple of examples for both the SDOF and MDOF systems under artificial simplified or real earthquakes were run of which some samples will be presented as follows.

AII.2.1 Single-Degree-Of-Freedom Oscillators

As aforementioned, various SDOF system responses under both the simplified artificial earthquakes and real ones were tested by the set up code. Consequently and for the sake of brevity, the spectral response of the undamped SDOF systems to the longitudinal component of the Near-Field Tabas earthquake 1978, with various frequencies in the $1 - 50\ Hz$ range and the $1\ Hz$ increment step are reproduced below. As observed per Fig.

(A.9), the maximum response of the defined SDOF structure by Fortran 95 linear time history code is quite stable and compatible with those obtained by the commercially available software "Seismosignal"[A1],[A2].

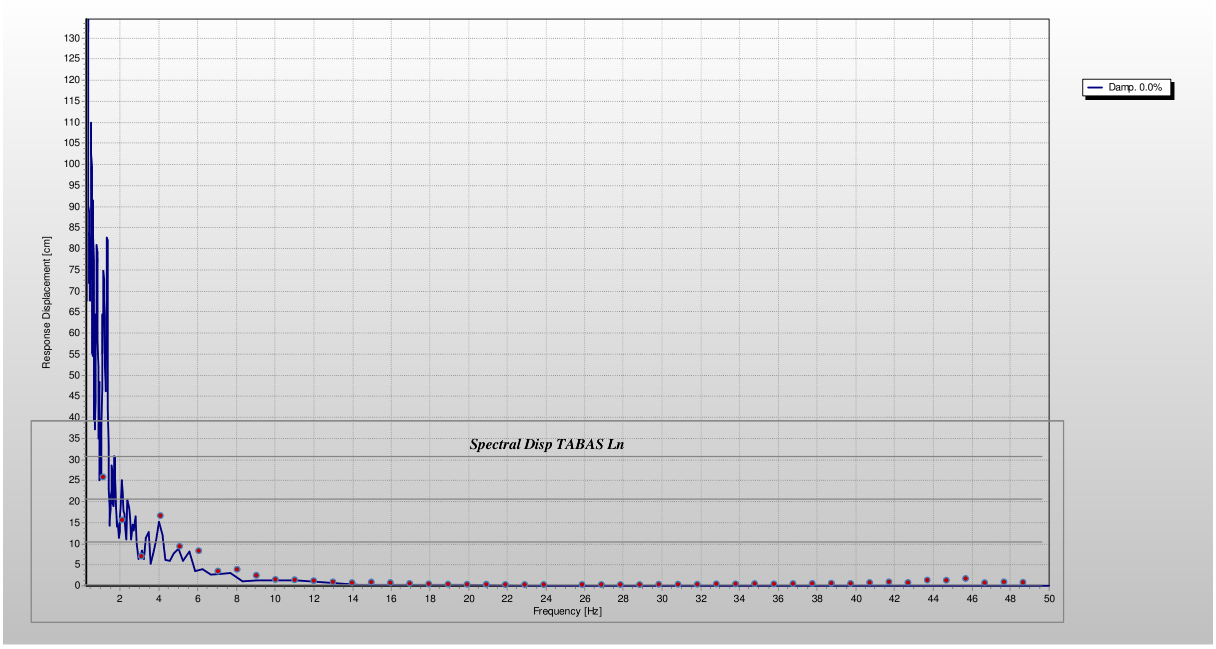


Fig (A.9). Verification of the spectral displacements of the SDOF systems in the frequency domain by set-up Fortran Linear Time History program (red dots) and the commercially available Seismosignal software (blue line) under the longitudinal component of Tabas earthquake 1978[A1],[A2]

AII.2.2. Multi-Degree-Of-Freedom Oscillators

In addition to the SDOF oscillators, the functionality of the set up linear time history code in handling the MDOF systems was also verified by various sample solutions among which, the response comparison of an undamped Two-Story building under constant unit magnitude in the scale of the gravity acceleration, g, in both the forced (t=7 s) and free (t=20 s) phases of vibrations is reproduced below. As notice per Table (A.1), the numerical analysis results match the closed form analytical solution accurately enough.

Table (A.1). The two-DOF response comparison

DOF	Mass	Stiffness	Angular Frequencies	Mode#1	Mode#2	Fortran Response t=7 (s)	Closed Form Response t=7 (s)	Fortran Response t=20 (s)	Closed Form Response t=20 (s)	Remarks
1	1	1	0.62	1	1	1.7	1.71	0.092	0.092	OK
2	1	1	1.61	1.62	-0.62	2.51	2.5	-0.0211	-0.021	OK

AII.3. Appendix (II) List of References

[A1]. Silverfrost FTN95: "Fortran for Windows", http://www.silverfrost.com/default.aspx
[A2]. SeismoSignal v4.3.0, SeismoSoft Ltd, 2011, http://www.seismosoft.com/en/HomePage.aspx

Annex B. List of Dissemination Activities (with NERA relevance)

LIST OF DISSEMINATION ACTIVITIES								
No	**Type of Activities (15)**	**Main Leader**	**Title**	**Date**	**Place**	**Type of Audience (16)**	**Size of Audience**	**Countries Addressed**
01	Workshop	VCE Holding GmbH	International Collaboration	26/11/2010	Taipei, Taiwan	Scientific community (higher education, Research) - Industry	60	International
02	Workshop	VCE Holding GmbH	Mini-workshop on IRIS and related technologies	02/12/2010	BARC, Mumbai, India	Scientific community (higher education, Research) - Industry	80	India, EU
03	Presentation	VCE Holding GmbH	International 202 Bridge Study	26/01/2011	TRB Washington, U.S.A	Scientific community (higher education, Research) - Industry	5600	International
04	Presentation	VCE Holding GmbH	Vision 2020	15/02/2011	Purdue University U.S.A.	Scientific community (higher education,	80	International

						Research) - Industry		
05	Presentation	VCE Holding GmbH	MAEviz for the Hungarian Demonstration	16/02/2011	University of Illinois Urbana Champaign U.S.A.	Scientific community (higher education, Research) - Industry	80	International
06	Conference	VCE Holding GmbH	IMAC Conference + University of Boston visit	01/02/2011	Boston, USA	Scientific community (higher education, Research)	811	International
07	Conference	VCE Holding GmbH	ETPIS General Assembly	11/03/2011	Brussels, Belgium	Scientific community (higher education, Research) - Industry	39	EU countries
08	Conference	VCE Holding GmbH	Application of the IRIS-Lifecycle-methodology Russia	16/03/2011	Geodynamica Moscow, Russia	Scientific community (higher education, Research) - Industry	15	Russia, Germany, Austria
09	Conference	UNIGE	IASS 2010 Conference	8/11/2010 – 12/11/2010	Tongji University, Shanghai, China	Scientific community (higher education, Research) - Industry	500	International
10	Conference	UNIGE	SMAR 2011 Conference	08-10/02/2011	American University, Dubai, UAE	Scientific community (higher	100	International

						education, Research) - Industry		
11	Conference	UNIGE	Smart Structures/NDE 2011	07-10/03/2011	San Diego, USA	Scientific community (higher education, Research) - Industry	700	International
12	Conference	JKU Linz	12th International Conference on Information Integration and Web Based Applications & Services	09/11/2010	Paris, France	Scientific community (higher education, Research)	300	International
13	Conference	JKU	13th International Conference on Computer Aided Systems Theory - Eurocast 2011	06 - 11/02/2011	Las Palmas, Spain	Scientific community (higher education, Research)	112	International
14	Conference	JKU	EUROCAST 2011	07 - 11/02/2011	Las Palmas, Spain	Scientific community (higher education, Research)	112	International
15	Conference	KUL	11th International Conference on Applications of Statistics and Probability in Civil Engineering (ICASP)	01-05/08/2011	Zurich, Switzerland	Scientific community (higher education, Research)	350	International
16	Conference	KUL	EURODYN 2011	04 - 06/07/2011	Leuven, Belgium	Scientific community (higher education,	approx. 600	International

						Research)		
17	Conference	VCE	3. RESA Workshop http://resaweb.dlr.de/index.php?id=330	23/-24/03/ 2011	Neustrelitz, Germany	Scientific community (higher education, Research	100	Germany
18	Conference	VCE	Gi4DM- Geo-Information for Disaster Management http://www.gi4dm2011.org/?page=conference	03 - 08/05/2011	Antalya, Turkey	Scientific community (higher education, Research	300	International
19	Conference	USFD	SPIE NDE2011	06-10/03/ 2011	San Diego	Scientific community (higher education, Research)	200 (estd.)	International
20	Thesis, Web	JKU	J. Kopecký, K. Matoušek (supervisor): Semantic Web-Based Content Management System (available online)	30/06/2011	Prague, Czech Republic	Scientific community (higher education, Research)	Available online	International
21	Conference, Workshop	JKU	DEXA Workshop on Information Systems for Situation Awareness and Situation Management (ISSASiM 2011) in conjunction with 22nd Int. Conference on Database and Expert Systems Applications (DEXA 2011)	29/08 – 02/09/2011	AC	Scientific community (higher education, Research)	214	International

22	Conference	VCE	Stanford SHM Workshop	10 - 14/09/2011	Stanford	Scientific community (higher education, Research)	1000	International
23	Conference	VCE	IOMAC	09-11/05/ 2011	Istanbul, Turkey	Scientific community (higher education, Research)	500	International
24	Conference	AiT	2nd International Symposium on Computational Geomechanics	27-29/04/2011	Dubrovnik, Croatia	Scientific community (higher education, Research)	120	International
25	Conference	AiT	3rd International Symposium on Geotechnical Safety and Risk	02-03/06/2011	Munich, Germany	Scientific community (higher education, Research)	150	International
26	Workshop	JKU Linz	ITACET Foundation, Training Session, Software Application in Tunnelling	14/07/2011	Hagenberg, Austria	Scientific community + Companies	40	International
27	Workshops	JKU Linz	1st Workshop on Information Systems for Situation Awareness and Situation Management	31/08/2011	Toulouse, France	Scientific community (higher education, Research)	30	International

