SERA
Seismology and Earthquake Engineering
Research Infrastructure Alliance for Europe

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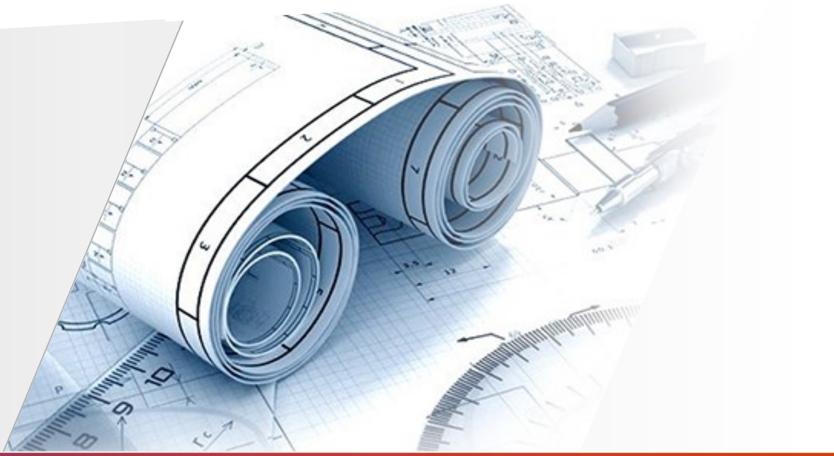

Earthquake Information in a Connected World

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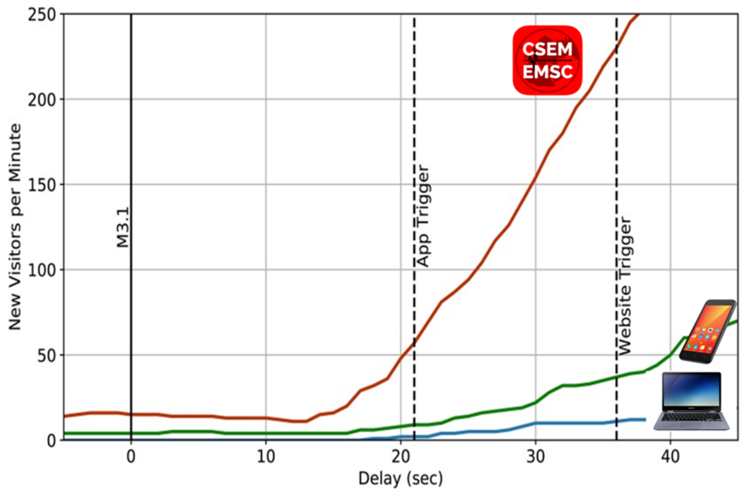
European-Mediterranean Seismological Centre (EMSC)

Thirty years ago, when people felt a tremor, they went to their phone to contact the seismological institute in the area. Today, eyewitnesses turn to social media (Twitter, Facebook, websites, smartphone apps) and the phones no longer ring in our laboratories! These online reactions of eyewitnesses occur typically only a few seconds after the ground shaking and are both a challenge and an opportunity for the seismological community. A challenge because they express an urgent desire for information from the public which, in order to be met in a timely manner, leaves little time for human intervention.

Yet how to balance between the rapidity of automated data analysis and the reliability of the disseminated information? Different strategies are being developed in Europe and beyond depending on the level of seismic hazard, whether the institute is staffed 24/7, etc. Despite these challenges, the use of social media is also an opportunity for the seismological community to better serve societal demands associated with earthquake risk, and an opportunity to collect data of scientific interest at little cost. This is the aim of LastQuake, a multichannel information system comprising of different websites, a Twitter quakebot and a smartphone app.



Reaction of eyewitnesses following a felt M 3.1 earthquake as observed through LastQuake app launches (red), EMSC website (www.emsc-csem.org) for desktops (blue) and the one for mobile devices (green). Visits start launching the app within a dozen seconds of the earthquake occurrence offering an efficient and fast way to automatically detect felt earthquakes.

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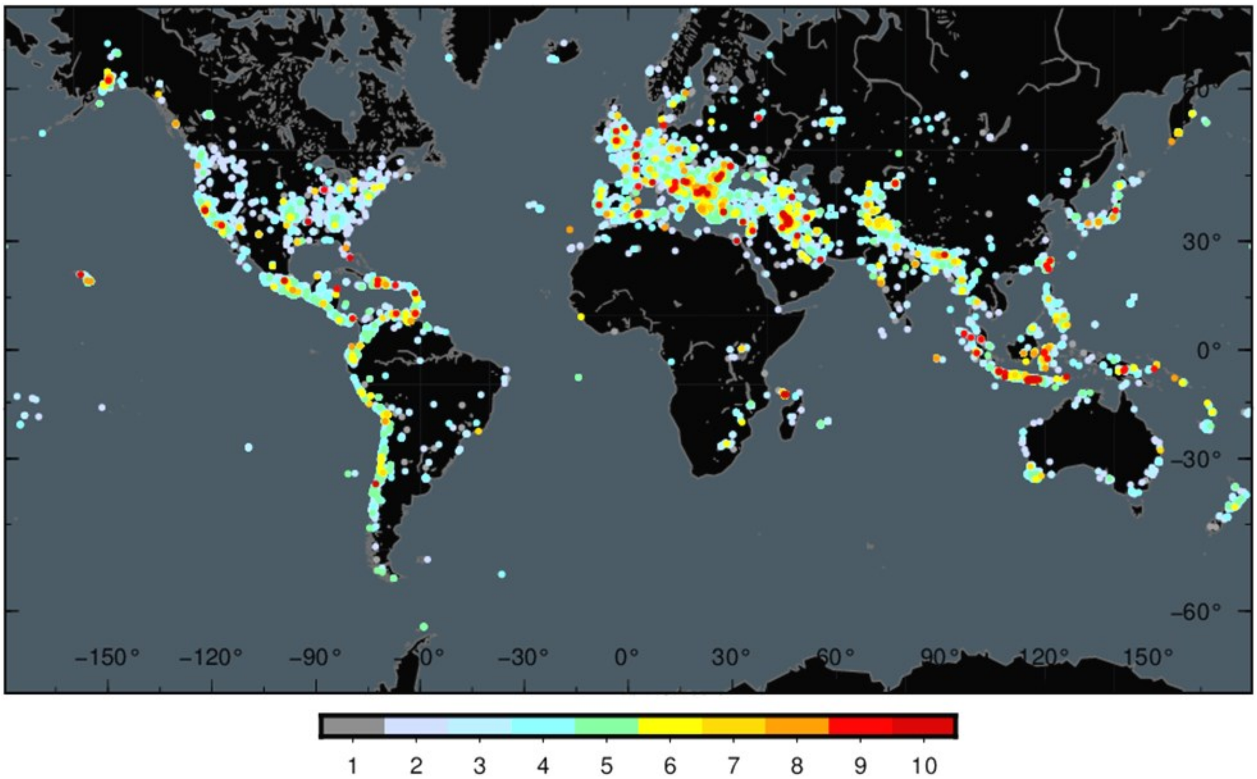
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730900.