28	Conference	JKU Linz	13th International Conference on Computer Aided Systems Theory	10/02/2011	Las Palmas, Gran Canaria, Spain	Scientific community (higher education, Research)	150	International
29	Workshops	JKU Linz	8th International Workshop for Structural Health Monitoring	13/09/2011	Stanford, US	Scientific community (higher education, Research)	400	International
30	Conference	VCE	SMIRT 2011, PostSMIRT	11/2011	Mumbay, India	Scientific community (higher education, Research	50	International
31	Conference	ETHZ	European Geosciences Union EGU – 2011	03 – 07/04/2011	Vienna, Austria.	Scientific Community (higher education, Research)	700	International
32	Conference	AUTH	III ECOMAS Thematic Conference in Computational Methods in Structural Dynamics and Earthquake Engineering (COMPDYN 2011)	26-28/05/2011	Corfu, Greece	Scientific community (higher education, Research)	220	International

33	Conference	AUTH	International Offshore (Ocean) and Polar Engineering Conference, ISOPE	19-24/06/2011	Maui, Hawaii, USA	Scientific community (higher education, Research)	1000	International
34	Conference	AUTH	International Conference on Construction in the 21st Century (CITC-VI) “Construction Challenges in the New Decade”	05-07/07/2011	Kuala Lumpur, Malaysia	Scientific community (higher education, Research), Industry, Policy makers	150	International
35	Conference	VCE	iNTeg-Risk conference	07-09/06/2011	Stuttgart, Germany	Scientific community (higher education, Research) - Industry	180	Germany, Austria
36	Workshop	VCE	International Bridge Study Workshop	14-15/06/2011	Rutgers University, USA	Scientific community (higher education, Research, Industry	40	USA, Austria
37	Conference	VCE	Eurodyn 2011	04-06/07/2011	Leuven, Belgium	Scientific community (higher	600	International

						education, Research)		
38	Conference	VCE	IWSHM 2011 workshop	13 - 15/09/2011	Stanford, USA	Scientific community (higher education, Research)	600	International
39	Seminar	VCE	Seminar on advances in seismic design of structures, systems and components of nuclear facilities	14-15/11/2011	Mumbai, India	Scientific community (higher education, Research)	100	International
40	Conference	VCE	SHMII Conference	11-15/12/2011	Cancun	Scientific community (higher education, Research)	30	International
41	Workshop	VCE	Fifth United Nations International UN-SPIDER Bonn Workshop on Disaster Management and Space Technology: "Strengthening global synergies through knowledge management, portals and networks". http://www.un-spider.org/workshop-bonn-2012	24. – 26. 04.2012	UN-Campus Bonn, Germany	Scientific community (higher education, Research	120	International

42	Conference	BAGF/VCE	IGARSS IEEE Geoscience and Remote Sensing Society http://www.igarss12.org/Welcome.asp	22.-27.07. 2012	Munich, Germany	Scientific community (higher education, Research)	>1200	International
43	Conference	BAGF/VCE	5th International Tsunami Symposium, Tsunami Society International	03.-05.09. 2012	JRC, Ispra, Italy	Scientific community (higher education, Research)	100	International
44	Conference	AUTH	2nd International Conference on Web Intelligence, Mining and Semantics (WIMS'12)	13–15/6 2012	Craiova, Romania	Scientific community (higher education, Research)	200	International
45	Conference	AUTH	22nd International Offshore and Polar Engineering Conference	17–22/6 2012	Rhodes (Rodos), Greece	Scientific community (higher education, Research)	1000	International
46	Conference	BAGF	The International Symposium of GIS users, Taza GIS_Days https://sites.google.com/a/usmba.ac.ma/taza-gis-en/	23.05.-24.05.2012	Taza, Morocco	Scientific community (higher education, Research	100	International

Annex C. List of Publications

Wide international publication has been a primary target in the NERA project. It is evident that industrial safety and the technologies to be developed are applicable worldwide. The establishment of a European dominated lead market has been targeted.

Over 280 international publications with reference to the NERA project have been counted during the project period. A comprehensive list of these presentations is given in enclosed chapters. The activities are also documented in minutes of meetings issued by the scientists performing the presentations at the conferences.
A copy of the papers is available at the IRIS database. Where copyrights are available the papers are offered for free download. Otherwise they can be requested from the respective publishers.

Nº	Title	Main Author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Date of publication	Relevant pages	Permanent identifiers (if available)	Open access is/will be provided to this publication
1	Conditional simulation for characterising the spatial variability of sand state	A.P. van den Eijnden	MSc thesis	2010	Delft University of Technology	Delft, Netherlands	16/12/2010	All		Yes
2	Set-Up of a Combined Indoor and Outdoor Positioning Solution and Experimental Results	L. Johannes, J. Degener and W. Niemeier	Proceedings of the International Conference on Indoor Positioning and Indoor Navigation (IPIN)	2010	IEEE Xplore, 971 p., Eds: Mautz, R., Kunz, M., and Ingensand, H	ZURICH, SWITZERLAND	29/11/2010	all	ISBN: 978-1-4244-5864-6, DOI: 10.1109/IPIN.2010.5648185	Yes
3	SYSTEM IDENTIFICATION UNDER DIFFERENT AMBIENT EXCITATIONS	M. Döhler, D. Siringoringo, L. Mevel	APWSHM			Tokyo, Japan	01/12/2010	all		No
4	Vibration-based Damage Detection to the Composite Tank Filled with Fluid	Wensong Zhou, Zhanjun Wu and Laurent Mevel	Structural Health Monitoring	Vol 9(5)			11/07/2011	433-445		No

5	Risk Assessment and Sensitivity Analysis for Offshore Wind Turbines	Alexandros A. Taflanidis, Eva Loukogeorgaki and Demos C. Angelides	Proceedings of the 21st International Offshore and Polar Engineering Conference	19.-24.06.2011	International Society of Offshore and Polar Engineers (ISOPE)	Maui, Hawaii, USA,	24/06/2011	pp. 479-486	http://www.isope.org/publications/proceedings/ISOPE/ISOPE%202011/data/papers/11TPC-895Taflan.pdf	Yes
6	Risk-Based Decision Making for Resilient Systems	Yiannis Xenidis, Alkisti S. Skiadopoulou and Demos C. Angelides	Proceedings of the Computational Methods in Structural Dynamics and Earthquake Engineering (COMPDYN) Conference	26.-28.05.2011	National Technical University of Athens, Greece	Corfu, Greece	28/05/2011	e-proceedings (no page numbering)		No
7	Automated Risk Assessment in Construction: Combining Novel Concepts with Cutting Edge Technologies	Yiannis Xenidis, Pavlos Tamvakis	Proceedings of the Sixth International Conference on Construction in the 21st Century (CITC-VI)	05.-07.07.2011	CITC-VI, Greenville, North Carolina, USA	Kuala Lumpur, Malaysia	07/07/2011	pp. 804-811		No
8	Remote Sensing and GIS Contribution to Earthquake Disaster Preparedness in Hungary	THEILEN-WILLIGE,B. and WENZEL,H.	Proceedings: GeoInformation for Disaster Managment Gi4DM,03-08.05.2011		ISPRS	Antalya	07/05/2011	OP62	http://www.isprs.org/proceedings/XXXVIII/Gi4DM/CDDATA/sessions.html	Yes

9	Earthquake Emergency Preparedness in Central-Hungary - Preparing rapid response measurements using remote sensing and GIS-methods.	B.THEILEN-WILLIGE and H.WENZEL	Proceedings of UN SPIDER Workshop, 12.-14.10.2010, Bonn		United Nations, UNOOSA, UN-SPIDER Knowledge Portal	Bonn	15/04/2011		http://www.un-spider.org/book/5142/4c-challenge-communication-coordination-cooperation-capacity-development	Yes
10	Local site conditions influencing earthquake intensities and secondary effects in the Sea of Marmara region -	PARARAS-CARAYANNI, G.,THEILEN-WILLIGE,B. and WENZEL,H.	Science of Tsunami Hazards	Vol. 30, No. 1			01/03/2011	63-77	ISSN 8755-6839, http://tsunamisociety.org/301GpcTheilen.pdf	Yes

Annex D. Database

A large collection of earthquake data in world has been accumulated to be used avoiding earthquake disasters. Enormous quantity of data, which increases with time, contains information of relevance in scientific und economical domain.

The Database in the NERA project serves for better communication and cooperation among institutions. It includes data sets of information about organizations and end-users who are interested in the fight against earthquake disasters.

Communication among research centers and institutions in the Database will enable the technology transfer and implementation of knowledge in seismological and engineering infrastructure and research communities. There is a big demand for integration and communication tools in this process. Therefore an interaction between networks and seismological service centers in Europe and world-wide is very important. Businesses (such as financial institutes, manufacturing operations and logistics), transportations, universities, government, etc. depend on networks of seismological centers as part of their processes. The Database contents also the names of companies operating in industry because the cooperation between research infrastructures and economy sector is of a huge importance.

Database is created manually from different federal and public websites and its users can download the required information. Because the effects of an earthquake are so varied, scenario developers need to plan to communicate to a wide audience (the planners and builders, policy makers, residents and emergency responders). The Database area extends across Europe, Asia, USA, Africa and Australia and the size of data that can be obtained in internet is very large.

The Database is international and can be useful to all organizations that operate observation networks or have strong databases, to academic institutions and researches, to government agencies that use data, and to organizations and individuals engaged in earthquake safety practice.

Table 3: Database of European institutions in seismology and earth science

Nm	Institution	City/ Country		Internet Homepage	Contact person	Contact details
1	Eidgenössische Technische Hochschule Zürich ETHZ	Zürich Switzerland		www.ethz.ch	Prof.Domenico Giardini	41446332610 giardini@sed.ethz.ch
2	Aristotelio Panepistimio Thessalonikis AUTH	Thessaloniki Greece		www.auth.gr	Prof. Kyriazis Pitilakis	30231099563 30231099582 kpitilak@civil.auth.gr
3	Bureau de	Orleans		www.brgm.fr	Francois	33(0)2386433

	Recherches Geologiques et Minieres BRGM	Cedex 2 France			Demarcq	82 f.demarcq@brgm.fr
4	Commission of the European Communities - Directorate General Joint Research Centre - JRC	Brussels Belgium		http://www.jrc.ec.europa.eu	Dr. Stephan Lechner	39033278678 39033278997 Stephan.lechner@ec.europa.eu
5	Stiftelsen Norges Geotekniskeinstitutt, NGI	Oslo Norway		www.ngi.no	Knut Henry Andersen	47-22023035 kha@ngi.no
6	Universita Degli Studi di Pavia UPAV	Pavia Italy		www.unipv.it	Prof. Angiolino Stella	390382984202 rettore@unipv.it
7	Universita Degli Studi di Roma la Sapienza, UROMA	Roam Italy		www.uniroma1.it	Prof. Renato Masiani	390644585322 390649919178 Renato.masiani@uniroma1.it
8	Middle East Technical University METU	Ankara Turkey		http://www.metu.edu.tr	Gulkan Polat	903122102446 903122101324 pgulkan@ce.metu.edu.tr
9	AMRA-Analisi e Minitoraggio del R Ischio Ambietale Scarl	Naples Italy		http://www.amracenter.com/en/index.html	Prof. Paolo Gasparini	390817685125 390817685125 Paolo.gasparini@na.infn.it
10	Universitaet Karlsruhe (Technische Hochschule) CEDIM	Karlsruhe Germany		www.uni-karlruhe.de www.kit.edu	Prof. Friedemann Wenzel	497216084431 friedemann.wenzel@gpi.uni-karlsruhe.de
11	University of Patras UPAT	Patras Greece		www.upatras.gr	Prof. Vassilios Anastassopoulos	302610996606 vrector_res@upatras.gr
12	Willis Limited	London United Kingdom		http://www.willis.com/	James Vickers	4402031248182 4402031246258 VICKERSJ@WILLIS.COM
13	Universita Degli Studi di	Padova Italy		www.unipd.it	Francesca da Porto	39 498275631 daporto@dic.u

	Padova UNIPD					nipd.it
14	Bundesanstalt fuer Materialforschung und - Pruefung BAM	Berlin Germany		www.bam.de		49 308112029 info@bam.de
15	Ustav teoreticke aplikovane mechaniky, akademie ved Ceske Republiky verejna vyzkumna instituce ITAM	Prague Czech Republik		www.itam.cas.cz	Prof. Drdácký Miloš*	420286882121 420286885382* Drdacky@ITAM.CAS.CZ* itam@itam.cas.cz
16	National Technical Institute of Athens, NTUA	Athens Greece		www.civil.ntua.gr	Prof. George Bouckovalas	302107723780 gbouck@central.ntua.gr
17	Politecnico di Milano POLIMI	Milan Italy		www.polimi.it http://www.best.polimi.it/	Prof. Emilio Pizzi	39 223996011 emilio.pizzi@polimi.it
18	Universidade do Minho UMINHO	Braga, Guimarães Portugal		www.civil.uminho.pt/masonry	Paulo B. Lourenço	pbl@civi.luminho.pt
19	Universitat Universitat Politecnica de Catalunya, UPC	Spain		www.upc.edu		
20	University of Bath UBATH	Bath United Kingdom		www.bath.ac.uk	Dr. Paul Allen	441225386644 (5246) P.Allen(@bath.ac.uk
21	Gazi University GUNI	Ankara Turkey		www.gazi.edu.tr	Prof.Dr. Bilal Toklu*	903122023701* fenbil@gazi.edu.tr
22	Bozza Legnami S.r.l. BOZZA	Bozza Italy		www.bozzalegnami.it		049629699 info@bozzalegnami.it
23	CINTEC International Ltd CINTEC	Newport, South Wales, United Kingdom		www.cintec.com		044(0)1633246614 solutions@cintec.com
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	Environment Institute of Geophysics and Tectonics					
260	Universität Leipzig Institut für Geophysik und Geologie (IGG) Geophysik	Leipzig Germany		http://www.uni-leipzig.de/~geo/geophysik/index.html	Prof. Dr. M. Korn	49(0)341/973 2803 mikorn@rz.uni-leipzig.de
261	Departamento de Fisica de la Tierra, Astronomia Y Astrofisica I, Geofisica Y Meteorologia	Madrid Spain		http://www.ucm.es/info/Geofis/Cursos.html	Dolores Muñoz Sobrino	domuso@fis.ucm.es
262	School Earth Atmospheric and Environmental Sciences University of Manchester	Manchester UK		http://www.seaes.manchester.ac.uk/undergraduate/courses/	Dr. Neil Mitchell	44(0)1612750779 neil.mitchell@manchester.ac.uk
263	Istituto di Scienze della Terra Laboratorio di Cartografia numerica e di Rischio Sismico, Vulcanico e di Frane	Messina Italy		http://ww2.unime.it/scienze-terra/cartogra.htm	Prof. Riccardo Rasà	39090(676)5226 rrasa@.unime.it
264	Dipartimento di Scienze della Terra "Ardito Desio" Sezione di Geofisica	Milano Italy		http://www.unimi.it/chiedove/schedaStrutturaXML.jsp?codice=693	Prof. Mauro Giudici	390250318478 mauro.giudici@unimi.it
265	Facultät für Geowissenschaften Ludwig-Maximilians Universität München Sektion Geophysik	Munich Germany		http://www.geo.uni-muenchen.de/depearthenv/geophys/index.html	Prof. Dr. Hans-Peter Bunge	49(0)89 / 2180 - 4225 bunge@lmu.de
266	Westfälische Wilhelms-Universität Münster Institut für Geophysik	Münster Germany		http://www.uni-muenster.de/Physik.GP/Seismologie/index.html	Prof. Dr. Christine Thomas	492518333591 tine@earth.uni-muenster.de

	Seismologie					
267	Dipartimento di scienze della terra - Universitá di Napoli Federico II Sismica	Naples Italy		http://www.dst.unina.it/en/research/sismica-appl-alle-vs	Prof. Vincenzo Morra	390812538115 vimorra@unina.it
268	Geosciences Azur Laboratoire CNRS-UNSA-PARIS VI-IRD (Université de Nice)	Nice France		http://geoazur.oca.eu/?lang=en	Guust Nolet	33(0)492942632 nolet@geoazur.unice.fr
269	Oxford University Earth Sciences Department Tectonics, volcanoes and hazards	Oxford UK		http://www.earth.ox.ac.uk/research/groups/seismology http://comet.nerc.ac.uk/	Prof. Barry Parsons	44(1865)272017 barry.parsons@earth.ox.ac.uk
270	Departament de Ciències de la Terra Universitat de les Illes Balears	Palma Illes Balears Spain		http://www.uib.es/lauib/Estructura/Departaments/dct/	Petrus Bey, Juana María Gelabert Ferrer, Bernadí*	(34)9713443 (34)9712370* joana.petrus@uib.es vdctbgf0@clust.uib.es
271	University of Parma Dipartment of Earth Science	Parma Italy		http://www.unipr.it/arpa/dipgeo/ENGLISH.html	Prof. Luigi Torelli	390521905319 luigi.torelli@unipr.it
272	Università degli Studi di Perugia Dipartimento di Scienze della Terra Gruppo di Geologia Strutturale e Geofisica GSG	Perugia Italy		http://www.unipg.it/~gpialli/Inglese/index.htm	Pauselli Cristina	390755867177 pauselli@unipg.it
273	Universita di Pisa	Pisa Italy		http://www.dst.unipi.it/gea/index.php?option=com_content&task=view&id=38&Itemid=50	Prof. Alfredo Mazzotti	050-2215779 mazzuoli@dst.unipi.it
274	University of Plymouth Centre for Research in Earth	Plymouth UK		http://www.plymouth.ac.uk/pages/view.asp?page=28220	Dr. Graeme Taylor	44(0)1752584770 G.Taylor@plymouth.ac.uk

	Sciences Department of Geological Sciences					
275	University of Portsmouth Earth and Environmental Sciences (SEES) Geological Hazards	Portsmouth UK		http://www.port.ac.uk/courses/coursetypes/undergraduate/BScHonsGeologicalHazards/	Dr. Rob Strachan	rob.strachan@port.ac.uk
276	Observatoire des Sciences de Rennes Universe Systèmes tectoniques	Rennes France		http://translate.google.com/translate?u=http://osur.univ-rennes1.fr/page.php?43&langpair=fr|en&hl=fr&ie=utf-8&oe=utf-8	Pierre Gautier*	33(0)223235222 pierre.gautier@univ-rennes1.fr*
277	Universitá si Siena Dipartimento di Scienze della Terra Geofisica	Siena Italy		http://www.dst.unisi.it/geofisica/WEB_ing/geo0i.htm	Prof. Enzo Mantovani	390577233819 mantovani@unisi.it
278	Bulgarian Academy of Science Geological Institute The Department of Geological Hazards	Sofia Bulgaria		http://www.geology.bas.bg/igd/geohaz.html	Prof. Dr. Nikolai Dobrev	35929792292 ndd@geology.bas.bg
279	University of Southampton National Ocesnography Centre	Southampton UK		http://www.noc.soton.ac.uk/gg/index.php	Dr Tim Henstock° Prof. Ian Wright*	44(0)2380596491° iw2s07@noc.soton.ac.uk*
280	École et Observatoire des Sciences de la Terre (EOST) L'Institut de Physique du Globe de Strasbourg Sismologie	Strasbourg France		http://eost.u-strasbg.fr/IPGS/Eq_Sismologie/index_SI.php	BANO Maksim	33(0)368850080 Maksim.Bano@eost.u-strasbg.fr
281	Université Paul Sabatier Laboratoire d'Etudes en Géophysique et	Toulouse France		http://www.ird.fr/la-recherche/unites-de-recherche/082-geosciences-	Guust Nolet Didier Brunel	nolet@geoazur.unice.fr brunel@geoazur.unice.fr