LastQuake automatically detects the online reaction of eyewitnesses to global earthquakes, reports these reactions and invites them to share their experiences. By doing so, at least 100 000 felt reports are collected each year describing the local level of shaking or damage, half of them being collected within 10 minutes after a specific earthquake. Data is curated and collated with traditional seismic data to continuously improve information products. Following requests from users, LastQuake also offers safety tips ("do's and don'ts after an earthquake"), which together with improved situation awareness can contribute to risk reduction. It also fosters discussion with society, raises awareness of seismic risk and extends existing collaborations in seismology with the social sciences.



Map of the 120 000 individual reports collected in 2018. It illustrates the global audience of LastQuake information system. Half of the reports were collected within 10 min of the earthquake occurrence

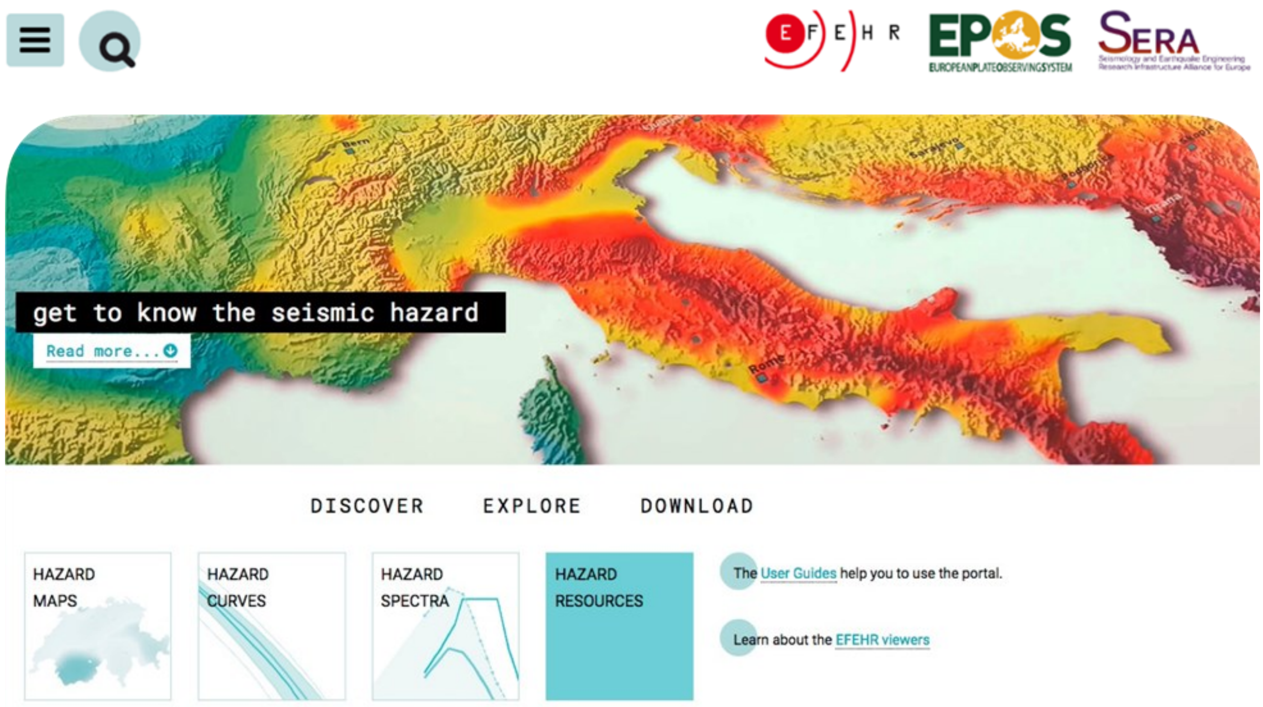
What about the advantages for the seismological community? A global database of felt reports is collected at little cost. These can provide constraints rapid assessment estimates (D. Wald at USGS is testing the integration of EMSC felt reports to constrain global shakemaps). As the database grows, new research topics are appearing (i.e. definition of regional intensity prediction equations, site effects mapping, vulnerability studies).

This dataset of felt reports has joined the other data and products collated at EMSC (rapid earthquake parameters, focal mechanisms, EventID, Flinn-Endahl regions, rupture models) and the data is now available through webservices which are themselves part of the EPOS initiative (European Plate Observing System). LastQuake represents a win-win strategy for both the public and seismologists. ■

European Facilities for Earthquake Hazard and Risk: Get to Know the Earthquake Hazard and Risk

Laurentiu Danciu

Swiss Seismological Service (SED), ETH Zürich



Understanding seismic hazard is essential for pre- and post-earthquake mitigation actions, including design rules of new buildings, identification and strengthening of vulnerable buildings, land use, development of preparedness action plans with involvement of decision makers, engineers, practitioners and academia. Seismic hazard indicates the likelihood of earthquake related phenomena (ground shaking, tsunami, landslides, liquefaction) in a region and provides an essential input to understand seismic risk, the likelihood of damage and loss for a region. In turn, the analysis of seismic risk combines information on seismic hazard, the natural phenomena, with information on the elements exposed - buildings, infrastructure, or people - and their vulnerability to earthquake effects (i.e. ground shaking).

The **European Facilities for Earthquake Hazard and Risk (EFEHR)** integrates the community resources for earthquake hazard and risk in Europe. A newly developed web-platform is the core gateway to scientifically credible seismic hazard models, related data, software and expertise which are relevant for assessing seismic hazard in Europe. The main services (databases and web-platform) of EFEHR are hosted at ETH Zurich and operated by the Swiss Seismological Service (SED). The management of EFEHR includes coordination of specialized activities as well as reporting, controlling, communicating, promoting acquisition of third-party projects and supporting industry relations. EFEHR is one of the three thematic core-services for seismology in the European Plate Observing System (EPOS) infrastructure.

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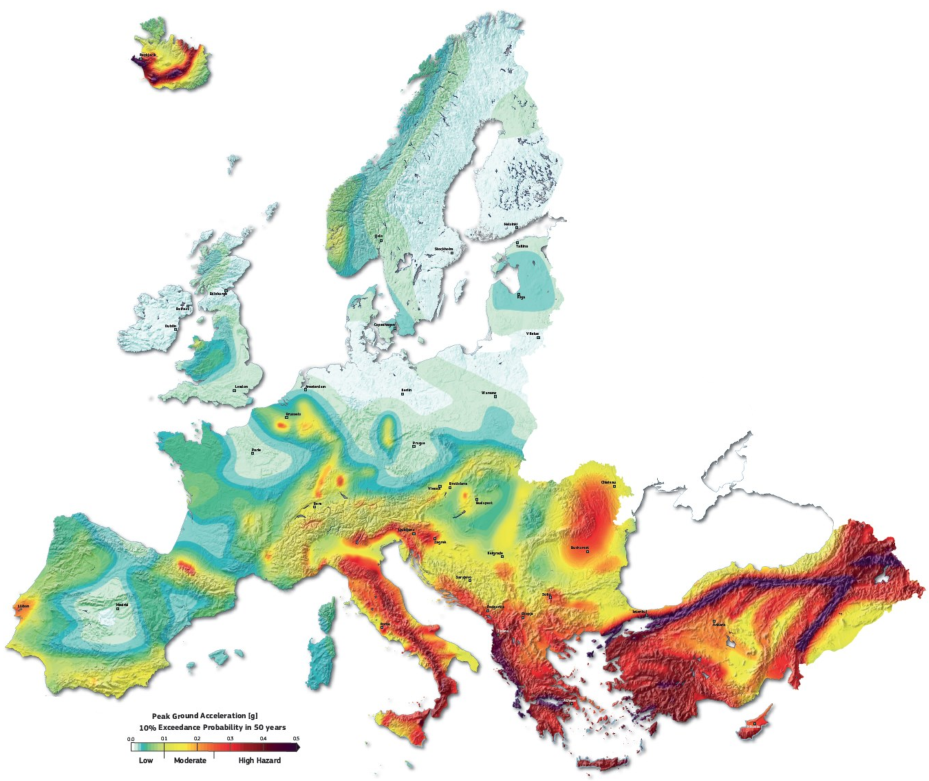
The EFEHR web platform (www.efehr.org) provides open access to seismic hazard and risk models. The EFEHR web-platform is the public interface of a complex system connecting databases of relevant datasets, inputs, outputs and model results with the functionality to access, visualize, and download the following hazard outputs: seismic hazard maps, seismic hazard curves and uniform hazard spectra. Web services are fully operational since 2013. The risk services are under development. In terms of available hazard models, the EFEHR web platform distributes the seismic hazard models for:

* The 2013 European Seismic Hazard Model (ESHM13, Woessner et al 2015)
* The 2014 Earthquake Model of the Middle East (EMME14, Giardini 2018)
* The 2015 Swiss Hazard Model (SuiHaz15, Wiemer et al 2015)
* The 1999 Global Hazard Map of the Global Seismic Hazard Assessment Program (GSHAP, Giardini 1999)

The EFEHR web platform provides a single access point for data, models and results. No user authorization is required.

Core activities:

- Provide open access to state of the art, authoritative and reproducible information on earthquake hazard and risk, harmonized across Europe and targeted to a wide range of stakeholders.
- Enable national and local hazard and risk assessment by providing access to the software, data, models, and expertise required for contemporary hazard and risk assessment.
- Conduct periodical reviews of the European hazard model and results, provide updated models when needed, thus moving to a "living" and dynamic seismic hazard model.
- Promote best practice and knowledge exchange within the research community.
- Review and quality control contributions to relevant databases for PSHA (e.g., active faults, site, EQ catalogues, GMPE, site).
- Promote standardization and connection to practitioners (e.g., Eurocode 8)
- Integrate with the engineering community in order to ensure a seamless transition from hazard to risk (exposure, vulnerability).
- Advise industry, national and regional governments.
- Support panels of experts.
- Provide access to computational capability. ■



source: Seismic Hazard Harmonization in Europe (SHARE): Online Data Resource (Giardini D. et al., 2013)

TA Project ARISTA: Seismic Assessment of ReInforced Concrete frames with SmooTh bArs - Proposals for EC8-Part 3

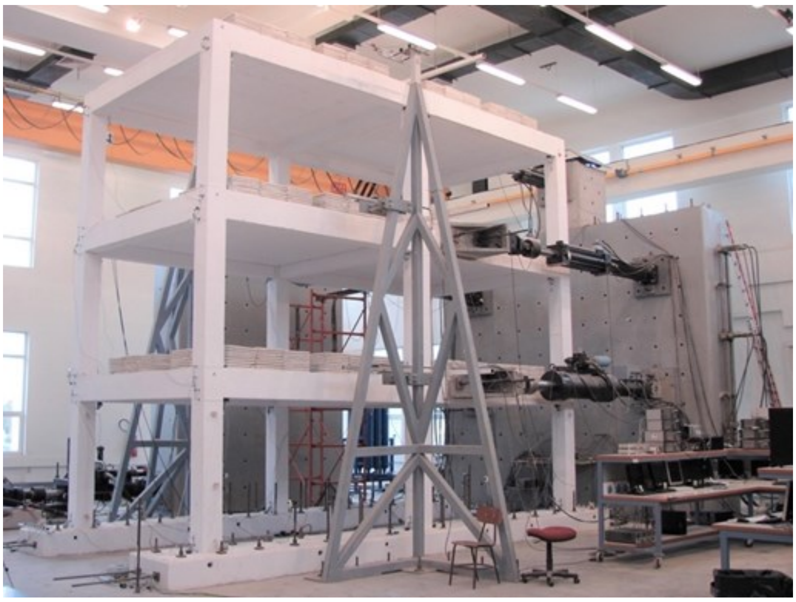
Christis Chrysostomou, Nicolas Kyriakides, Cyprus University of Technology, Panagiotis Kotronis, Centrale de Nantes, Sofia Grammatikou, DENCO Structural Engineering

TA facility: STRULAB reaction wall, University of Patras, Greece

Plain (smooth) bars are not used anymore as primary reinforcement of new concrete structures. The building codes of most countries have banned them from such a use for a long time now. Nonetheless, being common in old structures which are evaluated for rehabilitation, they enjoy the world's structural engineering community's renewed interest. Nevertheless, still little is known about how structure with plain bars behave in a strong earthquake.

The seismic behavior of a 1:1.5 scaled three-story two-bay Reinforced Concrete (RC) frame with smooth bar reinforcement was experimentally studied. The frame was designed for gravity loads and lacks any seismic design or detailing. An important parameter examined was the behavior of lapped column bars in comparison to continuous bars. Thus, two opposite columns of the specimen were constructed with continuous bars and the remaining four using spliced longitudinal bars, as per the standard design and construction practice used by older codes and designers. Columns had eight 12 mm plain vertical bars (at corners and mid-side), 6 mm perimeter ties at 150 mm centers (also inside the joints) with a 90-deg hook at one corner. Beams had two 16 mm deformed bars at top and bottom, continuous through interior joints and anchored at the corner ones with 90-deg bends; ties of 8 mm deformed bars at 100 mm centers had a 135-deg hook at one corner.