	Océanographie Spatiales, Département Environnement et Ressources, Géosciences Azur - (GÉOAZUR)			azur http://geoazur.oca.eu/?lang=en		
282	NTNU-Trondheim Norwegian University of Science and tTechnology	Trondheim Norway		http://www.ntnu.edu/ipt/research http://www.ipt.ntnu.no/rose/	Prof. Martin Landrø	martin.landro@ntnu.no
283	Faculty of Engineering of the University of Udine Dipartimento di Georisorse e Territorio	Udine Italy		http://udgtls.dgt.uniud.it/seismol/default.htm	Roberto Carniel* Marcello Riuscettiº	390432/558749* 39/432/558730º roberto.carniel@uniud.it riuscetti@dgt.uniud.it
284	Hungarian Academy of Sciences Geodetical and Geophysical Research Institute	Sopron Hungary		http://www2.mta.hu/index.php?id=747	Dr. A. Adamº Péter Varga*	3612482321* adam@ggki.huº varga@seismology.hu*
285	British Geological Survey	Keyworth Nottingham UK		http://www.bgs.ac.uk/research/earth_hazards.html	Dr Katherine Royse	44(0)1159363456
286	Geosystem srl	Milan Italy		http://www.geosystem.net/		390226684079
287	Centre national de la recherche scientifique - CNRS	Paris France		http://www.cnrs.fr/index.php	Christian Huber	christian.huber@cnrs-dir.fr
288	Centro Europeo di Formazione e Ricerca in Ingegneria Sismica - EUCENTRE	Pavia Italy		http://www.eucentre.it/	Barbara Borzi	390382516911 barbara.borzi@eucentre.it
289	Bogazici Universitesi, Kandilli Observatory and Earthquake Research	Istanbul Turkey		http://www.koeri.boun.edu.tr/eng/topeng.htm	Prof. Erdal Safak	902165163308 erdal.safak@boun.edu.tr

	Institute - KOERI					
290	Österreichisches Forschungs- und Prüfzentrum Arsenal Ges. M.B.H.	Vienna Austria		http://www.ait.ac.at/	Dr. Brigitte Bach	43(0)505506612 brigitte.bach@ait.ac.at
291	Vedurstofa Islands (Icelandic Met Office) - IMO	Reykjavík Iceland		http://en.vedur.is/about-imo/mission/	Sigrún Karlsdóttir	sigk@vedur.is
292	Natural Environment Research Council NERC-BGS	Swindon UK		http://www.nerc.ac.uk/	Zena Davis (Secretary)	4401793442614 zk@nerc.ac.uk
293	Fundacao da Faculdade de Ciecias da Universidade de Lisboa - FFCUL	Lisbon Portugal		http://www.fc.ul.pt/ http://www.idl.ul.pt/english/	Carlos Corela	ccorela@fc.ul.pt
294	Katholieke Universiteit Leuven	Leuven Belgium		http://ees.kuleuven.be/geology/index.html	Prof. Manuel Sintubin	32 16 326447 Manuel.Sintubin@ees.kuleuven.be
295	Universität Linz - JKU	Linz Austria		http://www.jku.at/content	Prof. Dr. Gabriele Kotsis	43(0)7322468-3391 gabriele.kotsis@jku.ac.at
296	Cambridge Architectural Reserch Limited CAR	Cambridge UK		http://www.carl.co.uk/disastermanagement.htm	Antonios Pomonis	antonios.pomonis@carltd.com
297	Petroleum Geo-Services	Lysaker Norway		http://www.pgs.com/Geophysical-Services/Seismic-processing/	Bård Stenberg*	4767514316* 4799245235* ir@pgs.com
298	Institute of Geophysics Polish Academy of Sciences	Warsaw Poland		http://www.igf.edu.pl/en/zaklady_naukowe/sejsmologii_i_fizyki_wnetrza_ziemi	Prof. Stanisław Lasocki	48 784420666 lasocki@igf.edu.pl
299	International Association for Bridge Maintenance and Safety - IABMAS	Guimaraes Portugal		http://www.iabmas.org/	Prof. Paulo J. S. Cruz	351253510504 pcruz@arquitectura.uminho.pt
300	International Association for Life -	Milan Italy		http://www.ialcce.org	Prof. Fabio Biondini	biondini@stru.polimi.it

	Cycle Civil Engineering - IALCCE					
301	GEOSCOPE Data Centre of IPGP	Paris France		http://geoscope.ipgp.fr/	Prof. Eléonore Stutzmann	33183957480 stutz@ipgp.fr
302	European Seismological Commission (ESC)			http://www.esc-web.org/	M. M. Garcia	mgarcia@mncn.csic.es

Table 4: Database of institutions in seismology and earth science in USA

Nm	Institution	City/ Country		Internet Homepage	Contact person	Contact details
1	The Board of Trustees of the University of Illinois	Champaign, Illinois United States		http://www2.ntia.doc.gov/grantees/UniversityofIllinois	Walter Knorr	217 333-2187 gcoaward@uillinois.edu
2	The Incorporated Research Institutions for Seismology IRIS	United States		http://www.iris.edu/hq/	Leslie Linn	(202)6822220 leslie@iris.edu
3	U.S. Geological Survey USGS	United States		http://earthquake.usgs.gov/	Jill McCarthy	3032738500
4	National Earthquake Information Centre NEIC	Illinois United States		http://earthquake.usgs.gov/regional/neic/	Jill McCarthy	(303)2738579
5	The Geological Survey of Canada, Department of Natural Resources	Canada		http://gsc.nrcan.gc.ca/index_e.php	Dr. Kelin Wang* Philippe Mailhot	12503636429 * 514 496 1622 Kelin.Wang@nrcan-rncan.gc.ca Philippe.Mailhot@NRCan-RNCan.gc.ca
6	Incorporated Research Institutions for Seismology	Washington USA		http://www.iris.edu/hq/about_iris/governance/ds	Olga Cabello (Dir.of intern. Developm. Seism.)	202-682-2220 ext. 121*
7	Institute of Geophysics, National University of Mexico	Mexico		http://www.geofisica.unam.mx/indexi.php	Arturo Baltazar Cárdenas Ramírez Casiano Cruz Jimenez	562 24100 ext 27 arturo@ssn.ssn.unam.mx 56-22-41-00 casiano@ollin.

						geofisica.unam.mx
8	California Institute of Technology	USA		http://www.caltech.edu/static/	Rayomand (Rayo) Bhadhaº Jean-Philippe Avouac* (Dir.Tectonic.Observ.)	626-3952407º avouac@gps.caltech.edu*
9	University of the West Indies	Jamaica		http://www.mona.uwi.edu/	Dr. Allister Hinds	allister.hinds@uwimona.edu.jm
10	Red Sismica de Puerto Rico	Puerto Rico		http://redsismica.uprm.edu/english/	Dr. Víctor A. Huérfano Moreno (Dir.) Prof. Guoquan Wang	victor@prsn.uprm.edu gwang@prsn.uprm.edu
11	University of Texas at Austin Institute for Geophysics	Texas USA		http://www.utexas.edu/ http://www.jsg.utexas.edu/people/	Dr. Cliff Frohlich (Assoc. Dir.)* Prof. Mrinal K. Senº	5124710460* cliff at ig.utexas.edu 512-4710466º mrinal@ig.utexas.edu
12	New Zealand Geonet	Lower Hut New Zealand		http://www.geonet.org.nz/index.html	Pilar Villamor	64 4 570 4875 P.Villamor
13	Redwood City Public Seismic Network	California USA		http://psn.quake.net/	Larry Cochrane	lcochrane@webtronics.com
14	Institute of Geological&Nuclear Sciences Ltd. Gracefield Research Centre	New Zealand		http://www.preventionweb.net/english/professional/contacts/v.php?id=1055	Dr. David Rhoades	d.rhoades@gns.cri.nz
15	Public Seismic Network	Alaska		http://wulik.com/		
16	National Earthquake Information Centre NEIC	Denver USA		http://earthquake.usgs.gov/regional/neic/	Dr. Stuart Sipkin	13032738415 sipkin@usgs.gov
17	National Geophysical Data Centre NGDC	Broadway USA		http://www.ngdc.noaa.gov/hazard/	Dr. Christopher G. Fox	(303)4976215 Christopher.G.Fox@noaa.gov
18	IASPEI, Facultad de Ciencias Astronómicas y Geofísicas Universidad Nacional de	Argentina		http://school2011.fcaglp.unlp.edu.ar/	Nora Cristina Sabbione	54110221 423 6593 /4 nora@fcaglp.unlp.edu.ar

	la La Plata					
19	IASPEI	Bolivia			MSc Estela Minaya	oscdrake@entelnet.bo
20	IASPEI, Inst. Astronomy, Geophysics, Atmospheric Sciences University of Sao Paulo	Sao Paulo Brazil		http://www.iag.usp.br/geofisica/grad_disciplinas.php	Marcelo Sousa de Assumpcão	551130914755 marcelo@iag.usp.br
21	IASPEI, Departamento de Geofísica Universidad de Chile	Santiago Chile		http://www.dgf.uchile.cl/index.php?i=en	Diana Comte	56 2 978 4568 dcomte@dgf.uchile.cl
22	Universidad Nacional de Colombia Departamento de Geociencias Ciudad Universitaria	Colombia		http://www.geociencias.unal.edu.co/?itpad=0&niv=0&itact=421&ti=false&dep=12	Carlos Vargas	57 1 316 5000 ext.16506/14/25 cavargasj@unal.edu.co
23	Inst. de Geofisica UNAM Ciudad Universitaria	Mexico		http://www.geofisica.unam.mx/indexi.php	Dr. Shri Krishna Singh	52 5 622 4134 krishna@ollin.igeofcu.unam.mx
24	Program in Public Health University of California Irvine	Irvine USA		http://publichealth.uci.edu/ph_docs/geohazards_disasters_research	Dr. Lisa Grant Ludwig	1949824 2889 lgrant@uci.edu
25	Jefe del Dpto. Ciencias de la Tierra Prolongacion Calle Mara, Urbanizacion El Llanito	Caracas Venezuela		http://www.funvisis.gob.ve/dct_prof_adsc.php	Dr. Franck Audemard* Dr. Herbert Rendon	582122577672* 582122577672 faudemard@funvisis.org.ve* hrendon@funvisis.org.ve
26	University of Memphis	Memphis USA		http://www.memphis.edu/	Prof. Chris Cramer	ccramer@memphis.edu
27	Louisiana State University College of Engineering	Louisiana USA		http://www.eng.lsu.edu/research	Prof. Levent Yilmaz	(225) 334-6985 lyilmaz@itu.edu.tr
28	Lamont-Doherty Earth Observatory, Seismology Geology and Tectonophysics, Columbia	New York USA		http://www.ldeo.columbia.edu/research/seismology-geology-tectonophysics/seismology-geology-tectonophysics-	Prof. David Schaff	dschaff@ldeo.columbia.edu