Additional dead loads of about 70 kN on each floor slab were placed to simulate the part of the permanent/useful loads acting concurrently to the earthquake.



Three-story, nearly full-scale specimen in STRULAB TA facility (arrows indicate columns with continuous reinforcement – in all others, bars are spliced)

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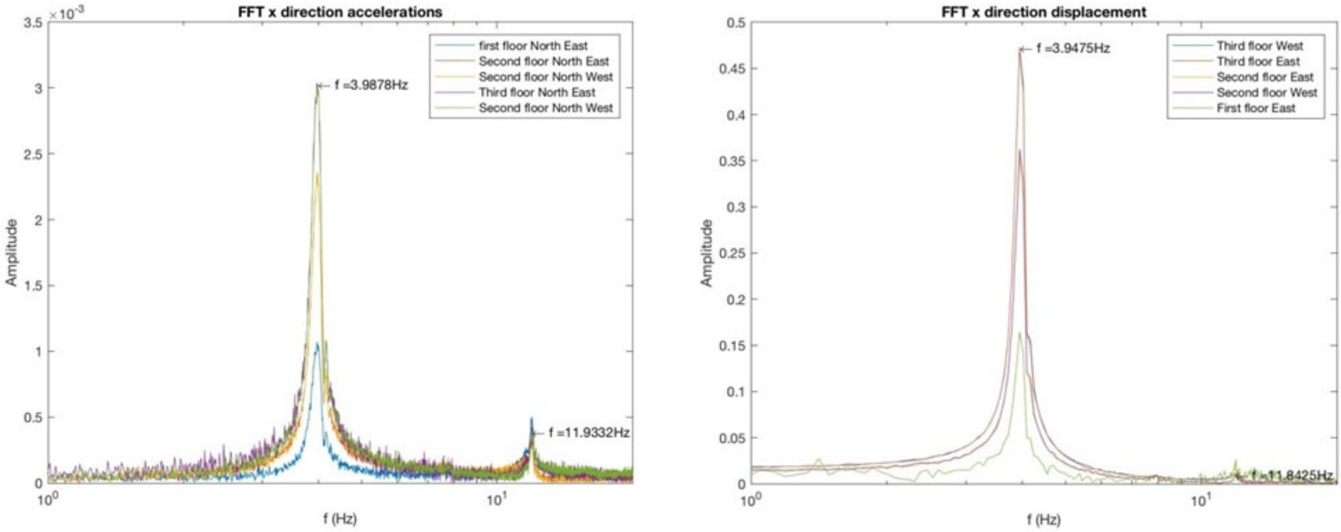


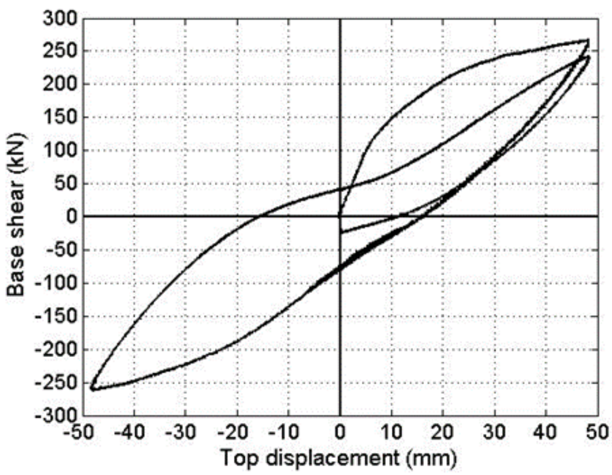
Response spectral accelerations and displacements of the specimen in the X-direction

Initially, a free-vibration test (snapback-type) was conducted to determine the dynamic properties of the specimen. The response spectral acceleration and displacements indicate a fundamental frequency of approximately 3.95 Hz in the X-direction.

The structure was then subjected to lateral loads applied along the long side of the structure. A prescribed history of cyclic roof displacements of increasing amplitude was applied by the actuator at the top. The actuators at the two lower floors were slaved to the top one so that an inverted triangular pattern of floor forces was applied, anchored to the force produced in the top actuator by the prescribed history of roof displacements. The horizontal deformation pattern comprised displacement cycles of +/-50mm amplitude at the top of the structure.
Several response parameters (forces, displacements, local deformations, strains) were acquired via a network of more than 100 transducers.

During the tests, the first and second story clearly yielded in the first half-cycle of loading, while overall yielding of the third story didn't take place until the end of the test. The inverted-S shape of base shear vs. top displacement loops is typical for cyclic bond-slip behavior and shows that the hysteretic behavior of all stories is dominated by bond along the column bars.

The top and base sections of all six columns in the two lower stories opened up from the first load cycle, while hairline diagonal cracks at the exterior face of every beam-column joint - with the exception of those at the roof - opened during this phase of testing, but were not visible after it.



Base shear force vs top displacement curves for the first cyclic test

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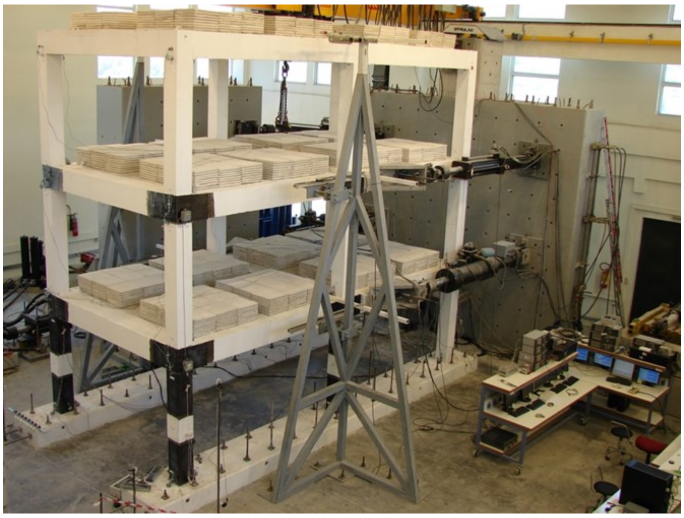
Observed damage after first cyclic test

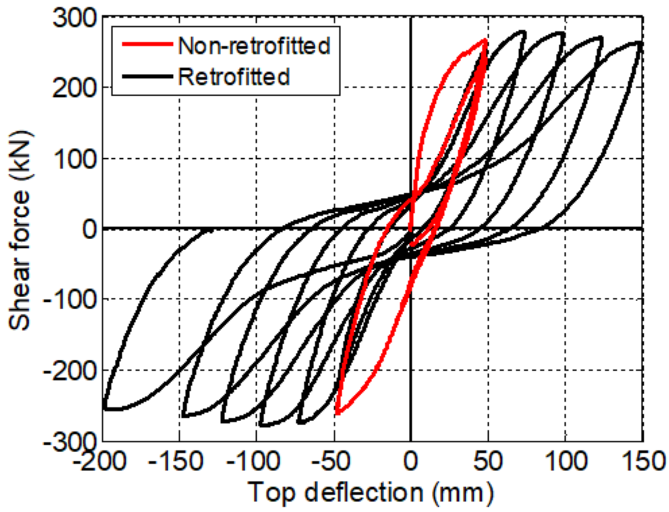
In the next phase of testing, the top and bottom part of three columns (two with lap-spliced bars and one with continuous ones) and the respective joints at first and second stories were retrofitted with two plies of epoxy-glued carbon-fiber reinforced polymer (CFRP) sheets providing of adequate anchorage.



FRP retrofitted frame

A second cyclic test took place up to a top displacement of 150mm. The test showed that neither the lap splices nor the Fiber Reinforced Polymer (FRP) wrapping of the column end regions had a systematic effect on the behavior of columns. The FRP wrapping had only little impact on the column response. The reason is that the FRP wrapping slightly increases the yield moment and the stiffness of a member, but it drastically improves the flexural deformation capacity. In this case, however, deformation capacity was beyond the deformation demands.

Cracking at the interfaces of columns and joints but also at the interface with the foundation beam were more obvious after this second test at all interfaces of the first floor.



Base shear vs top displacement of the initial and the retrofitted frame

A final monotonic test was conducted to define the capacity of the retrofitted frame, pushing it to 200mm. After removing the - already detached - FRP wrapping from joints and column ends, larger cracks at the interfaces became evident. The same applies for the diagonal cracking in joints which reached a width of 10 -20mm.

Overall, structural performance was not adversely affected by the use of plain bars; in fact, the large fixed-end-rotations due to slippage of column bars made possible the development of appreciable chord rotations and interstory drifts, without serious damage or residual deformations. Despite that the hysteretic behavior of all stories in the frame was governed by the bond along the column bars, cyclic strength decay - typical of bond-slip loops - was not observed. Apart from the visible residual cracks at column end sections, the rest damage inflicted by cyclic loading had little to do with the use of plain bars in the columns.

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Column deformations were concentrated at flexural cracks at the top and bottom sections, thanks to slippage of the plain bars.

Neither the lap splices nor the FRP wrapping of the column end regions were found to have a systematic effect on the behavior of columns.

The cyclic behavior and performance of the frame may be considered satisfactory, apart from the diagonal cracking of joints, which had little to do, though, with the plain bars in the columns. ■

Cracking at column-foundation and column-joint interfaces of the first floor

Cracking at interfaces and joints after final monotonic test

3D Model of a Soft Basin Embedded in Bedrock, the EUROSEISTEST Case Study - TA Project IMPEC

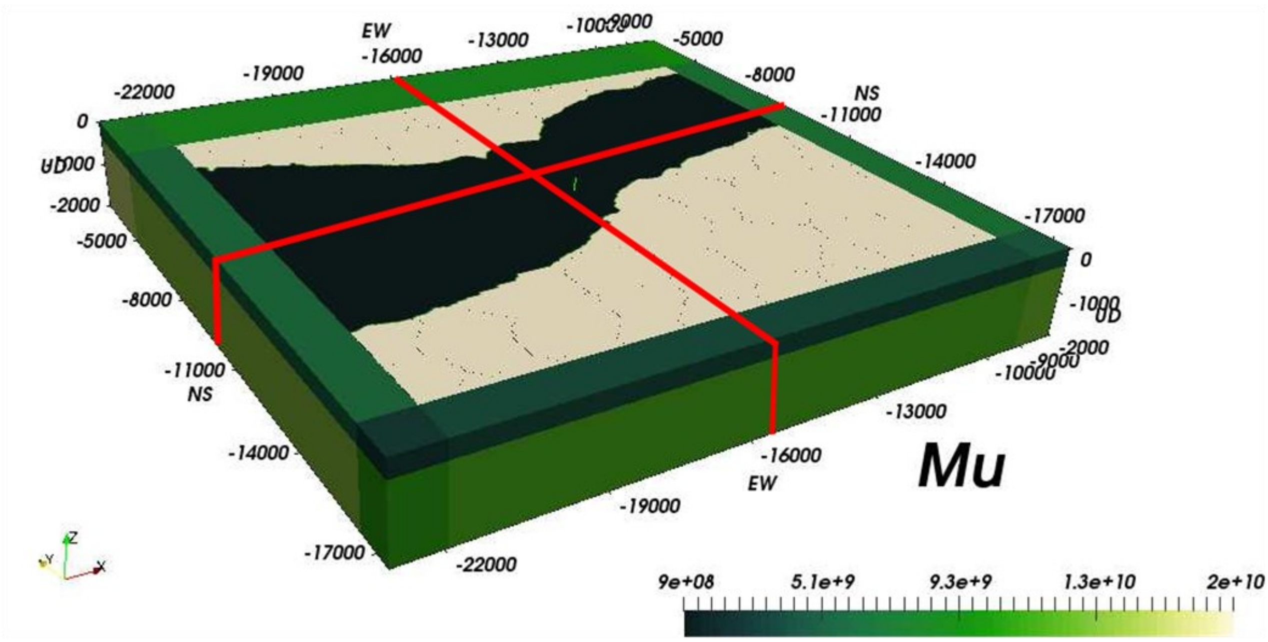
Gatti, F., Touhami, S., Lopez-Caballero, F.

CentraleSupelec, FR

Surface morphology as well as soil stratification and composition are decisive parameters influencing seismic motion time histories recorded on the earth surface. To study these effects at the Volvi basin (Thessaloniki, Greece), geological data from the Euro-SeisTest experimental station on site were employed to construct a 3D numerical model of the basin.

The investigation targeted at exploring how soft sediments affect the dispersion of the earthquake ground motions and at assessing its impact on the 3D geological interfaces and the spatial fluctuations of the mechanical properties.

A source-to-site computational model is built, configured as a three-dimensional soft basin embedded in bedrock. The transient wave-field is computed applying the 3-D spectral element method in elastodynamics, to enhance compositional efficiency, the effort is divided over large parallel supercomputers. Earthquake simulations at regional scale (tens of kilometers) is performed, including the irregular edges of the basin.