	University in the City of New York			events		
29	Centre for Earth Observing and Space Research, George Mason University	Fairfax, Virginia USA		http://ceosr.gmu.edu/	Prof. Menas Kafatos	mkafatos@crete.gmu.edu
30	U.S. Geological Survey, Denver Federal Centre	Denver USA		http://geohazards.cr.usgs.gov/staffweb/mcnamara	Dr. Daniel E. McNamara	303-273-8550 3032499081@vtext.com
31	California Geological Survey	Sacramento USA		http://www.conservation.ca.gov/CGS/Pages/Index.aspx	Dr. Vladimir Graizer*	(916)3229309 * (916)3247299 vgraizer@consrv.ca.gov* shmp@consrv.ca.gov
32	US Geological Survey, National Earthquake Information Centre - NEIC	Denver, Colorado USA		http://earthquake.usgs.gov/regional/neic/	Ph.D. Shengzao Chen	
33	University of Texas at Austin	Austin USA		http://www.jsg.utexas.edu/	Dr. Steve Grand	512-471-5172 geochair@geo.utexas.edu
34	University of Calgary	Calgary Canada		http://geoscience.ucalgary.ca/Why_Geoscience	Dr. Benoit Beauchamp* Dr. Larry R. Bentleyº	1(403)2207516* mailto:bbeaucha@nrcan.gc.ca* 1(403)2204512º lbentley@ucalgary.caº
35	Colombian Institute of Geology and Mining	Bogota Colombia		http://www.ingeominas.gov.co/english/ http://seisan.ingeominas.gov.co/RSNC/	Fernando Gil Cruz* Ing. Civ. Jaime Fernando Erasoº	2200246* 2200016º jeraso@ingeominas.gov.coº
36	Volcanological and Seismological Observatory of Costa Rica at the National	Heredia Costa Rica		http://www.wovo.org/1405_ovsicori.html www.una.ac.cr/ovsi	Dr. Eduardo Malavassi	(506)261078; 261 0611 ovsicori@irazu.una.ac.cr

	University OVSICORI UNA					
37	Institute Geofisic Politenic High School	Ecuador			Andres Ojeda	
38	University of Puerto Rico	Mayague z Puerto Rico		http://civil.uprm.edu/index_en.html	Prof. Juan B. Bernal Vera* Prof. Luis A. Godoyº	(787)8324040, Ext. 3668* (787)8324040, Ext. 3465º juan.bernal@upr.edu* luis.godoy@upr.eduº
39	Seismic Research Centre Trinidad	Trinidad and Tobago		http://www.uwiseismic.com/	Walter Salazar	walter.salazar@uwiseismic.com
40	Servicio Geológico Mexicano	Oaxaca Mexico		http://www.proteccioncivil oaxaca.net/Default1.asp?popup=1	Carlos M. Valdes Gonzalez Casiano Jiménez Cruz	carlosv@ollin.igeofcu.unam.mx casiano@ollin.igeofcu.unam.mx
41	Servicio Geológico Mexicano	Pachuca Mexico		http://www.sgm.gob.mx/index.php?option=com_content&task=view&id=69&Itemid=156	Ing. Israel Hernández Pérez	01(771)711-36-96 ext. 1218 israelh@sgm.gob.mx
42	University of Canterbury	Christchurch New Zealand		http://www.nhrc.canterbury.ac.nz/	Prof. Jarg Pettinga* Dr. Brendon Bradleyº	(643)3642987 ext 7716* 6433642987 7395º jarg.pettinga@canterbury.ac.nz brendon.bradley@canterbury.ac.nz
43	Research Institute	Havana Cuba		http://casgroup.fiu.edu/cri/pages.php?id=1176	Prof. Grenville Draper	Grenville.Draper@fiu.edu
44	The University of Toronto Department of Physics	Toronto Canada		http://www.physics.utoronto.ca/research/geophysics	Prof. Richard C. Bailey	416-978-3231 bailey@physics.utoronto.ca
45	USGS-Geological Survey, Earthquake Hazards Program	Memphis USA		http://earthquake.usgs.gov/regional/ceus/	David Applegate Martitia Tuttle	901-678-4974 mptuttle@usgs.gov
46	GNS Science	Lower		http://www.gns	Stephen	64-4570 4678

	Natural Hazards / Earth's Forces / Earthquakes	Hutt New Zealand		.cri.nz/Home/Our-Science/Natural-Hazards/Earth-s-Forces/Earthquakes	Bannister	
47	University of Alberta Edmonton Department of Physics	Alberta Edmonton Canada		http://www.physics.ualberta.ca/Research/GeophysicalSciences.aspx	Prof. Mauricio D. Sacchi	17804921060 msacchi@ualberta.ca
48	University of Washington Department of Earth and Space Sciences Seismology and Tectonics	Washington USA		http://www.ess.washington.edu/ess/research/seis/index.html	Prof. John Vidale	206-543-6790 vidale@ess.washington.edu
49	University of New Brunswick Department of Geology	New Brunswick Canada		http://www.unb.ca/fredericton/science/geology/about.php	Paul F. Williams	(506)4526035 pfw@unb.ca
50	Phoenix Geophysics	Toronto, Ontario Canada		http://www.phoenix-geophysics.com/applications/earthquake_research/?		1 4164917340 mail@phoenix-geophysics.com
51	Institute of Geophysics and Planetary Physics Scripps Institution of Oceanography	San Diego, California USA		http://igpp.ucsd.edu/	Gabi Laske	(858)5348774 glaske@ucsd.edu
52	Natural Resources Canada Earth Sciences Sector	Ottawa, Ontario Canada		http://ess.nrcan.gc.ca/disdan/index_e.php		1 6139950947 questions@nrcan.gc.ca
53	CICESE/Earth Sciences	Ensenada Mexico		http://geologia.cicese.mx/ahinojosa/curriculum.htm	Alejandro Hinojosa Corona	01152646 175-0500 ext. 26045 alhinc@cicese.mx
54	Institute of Geological and Nuclear Sciences Ltd. (GNS)	New Zealand		http://www.gns.cri.nz/	Dr. Martin Reyners° Prof. Steve Weaver Pilar	64(04)5701444° m.reyners@gns.cri.nz° 644570 4875*

					Villamor*(Ms)	
55	Minnesota University	Minneapolis USA		http://cse.umn.edu/deptsmajors/depts/CSE_CONTENT_202419.php	Mos Kaveh	612 624 2006 cseinfo@umn.edu
56	International Society for Structural Health Monitoring of Intelligent Infrastructure - ISHMII	Winnipeg, Manitoba Canada		http://www.ialcce.org/	Charleen Choboter	204-474-7969 choboter@cc.umanitoba.ca
57	Instituto Nacional de Sismologia, Vulcanologia, Meteorologia e Hidrologia (INSIVUMEH)	Guatemala		http://www.insivumeh.gob.gt/	Ing. Estuardo Velasquez V.	502 22613238
58	Inst. Geofisico del Peru	Lima Peru		http://www.igp.gob.pe/	Dr. L.C. Ocola	ocolalc@geo.igp.gob.pe

Table 5: Database of institutions in seismology and earth science in Asia

Nm	Institution	City/ Country		Internet Homepage	Contact person	Contact details
1	National University Corporation Kobe University UKOBE	Kobe-city Japan		http://www.kobe-u.ac.jp/en/	Prof. Yasuo Ariki	81788036226 ariki@kobe-u.ac.jp
2	Israel Antiquities Authority IAA	Israel		www.antiquities.org.il	Dr. Uzi Dahari	9722 6204603 uzi@israntique.org.il
3	Geological Survey of Estonia	Estonia		www.egk.ee	Dr. Jaan Kivisilla	672 0072 j.kivisilla@egk.ee
4	Seismological Division, Geophysical Institute of Israel	Lod Israel		http://www.gii.co.il/	Dr. Rami Hofstetter	97289785854 rami@seis.mni.gov.il
5	National Data Centre	Israel		http://isramar.ocean.org.il/isramar2009/	Dr. Yochai Ben Horin Ms. Lea Teitelbaum (secretary of IOLR)*	04-8565221* lea@ocean.org.il
6	Geophysical Survey of	Russia		http://www.gcras.ru/index_e.h	Prof. Alexei Malovichko	74959300546 gcras@gcras.r

	Russian Academy of Sciences			tml		u
7	National Survey for Seismic Protection (NSSP)	Armenia		http://www.nssp-gov.am/	Dr. Alvaro Sh. Antonyan	374 10/ 28-64-94 (presid. office) president@nssp-gov.am; office@nssp-gov.am
8	Republican Seismic Survey Center of Azerbaijan National Academy of Sciences (RSSC)	Azerbaijan		http://www.seismology.az/?menu=2&submenu=23&lang=en	Dr.Gurban.J.Yetirmishli	994124924926 science@azeurotel.com
9	Centre of Geophysical Monitoring (CGM)	Minsk Belarus		http://www.cgm.org.by/index.php?id=356	Dr. Arkady. G. Aronov	375172638116 aronov@cgm.org.by
10	Seismic Monitoring Centre of Georgia (SMC)	Georgia		http://www.iode.org/index.php?option=com_oe&task=viewInstitutionRecord&institutionID=10785	Prof. Tamaz Chelidze	99532332867 Chelidze@ig.acnet.ge
11	National Data Centre (NDC) of Israel, Soreq Nuclear Research Centre	Israel		http://www.soreq.gov.il/default_EN.asp	Dr. Y. Ben Horin Dr. Yehuda Nafcha	yehuda_nafcha@soreq.gov.il
12	Jordan Seismological Observatory	Jordan		http://www.nra.gov.jo/index.php	Dr. Tawfiq Al-Yazjeen	tyazjeen@nra.gov.jo
13	Academy of Sciences of Republic of Moldova	Moldova		http://www.asm.md/?new_language=1 http://igs.asm.md/en/node/57	Dr. Vasile Alcaz*	373(22)723608 alcazv@yahoo.com
14	Centre of Geophysical Computer Data Studies (CGDS)	Russia		http://www.gcras.ru/hist_e.htm	Dr. Alexei Gvishiani*	7(495)9300546* gcras@gcras.ru
15	World Data Centre for Solid Earth Physics	Russia		http://www.wdcb.ru/sep/index.html		7(495)9305649 sep@wdcb.ru
16	King Abdulaziz	Saudi Arabia		http://www.kacst.edu.sa/	Dr. T. Al-Khalifah	966 1 4883555*

	City for Sciences and Technology (KACST)					
17	Main Centre for Special Monitoring (MCSM)	Ukraine			M. I. Kachalin	
18	Dubai Municipality Dubai Central Laboratory	United Arab Emirates		http://login.dm.gov.ae/wps/portal/MyHomeEn	M. Y. A. Almarzooqi	97143027143 /7145 AHMARZOOQI @dm.gov.ae
19	National Seismological Observatory Centre (NSOC) Mineral Resources and Geological Survey Corporation	Yemen		http://sciencelinks.jp/j-east/article/200512/000020051205A0486608.php	Dr. Jamal M. Sholan	269699 sholan12@y.net.ye
20	India Meteorological Department	India		http://www.imd.gov.in/main_new.htm	Shri P. R. Baidy*	01124629770 * 01124619943 * imetsociety@gmail.com
21	Iraqi Seismic Network	Iraq		http://www.imos-tm.com/english/	Sahil A. Alsinawi	salsinawi@comcast.net sahil.alsinawi@itt.com salsinawi@verizon.net
22	The Japan Meteorological Agency (JMA)	Japan		http://www.jma.go.jp/jma/indexe.html	Koichi UHIRA	
23	Geoscience Australia	Australia		http://www.ga.gov.au/		naturalhazards@ga.gov.au earthquakes@ga.gov.au
24	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)	Japan		http://www.jamstec.go.jp/e/	(Yokohama Institute for Earth Science)	81457783811
25	Earthquake Research Institute University of Tokyo	Tokyo Japan		http://www.eri.u-tokyo.ac.jp/eng/	Prof. Hiroshi Sato Prof. Kenji Satake*	81358410219 * satake@eri.u-tokyo.ac.jp*
26	Natural Resources	Amman Jordan		http://www.nra.gov.jo/index.ph	Dr. Maher Hijazin	dirgen@nra.gov.jo

	Authority, Amman			p	Dr. Tawfiq Yazjeen (Seismol. Observ.)	tyazjeen@nra.gov.jo
27	Kuwait Institute for Scientific Research Kuwait National Seismic Network	Kuwait		http://www.kisr.edu.kw/		965 24836100 (24818630) public_relations@safat.kisr.edu.kw
28	Kuwait National Meteorological Network	Kuwait		http://www.kisr.edu.kw/Default.aspx?pageId=499&	Dr. Ashraf Ramadan*	96524989134 * aramadan@kisr.edu.kw
29	Geological Research Authority of Sudan	Sudan		http://www.mbendi.com/orgs/ct2n.htm		24911777939 fax: 249 11 77-6681
30	Korean Meteorological Administration	Korea		http://www.metri.re.kr/metri_home/english/Introduction/uAboutE.jsp		master@metri.re.k
31	University of the West Indies, Trinidad and Tobago	India		http://sta.uwi.edu/	Dr. Prof. Derek Gay Dr. Vasudevu Kanithi*	868-662-2002 ext. 3437* vasudevu.kanithi@sta.uwi.ed
32	IASPEI, Armenian Association of Seismology and Physics of the Earth (AASPE)	Armenia		http://www.aaspe.am	Dr. Avetis R. Arakelyan	374 10269282 office@aaspe.am
33	Institute of Geology, Academy of Sciences	Azerbaijan		http://www.gia.az/	Dr. O.B. Babazade	bnigyar@hotmail.com
34	Bangladesh Earthquake Society (BES), Department of Civil Engineering Bangladesh University of Engineering and Technology (BUET)	Bangladesh		http://www.icsroscher.de/CAEM/BUET.htm	Prof. Aftab Alam Khan	8802966 5650 aftab@du.bangla.net
35	Institute of	China		http://www.cea	Prof. Zhu	(010)6841537

	Geophysics			-igp.ac.cn/English.htm	Chuanzhen	7 zhucz@public.fhnet.cn.net Zhucz@ihw.co.cn
36	National Geophysical Research Institute	India		http://www.kooperation-international.de/en/indien/themes/wg/0/	Dr. H.K. Gupta	91407171124 91407171618 dodsec@dod.delhi.nic.in
37	National Seismological Centre of Indonesia	Indonesia			Dr. Fauzi	
38	National Seismological Centre Nepal NSC	Nepal		http://seismonepal.gov.np/	Soma Nath Sapkota	016205791 (home) 9851018141(cell) somanathsapkota@yahoo.com
39	Institute of Geophysics Tehran University	Tehran Iran		http://geophysics.ut.ac.ir/En/	Prof. Dr. Mohammad Reza Gheitanchi	98218028161 98218021072 mrghchee@chamran.ut.ac.ir
40	The Geophysical Institute of Israel Academy of Sciences & Humanities	Israel		http://www.gii.co.il/	Dr. Rami Hofstetter	972-8-978-5853/4 rami@gii.co.il
41	Nagoya University Chikusa, Graduate School of Environmental Studies	Japan		http://www.env.nagoya-u.ac.jp/en/admission/exam.html	Prof. Kazuro Hirahara	052-789-4651 hirahara@eps.nagoya-u.ac.jp
42	Kazakh National Technical University	Republic of Kazakhstan		http://www.ceebd.co.uk/ceeed/un/kaz/ka014.htm	Dr. D. Sadykov	73272472300 saddsh@mail.ru
43	Korea Institute of Geology Mining and Materials, Daejon, Korea	Korea		http://www.insidedaejeon.info/index.php5/Korea_Institute_of_Geosciences_and_Mineral_Resources_%28KIGAM%29	Dr. Myung-Soon Jun	042-868-3344 junms@rock4680.kigam.re.kr
44	Institute of Seismology Asanbay	Kyrgyzstan		http://www.springerlink.com/content/v132887256j15617/	Dr. A.T. Turdukulov	996312469242 kis@mail.elcat.kg
45	G. Mavlyanov	Tashkent		http://www.seis	Prof.	(998712)1357

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46	Malaysiam Meteorological Service Jalan	Malaysia		http://www.met.gov.my/index.php?option=com_joomap&Itemid=139	Mr. Low Kong Chiew	kclow@kjc.gov.my
47	Seismological Monitoring system of Myanmar	Myanmar		http://aeic.bmg.go.id/aeic/myanmar.asp	Ms. Ye Ye Nyein	dg.dmh@mptmail.net.mm
48	Philippine Institute of Volcanology and Seismology	Philippines		http://www.phivolcs.dost.gov.ph/	Dr. R.S. Punongbayan	rayspu@info.com.ph
49	Institute of Geophysics, Russian Academy of Science, Siberian Branch	Novosibirsk Russia		http://gis.mapsofworld.com/government/government-agencies/institute-of-geophysics-sbras.html	Dr. Sergey Goldin	3832 33 2513 sgoldin@uiggm.nsc.ru
50	Institute of Earth Sciences Academia Sinica	Taipei China		http://www.earth.sinica.edu.tw/en/	Dr. Yih-Hsiung Yeh	886227839403 yehyh@earth.sinica.edu.tw
51	Tajik Institute of Seismic Resistance Construction and Seismology	Republic of Tajikistan		http://www.semp.us/publications/biot_reader.php?BiotID=661	Dr. S. Negmatullaev	992372217284 pmp_international@yahoo.com
52	Metrological Department	Bangkok Thailand		http://www.tmd.go.th/en/thailand.php	Mr. Wanchai Salathulthat* Mrs. Sumalee Prachuab	6623991425* 662-399-4547 Burin@pacific.net.th
53	Institute of Geophysics, Vietnam National Centre for Natural Science and Technology	Vietnam		http://www.vast.ac.vn/index.php?option=com_content&view=article&id=407&Itemid=79&lang=en	Prof. Nguyen Dinch Xuyen	xuyen@igp.ncst.ac.vn
54	National Seismological	Republic of Yemen		http://sciencelinks.jp/j-	Mr. Jamal M. Sholan	269699 sholan12@y.n

	Observatory Centre (NSOC) Mineral Resources and Geological Survey Corporation			east/article/200512/000020051205A0486608.php		et.ye
55	World data Centre for Seismology	Beijing China		http://www.ngdc.noaa.gov/wdc/china/seismology.html	Dr. Refeng Liu	861088015249 liufr@csndmc.ac.cn
56	IASPEI, Institute of Geophysics China Earthquake Administration	Beijing China			Dr. Zhifeng Ding	861068729308 ding@cdsn.org.cn
57	IASPEI, Institute of Earth Sciences Academia Sinica	Taipei Taiwan		http://www.earth.sinica.edu.tw/en/	Prof. Yih-Hsiung Yeh	886227899403 yehyh@earth.sinica.edu.tw
58	Geological Survey of Estonia	Tallinn Estonia		http://www.egk.ee/egk/?r=r1&ra=r1_1_1&lang=eng	M.Sc. Tarmo All	372 6 720 371 t.all@egk.ee
59	Jadavpur University	Kolkata India		http://www.jaduniv.edu.in/	Prof. J. R. Kayal	913324380606 jr_kayal@hotmail.com
60	Geophysics Group, Bandung Institute of Technology	Bandung Indonesia		http://www.fitb.itb.ac.id/en/index.php?center=pascasarjana&id=13	Dr. Sri Widiyantoro	62222500494 sriwid@geoph.itb.ac.id
61	Institute of Geophysics Tehran University	Tehran Iran		http://utehran.ir/en/contents/Departments-institute/Departments.and.Degrees.html	Prof. Dr. Mohammad Reza Gheitanchi	98218021072 mrghchee@ut.ac.ir
62	School of Earth and Environmental Science Seoul National University	Seoul Republic of Korea		http://cns0.snu.ac.kr/eng/se07_ac/se07_ac_f/se07_ac_f01/se07_ac_f01.jsp	Prof. Chang-Eob Baag	82 2 880 6735 baagce@snu.ac.kr
63	Department of Geology Kyongpook National	Seoul Republic of Korea		http://cns.knu.ac.kr/eng/cons-2/Dep-GEOL.php	Prof. Jung-Mo Lee	82539505347 jung@knu.ac.kr