Layout of the spectral element model of the Mygdonian basin

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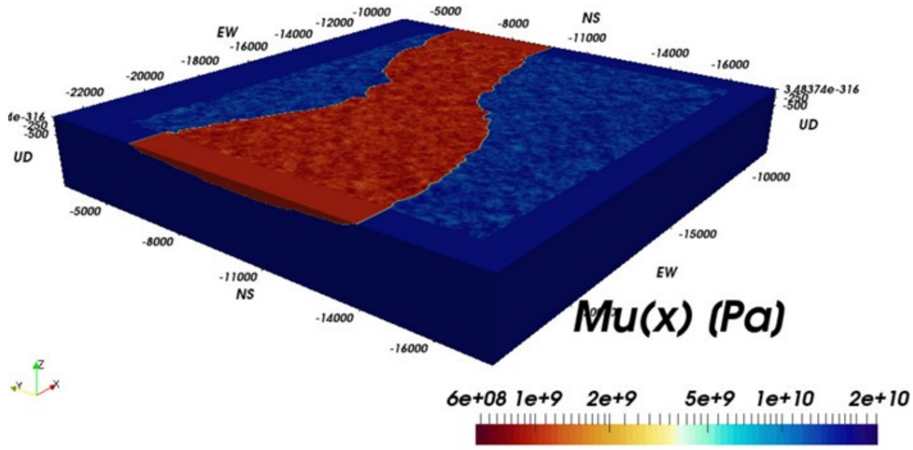
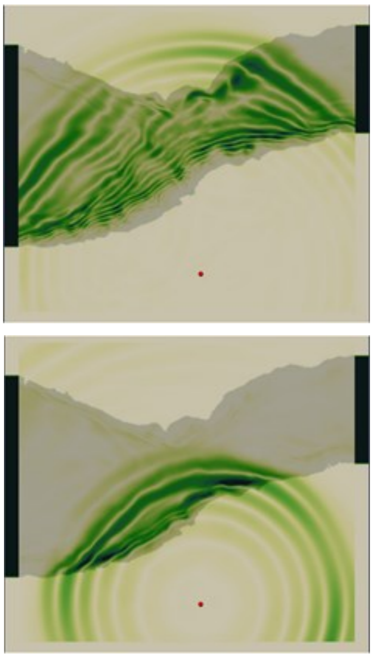
The spatial modification of the soil shear modulus is integrated into the model as a multi-variate stationary random field. The effect of soil heterogeneity is compared to the homogeneous soil. This allows to assess the influence of the soft basin behaviour on the ground motion.

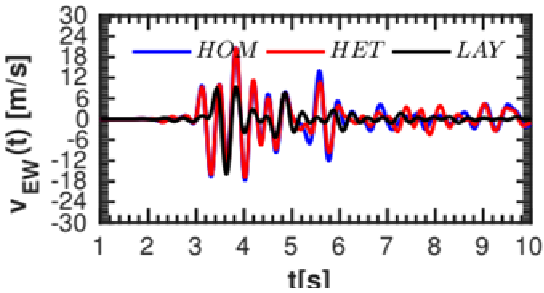


Example of the heterogeneous shear modulus.

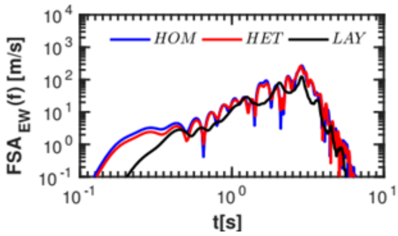
The effect of the soft basin is studied in terms of time series recorded at the soil surface and in terms of wave motion coherency. The basin scatters the wave motion propagated from the hypothetical fault, trapping the radiated energy due to the great basin-crust large stiffness contrast. In contrast, the soil heterogeneity acts at a smaller scale, inducing local scattering which is poorly visible in this low frequency range. As future developments, the softer basin layers will be included in the analysis, along with an increased frequency range, allowing to evaluate the role of the soil heterogeneity at higher frequencies.



Velocity Contour plots



Time history at the center of the basin.



Fourier spectrum at the center of the basin.

What is Hybrid testing and geographically distributed hybrid testing?

Patrick Covi, Nicola Tondini, University of Trento, Italy

Earthquakes are one of the most destructive and unpredictable events of nature with catastrophic consequences for both people and built environment. Secondary triggered effects can strike further an already weakened community, i.e. ground shaking, surface faults, landslides and tsunamis. In this respect, also fires following earthquake (FFE) are a considerable threat. They can be widespread both at the building level as well as at a regional level within the area affected by ground shaking due to damaged gas lines, failure of electrical systems etc. together with the failure of the compartmentation measures.

Such catastrophic events also cause damage to structures and impact local, regional and sometimes even international economies in the long-term. The reliable prediction of nonlinear structural behaviour and the failure mechanism during severe seismic or FFE events has proven to be an extremely difficult task.

Experimental research therefore is critical towards better understanding and prediction of the seismic and fire response of structural and non-structural components. There are different experimental techniques that can be used to test the response of structures to verify their seismic and fire performance:

- Numerical simulation of the structure: the real behaviour of the elements/structures may be very different.
- Physical tests on single components: for example, tests on single components subjected to standard heating curves or partial subassemblies. They offer significant information for the understanding of seismic and fire performance of specific structural elements, but they do not provide insight on the interaction between the fire development or the seismic actions and the whole structure.
- Physical full-scale tests of the whole structure: For example, by using an earthquake shake table, where structures are excited in such a way that they are subjected to conditions representative of true ground motions caused by an earthquake. However, large-scale structural seismic or fire tests are expensive and need specialized facilities.
- Physical small-scale test of the full structure: due to the limitation on the size and capacity of facilities, structures are typically tested on a reduced scale or a highly simplified model is used. Testing with reduced scales or simplified models has the downside of not adequately representing the response of the full-scale structure which questions the validity of this type of test.

In order to overcome such limitations, Hybrid Simulation (HS), which is also called pseudo-dynamic test method, represents a tempting approach.

Kobe Earthquake 1995 (Japan)

Hybrid simulation, extensively investigated in the seismic domain, is a hybrid procedure that combines classical experimental techniques with online computer simulation for cost-effective large-scale testing of the structure under simulated loads.

In detail, hybrid simulation facilitates the study of structural response by experimentally testing only the critical portion of the structure (for example the part of the structure being studied or some part, where it is difficult to simulate its behaviour), while the rest of the structure is modelled numerically in a real-time computer.

The hybrid model of the prototype structural system **combines numerical and physical substructures** (NSs and PSs).