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64	Philippine Institute of Volcanology and Seismology Department of Science and Technology	Quezon City Philippines		http://volcano.phivolcs.dost.gov.ph/	Dr. Bartolome C. Bautista	63 2 926 2611 bart@phivolcs.dost.gov.ph bart_bautista@yahoo.com
65	Schmidt Institute of Physics of the Earth Russian Academy of Sciences	Moscow Russia		http://www.ifz.ru/engilsh_version/index.htm.	Prof. Alexandr O.Gliko	7495252 0726 gliko@ifz.ru
66	Institute of Geophysics, Vietnamese Academy of Sciences and Technology (VAST)	Hanoi Vietnam		http://www.vast.ac.vn/index.php?option=com_content&view=article&id=374%3Avvldc&catid=42%3Acac-vin-nghien-cu&Itemid=103&lang=en	N.D. Xuyen	xuyen@igp.ncst.ac.vn ndxuyen@gmail.com
67	Institute of Geotechnical Engineering, Chongqing Jiaotong University	China		http://www.admissions.cn/cquc/index.htm	Prof. Hong-Kai Chen	86-023-6265 2719 Bialik@163.net Chk_cq@163.com Rxzj@yahoo.com
68	Department of Geophysics Peking University	Beijing China		http://geophy.pku.edu.cn/itag/en/#	Prof. Shiyong Zhou	zsy@pku.edu.cn
69	M.Nodia Institute of Geophysics	Tbilisi Georgia		http://www.ig-geophysics.ge/Devadze%20ENG.html	Prof. Tamaz Chelidze	99532332867 Chelidze@ig.acnet.ge
70	Geological Survey of India	Calcutta India		http://www.portal.gsi.gov.in/portal/page?_pageid=127,529293&_dad=portal&_schema=PORTAL	Dr. J. R. Kayal	(91)-33-2286-1633 jr_kayal@hotmail.com
71	Hong Kong Observatory	Hong Kong		http://www.hko.gov.hk/contente.htm		8522926 8200 wtwong@hko.gcn.gov.hk
72	Japan Meteorologic	Tokyo Japan		http://www.jma.go.jp/jma/en/	Hironori Hayashibara	81-3-3212-8341ext. 5139

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73	Centre de Recherches Geophysiques, Conseil National de la Recherche Scientifique	Beyrouth Lebanon			Dr. Alexandre Sursock	9614 981885 asursock@cnrs.edu.lb
74	Nanyang Technological University (NTU)	Singapore		http://www.ntu.edu.sg/Pages/default.aspx	Paul Tapponnier	(65)67911744 * d-rso@ntu.edu.sg* (researchdevelopment)
75	UNISDR Asia and the Pacific	Bangkok Thailand		http://www.unisdr.org/asiapacific/index.php		66(0)22882745 Isdr-bkk@un.org
76	Outreach office in Central Asia	Dushanbe Tajikistan		http://www.unisdr.org/asiapacific/index.php		992 48 701 16 20/21 goulsara.pulotova@undp.org
77	Japan and IRP Liaison Office UNISDR Hyogo Office	Japan		http://www.unisdr.org/asiapacific/index.php		81 (0)78 262 5550 matsuoka@un.org
78	Centre de Recherches Geophysiques, Conseil National de la Recherche Scientifique	Beyrouth Lebanon		http://www.cnrs.edu.lb/	Dr. Alexandre Sursock	9614 981885 asursock@cnrs.edu.lb
79	Institute of Earth Crust of the Siberian Branch of the RAS	Irkutsk Russia		http://www.en.crust.irk.ru/	Dr. Yevgeniy Sklarov	7(3952)427000 *
80	Institute of Physics of the Earth of the RAS	Moscow Russia		http://www.ifz.ru/engilsh_version/index.htm	Prof. Dr. Yevgeniy Rogojin Глико Александр Олегович	7 (499)766-26-56* direction@ifz.ru
81	Dagestan branch of the Institution of the Russian Academy of Sciences Geophysical Service,	Makhachkala, Dagestan Republic, Russia		ftp://hazards.cr.usgs.gov/LAHR/iaspei/europe/russia/russia_four/gs_ras.htm	Marat Daniyalov G.	(8722)670273 uuball12@ball12.dagestan.su

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82	A.A. Trofimuk Institute of Petroleum Geology and Geophysics SB RAS	Novosibirsk Russia		http://www.ipgg.nsc.ru/en/Pages/default.aspx	Dr.Sci.Tech. Vladimir V. Kuznetsov Dr. Vladimir D. Suvorov*	SuvorovVD@ipgg.nsc.ru*
83	Radio-Environmental Centre of National Academy of Sciences of Ukraine Institute of Geophysics	Kiev Ukraine		http://www.igph.kiev.ua/	Starostenko Vitaly Ivanovich	kiev2010@igph.kiev.ua earth@igph.kiev.ua
84	Department of Earthquake Engineering, Indian Institute of Technology Roorkee	Uttara Khand India		http://www.iitr.ac.in/departments/EQ/pages/index.html	Dr.Amita Sinval* Dr.Ashok D Pandey°	91-01332-285517* 91-01332-285531° amitafeq@iitr.ernet.in* adpanfeq[at]iitr.ernet.in°
85	Department of Geophysics Kurukshetra University	Kurukshetra India		http://www.kuk.ac.in/information.php?action=showContent&L01_id=8&L01_direction=H&L03_id=61&L02_id=39&sublevel=y	Dr. Dinesh Kumar Dr. B. S. Chaudhary	dineshk5@rediffmail.com bsgeokuk@yahoo.com
86	Centre for Disaser Mitigation and Management, Vellore Institute of Technology University	Vellore India		http://www.vit.ac.in/cdmm/index.html	Prof. Ganapathy. G.P.	914162202284 gpganapathy@vit.ac.in seismogans@yahoo.com
87	Department for Applied Physics and Electronic Engineering, Faculty of Engineering University of Rajshahi	Rajshahi Bangladesh		http://www.ru.ac.bd/	Dr. Syed Mustafizur Rahman Prof.Dr. M. Rostom Ali*	88-0721-750041- extn. 4186* dmrali@yahoo.com*

88	Institute of Seismology of the Academy of Sciences of Uzbekistan	Tashkent Uzbekistan		http://isas.uzsci.net/	Dr. Alisher Ibragimov	alisher_ibragimov@yahoo.com
89	Institute of mechanics and Seismic Stability of Structures of the Academy of Sciences of Uzbekistan	Tashkent Uzbekistan		http://geoforum.com/contacts/directory/view.asp?PersonID=-1466828933&Lang=		(99871)1627152 saidullo@yahoo.com
90	Korea Institute of Geosciences and Mineral Resource Earthquake Disaster Research Department	Daejeon South Korea		http://www.intute.ac.uk/cgi-bin/fullrecord.pl?handle=1025105286-21815	Shin Jin Soo	82428683266
91	National Council for Scientific Research	Beirut Lebanon		http://www.cnrs.edu.lb/research/geophysicalresearch.html		9614981885 geophys@cnrs.edu.lb
92	Central Asian Institute for Applied Geosciences	Bishkek Kyrgyzstan		http://www.caiag.kg/index.php?id=378&L=2	Ph.D. Zoia Kalmetieva	996(312)555775 z.kalmetyva@caiag.kg kiszoya@mail.ru
93	Tel Aviv University, Geophysics	Tel Aviv Israel		http://geophysics.tau.ac.il/	Yellin Dror Annat	97236407667 annat@post.tau.ac.il
94	Weizmann Institute of Science Computer Science&Applied Mathematics Earthquake and Exploration Seismology	Rehovot Israel		http://www.wisdom.weizmann.ac.il/	Ari Ben-Menahem	9728934 3474 Ari.Ben-menahem@weizmann.ac.il
95	Scientific Research Institute of Prognosis and Studying of Earthquakes	Baku Azerbaijan		http://www.icep-atropatena.com/contacts.htm	Mr.Iskandar Kafarov	994124398314 kafarov@seismonet.org
96	Scientific Research	Baku Azerbaija		http://www.eco.gov.az/en/g-	Hadjıkerimov Qazi İbadulla	(012)5100672

	Institute of Hydrometeorology of Ministry of Ecology and Natural Resources of Republic of Azerbaijan National Geological Survey Service	n		seysmo.php		
97	Centre for Earthquake Studies (CES) National Centre for Physics	Islamabad Pakistan		http://seismonet.org/page.html?id_node=152	Dr. Ahsan Mubarakº Prof. Dr. Muhammad Qaisar*	92 0302 8564994 ma_mubarak@hotmail.com º m_qaisar@seismonet.org*
98	Gadjah Mada University, Faculty of Engineering, Physics Department	Yogyakarta Indonesia		http://www.fakultas-teknik.ugm.ac.id/		62 274 (513665, 6492190, 6492191) teknik[at]ugm.ac.id ftugm[at]telkom.net.id
99	Jordan University of Science and Technology	Jordan		http://www.just.edu.jo/Pages/default.aspx	Prof. Rami H. Haddad	962 2 7201000 22119 rhaddad@just.edu.jo
100	Natural Resources Authority Jordan Seismological Observatory	Amman Jordan		http://www.nra.gov.jo/index.php	Dr. Tawfiq Yazjeen*	962-6-5504390 962-6-5857612 tyazjeen@nra.gov.jo*
101	Academy of Sciences of Moldova Institute of Geology and Seismology	Chisinau Republic of Moldova		http://igs.asm.md/en	Dr. Vasile Alcaz	373(22)723608 alcaz@yandex.ru alcazv@yahoo.com
102	The Institute of Geology of Ore Deposits, Petrography, Mineralogy, and Geochemistry, Russian Academy of Sciences (IGEM RAS)	Moscow Russia		http://www.igem.ru/site/isled_eng.html	Nikolay P. Laverov* Dr. Andrey D. Babansky	7(499)2308249* 7(495)9517772 baban@igem.ru
103	Russian	Troitsk,		http://www.ige	Prof. Edouard	7(495)777721

	Academy of Sciences Geoelectromagnetic Research Centre (GEMRC IPE RAS)	Moscow Region Russia		mi.troitsk.ru/eng/	B. Fainberg	8º fain@igemi.troitsk.ru
104	National Geophysical Research Institute Uppal Road, Hyderabad	Hyderabad Andhra Pradesh India		http://www.ngri.org.in/htmlfiles/coreresearch/earthquake/earthquakehazard.html	Chadha R K*	914023434630*
105	Indian Institute of Technology Department of Earth Sciences	Bombay India		http://www.geos.iitb.ac.in/	Mohan G.	912225767274 gmohan@iitb.ac.in
106	Academia SinicaTaipei Institute of Earth Sciences	Taipei Taiwan		http://dmc.earth.sinica.edu.tw//index.php?option=com_content&task=view&id=12&Itemid=26	Lee, Jian-Cheng	886-2-2783-9910 ext. 413 jclee@earth.sinica.edu.tw
107	Indian School or Mines Department of applied Geophysics	Dhanbad, Jharkhand India		http://www.ismdhanbad.ac.in/depart/geophysics/research.htm	Dr P. N. Singha Roy	91-326-2235469 pnsmay1@gmail.com pns_may1@yahoo.com
108	National Central University Research	Jhongli City, Taoyuan County Taiwan		http://www.ncu.edu.tw/en/research.html	Research and Development Office	886-3-4227151 ext: 57020 ncu7020@ncu.edu.tw
109	Faculty of Geosciences and Resources, China University of Geoscience (Beijing)	Beijing China		http://en.cug.edu.cn/cug/Content.asp?ID=4569&ClassID=500	Prof. Shaofeng Liu Mr. Zhang Lijun*	0086-27-87515986 / 67883075* ljzhang@cug.edu.cn*

Table 6: Database of institutions in seismology and earth science in Africa

Nm	**Institution**	**City/ Country**		**Internet Homepage**	**Contact person**	**Contact details**
1	Ecole Nationale d'Architecture ENA	Morocco		www.archi.ac.ma	Tayyibi Abdelghani	212 (0) 661114261 atayyibi@gmail.com

2	Conservation department-Cairo University CDCU	Cairo Egypt		www.cu.edu.eg http://193.227.13.20/index.php		
3	University of science and technology Houari Boumediene USTHB	Algiers Algeria		www.lbe.usthb.dz	Djillali Benouar Samia Chergui	dbenouar@gmail.com chergui_s@yahoo.fr
4	Centre de Recherche en Astronomie, Astrophysique et Geophysique (CRAAG)	Algeria		http://www.craag.dz	Dr. K. Yelles	213 21 90 44 54/55/56 kyelles@yahoo.fr
5	Observatoire Geophysique d'Arta	Djibouti Africa		http://www.ipgp.fr/index2.php?langue=1	M. Kassim Mohammed	253422192/422009 kassimk2004@yahoo.fr
6	National Research Institute of Astronomy and Geophysics (NRIAG)	Egypt		http://www.nriag.sci.eg/	Prof. Mohamed Abuo El-Ela Amin	20225541100* 2025583887* abouelela99@hotmail.com
7	Geophysics Centre at Bhannes (SGB)	Lebanon		http://www.cnrs.edu.lb/	Dr. Alexandre Sursock	geophys@cnrs.edu.lb*
8	Libyan Centre for Remote Sensing and Space Science (LCRSSS)	Libya		http://www.lcrsss.org	M. H. Gashut	281214900885* lcrsss@hotmail.com*
9	Centre National de la Recherche (CNR)	Morocco		http://www.cnr.ac.ma/	Dr. A. I. Ibrahim	212 (0) 537 56 98 10*
10	Institut Scientifique Département de Physique du Globe	Agdal-Rabat Morocco		http://www.israbat.ac.ma/spip.php?article126	Prof. Ben Aissa Tadili	212 7 774543 tadili@israbat.ac.ma tadili@yahoo.com
11	Institut National de la Météorologie (INMT)	Tunisia		http://www.meteo.tn/htmlen/accueil.php	Dr. Moncef Rajhi	moncef.rajhi@meteo.tn
12	Council for Geosciences,	South Africa		http://www.geoscience.org.za/	Artur Cichowicz*	27 12 841 1457 8603*

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13	Egyptian Meteorological Agency	Egypt		http://nwp.gov.eg/e/index.php?id=2		202-6820790 support@ema.gouv.eg
14	Centre de Recherche en Geophysique (CRG)	Kinshasa Congo			Ndontoni Zana	242815171399 Azanan2002@yahoo.fr Rst_crq@yahoo.fr
15	Direccao Nacional de Geologia	Maputo Mozambique		http://www.dng.gov.mz/index_en.htm	Dr. Paulino Feitio* Eng. Veratio Sambocoº	25821312082* 25821312082º pfeitio@hotmail.com viriatosambooco@yahoo.com.br
16	Department of Physics, Ladoke Akintola University	Ogbomoso Nigeria		http://www.4icu.org/reviews/10767.htm	Prof. A.O. Alabi	2348033298249 aoalabi@yahoo.co.uk
17	Rock Engineering Dept CSIR Miningtek	South Africa		http://ntww1.csir.co.za/plsql/ptl0002/PTL0002_PGE013_MEDIA_REL?MEDIA_RELEASE_NO=7165212	Dr. Lindsay Linzer	27113580261 llinzer@csir.co.za Lindsay.Linzer@gmail.com
18	Instituto Nacional de Meterologia e Geoficica	Praia Cape Verde Africa		http://www.madrm.gov.cv/index.php?option=com_content&task=view&id=39	Mr. Jose Mannuel Gomes Moreno	238 2 41 1276 institutometeo@cvtelecom.cv
19	Geology Department, Faculty of Science, Alexandria University	Alexandria Egypt		http://www.sci.alex.edu.eg/En/departments/Default.aspx?Dept=4	Prof. Tharwat A. Abdel Fattah	TAhmed@sci.alex.edu.eg
20	Council for Geosciences	Pretoria South Africa		http://www.geoscience.org.za/index.php?option=com_content&view=section&id=10&Itemid=587	Michelle Grobbelaar* Linda Akromahº	27 12 841 1200* 27 12 841 1187º michelle@geoscience.org.za* lakromah@geoscience.org.z

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21	BTSK / WTS Geophysic	Pretoria South Africa		http://www.wtsgeo.com/en/about/index.html		86 755 26498216 sales@wtsgeo.com zhou.zhou@wtsgeo.com
22	University of Nairobi Department of Geophysics	Nairobi Kenya		http://www.uonbi.ac.ke/departments/?dept_code=KG&&fac_code=145	Prof. Patel Jayantip	254-20-4447552 jayanti@uonbi.ac.ke
23	Geological Survey of Namibia - Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)	Windhoek Namibia		http://www.bgr.bund.de/cln_169/nn_348380/EN/Themen/Georisiko/georisiko__node__en.html?__nnn=true	Georg Delisle	49(0)511-643-2627 Georg.Delisle@bgr.de
24	Obafemi Awolowo University, Faculty of Science Geophysic	Ile-Ife Nigeria		http://www.oauife.edu.ng/faculties/science/index.php	Professor V. O. Olarewaju	volarewaju@oauife.edu.ng
25	Council for Geosciences	Pretoria South Africa		http://www.geoscience.org.za/index.php?option=com_content&view=section&id=10&Itemid=587	Timothy Molea	27 12 841 1184 8611 timothy@geoscience.org.za

Table 7: Database of institutions in seismology and earth science in Australia

Nm	Institution	City/ Country		Internet Homepage	Contact person	Contact details
1	Seismology Research Centre (SRC)	Australia		http://www.seis.com.au/		61(0)38420 8999
2	RMIT University Seismology Research	Australia		http://www.seis.com.au/AusSeis.html	Dr. G. Gibson	gary@rmit.edu.au gary@seis.com.au
3	Geosciences Australia (GA)	Canberra Australia		http://www.ga.gov.au/hazards/earthquakes.html	Dr. Ned Stolz	61 2 6249 9763 ned.stolz@ga.gov.au
4	Queensland University (ESSCC)	Brisbane Australia		http://www.uq.edu.au/esscc/ http://www.eait.uq.edu.au/	Prof. Graham Schaffer Dr. Robert Day*	61 7 3365 3896* r.day@uq.edu.au*
5	Primary	Adelaide		http://www.pir.		61 8 8463

	Industries & Resources SA (PIRSA)	Australia		sa.gov.au/minerals/earthquakes		3000 PIRSA.minerals@sa.gov.au PIRSA.customerservices@sa.gov.au
6	The Australian Earthquake Engineering Society	Australia		http://www.aees.org.au/	Paul Somerville	61 2 9850 4416 psomervi@els.mq.edu.au
7	University of Western Australia (School of Earth and Environment)	Australia		http://www.seismicity.see.uwa.edu.au/ http://www.see.uwa.edu.au/	Prof. Matthew Tonts Prof. Thomas Angerer	6488 2683 matthew.tonts@uwa.edu.au 6488 7150 thomas.angerer@uwa.edu.au
8	IASPEI, Research School of Earth Sciences	Canberra Australia		http://rses.anu.edu.au/	Prof. Ian Jackson	61 2 6125 2498 jan.jackson@anu.edu.au
9	Research School of Earth Sciences, Australian National University	Canberra Australia		http://rses.anu.edu.au/research/ep/	Prof. Malcolm Sambridge* Prof. Phil Cummins°	61(0)2612 54557* malcolm.sambridge@anu.edu.au* phil.cummins@anu.edu.au°