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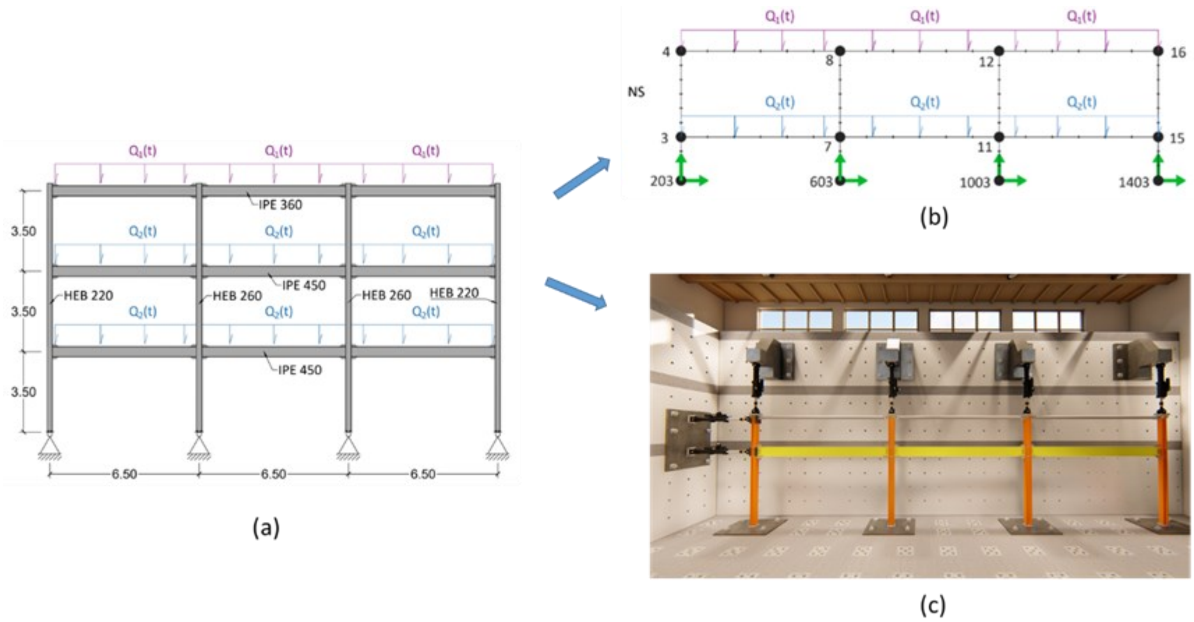
Example of physical substructure

At each step of the analysis, the governing equation of motion is solved, similar to pure numerical simulations using a time stepping integration. The calculated displacement demands are then sent to the laboratory and applied to the physical substructure using computer-controlled actuators while the numerical portion is analyzed in real-time. The resisting forces (typically axial and shear reactions and sometimes also moment reactions) are measured and sent back to the computation solver to calculate the displacements corresponding to the next time step. This is an iterative process and it is repeated until the time-history loads (like ground motion, temperature increment) are concluded.

Geographically distributed hybrid testing is one recent concept that has been developed from the use of substructuring techniques and benefited from technological advances in data transfer and computing. The concept of geographically distributed testing is that individual substructures do not need to be within the same facility and do not need to be in the same laboratory, but can be linked by methods of data transfer with minimal latency between the laboratories, like RTC (Real-Time Communications).

For the experimental substructure, one or more laboratories with different facilities can be chosen and used. In terms of the numerical portion of the hybrid simulation, there are also benefits in allowing for the use of more powerful computers or even supercomputing facilities to run the hybrid simulation test since those supercomputers do not need to be in the same laboratory. ■

Example of a geographically distributed scheme



Example of substructuring: a) full structure; b) numerical substructure; c) physical substructure.

EXPERIMENTAL INVESTIGATION OF INDUSTRIAL PIPELINES SEISMIC RESPONSE

Rocco di Filippo, Oreste S. Bursi, University of Trento, Italy

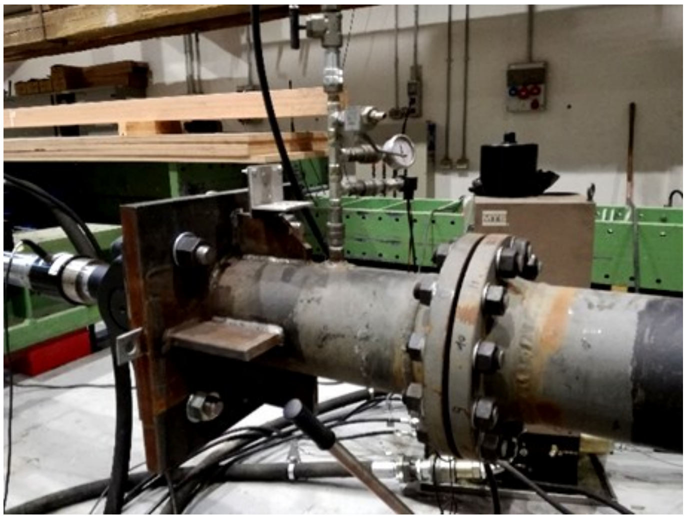
Industrial facilities like chemical, oil and gas plants can trigger severe environmental and human consequences when subjected to seismic action. Moreover, such consequences are not always limited to the facilities themselves but possibly affecting nearby communities, infrastructures and plants. As a matter of fact, earthquakes can cause exceptional human and economic losses in the case of natural-technological, or NaTech events. Some recent examples of such events are petrochemical plant fires during the Izmint earthquake of 1999, environmental chemical contaminations following the Sichuan earthquake of 2008 and the nuclear and radiation accident caused by the 2011 Fukushima earthquake.

Oil refinery in Ichihara after Fukushima earthquake

In order to prevent serious consequences of NaTech events, the European directive Seveso-III (Directive 2012/18/EU) explicitly states that safety reports for industrial plants involving hazardous substances should include “detailed description of the possible major-accident scenarios and their probability or the conditions under which they occur”. The methodology of performance-based earthquake engineering (PBEE) can compute the probability of failure under seismic action and is generally applied to quantify seismic risk of nuclear power plants. However, this framework is not so commonly adopted for petrochemical plants.

As a matter of fact, industrial plants often encompass numerous components with different associated risks to external actions. One of these components are pipelines, widely adopted in petrochemical facilities and demonstrated to be vulnerable to seismic action. Common vulnerable components of industrial pipelines are bolted flange joints, tee joints and piping bends or elbows. Among realistic failure scenarios, leakage or loss of containment of hazardous substances is one of the possible effects of pipelines failure and can severely affect the environment and the nearby communities.

Focusing on pipeline components, bolted flange joints are quite complex since they are highly confined, statically indeterminate systems and because they involve a high degree of non-linearity. As a result, it is difficult to correctly estimate their resistance and stiffness, as also the threshold of leakage.



Bolted flange joint from the tank-piping system under study

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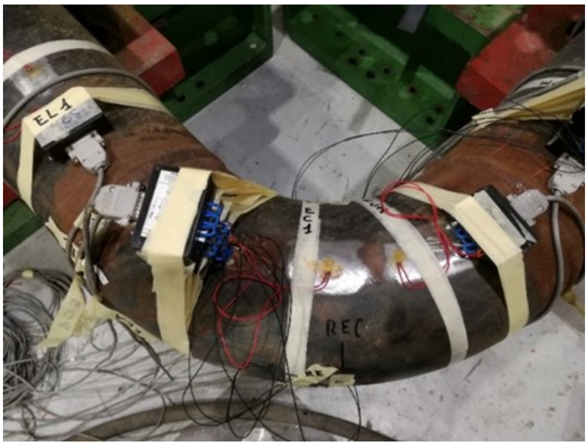
Among industrial piping components, tee joints are one of the most critical components due to stress concentration. Considering the specific case of petrochemical plants, the event of loss of containment in tee joints can generate severe consequences. However, tee joints' seismic resistance is poorly investigated and, consequently, related regulations prescriptions lack of details and accuracy which can lead to an inefficient design and incorrect safety assessment.

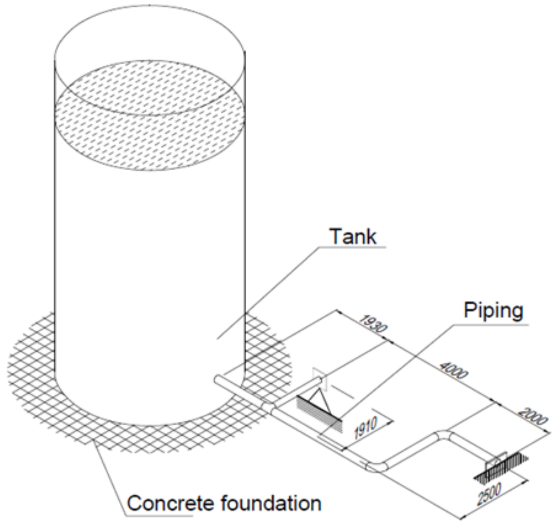
Tee joint from the tank-piping system under study

Piping elbows are a critical component in a piping system characterized by high flexibility, level of stresses and strains and a significant cross-sectional deformation. Since the goal of this experimental campaign is the investigation of the onset of leakage triggered by seismic action, particular attention is paid to pipe bends due to their vulnerability.



Piping elbow from the tank-piping system under study

Within the SERA project, we study the seismic response of a coupled tank-piping system by means of hybrid simulation. Specifically, the hybrid model of the system under study combines numerical (NSs) and physical substructures (PSs). In our case, the steel tank is the NS and the piping network the PS.

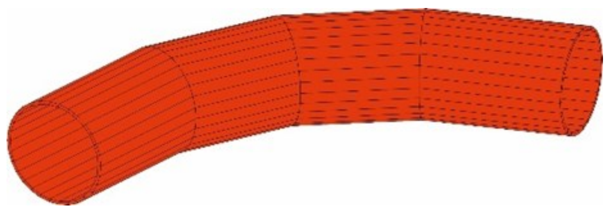


Scheme of the realistic tank-piping system under study

Experimental hybrid test setup

As a first step we define a seismic scenario associated to a geographical site by means of a probabilistic seismic hazard analysis. Then, based on this analysis we provide an adequate seismic input employing a stochastic ground motion model calibrated against coherent natural seismic records. Moreover, we carry out a global sensitivity analysis to reduce the space parameters of the stochastic model and we synthetize a large set of ground motions to be used in both experimental tests and finite element simulations.

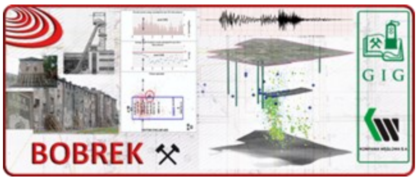
In addition, two different finite element models, a refined high-fidelity and a faster low-fidelity model are calibrated against both hybrid simulations of the whole system and cycling tests of vulnerable components, i.e. piping tee joints and bolted flange joints. ■



Computer finite element model of a piping elbow

Access to Data and Products on the IS-EPOS Platform for Induced Seismicity and Anthropogenic Hazard

Monika Sobiesiak, IGPAS, Stanisław Lasocki, IGPAS, Kostas Leptokaropoulos, IGPAS



Deep underground mining for metal resources, geothermal power production, exploitation of hydrocabons by fracking procedures or water reservoir impoundments are human technological activities which not only make the desired resources available to us but also may induce unfavorable side effects. These can be the triggering of micro-earthquake or large earthquake, landslides, rockfalls, and contamination of groundwater, just to name a few. These biased consequences of human actions on the natural environment cause numerous controversies which foster the need of objective information as well as scientific approaches for the understanding of the observed phenomena. Responding to these needs, the IS-EPOS platform for induced seismicity and anthropogenic hazard offers an Internet environment where relevant data sets (episodes) as well as software tools (applications) for scientific data analysis are available. Hence, the platform is dedicated to all users from research experts, over engineers from industry, governmental and political entities and, last but not least to the interested and concerned public. In the framework of the SERA project, the platform facilitates the direct virtual access to its resources. IS-EPOS platform is accessible through https://tcs.ah-epos.eu. The platform resources are open to all; however, the user has to go through a simple registration process, for statistical purposes.

Episodes: The collection of episodes on the platform gives a representative overview of available data on seismic processes linked to all types of inducing technological activities from water reservoir impoundments to deep underground mining. Such a collection facilitates e.g. comparative studies, where researchers want to see how specific parameters behave in other environments and conditions. No time consuming search is needed in this case as the platform offers a multitude of data from different environments.

Each episode is composed of a time correlated collection of seismic data and data which represents the technological activity, which is the cause of the undesired observed process. Also included is relevant geodata describing the respective environmental constraints of the area where human activity and the seismic processes take place. The contents of an episode depend also on the availability and the decisions of the respective data suppliers. All episodes have a seismological catalog and most of them also event related or even continuous waveforms.

Depending on the type of anthropogenic activity, industrial data can consist of water injection rates, water levels and volumes, mining front advances, injection pressures etc. among other monitored parameters. Geodata incorporates most frequently used models of mines, velocity models for seismic event location, deformation measurements, etc., all in georeferenced data. What can result from the combination of injection rates and seismicity event rate at a geothermal power production site is shown in the figure below.

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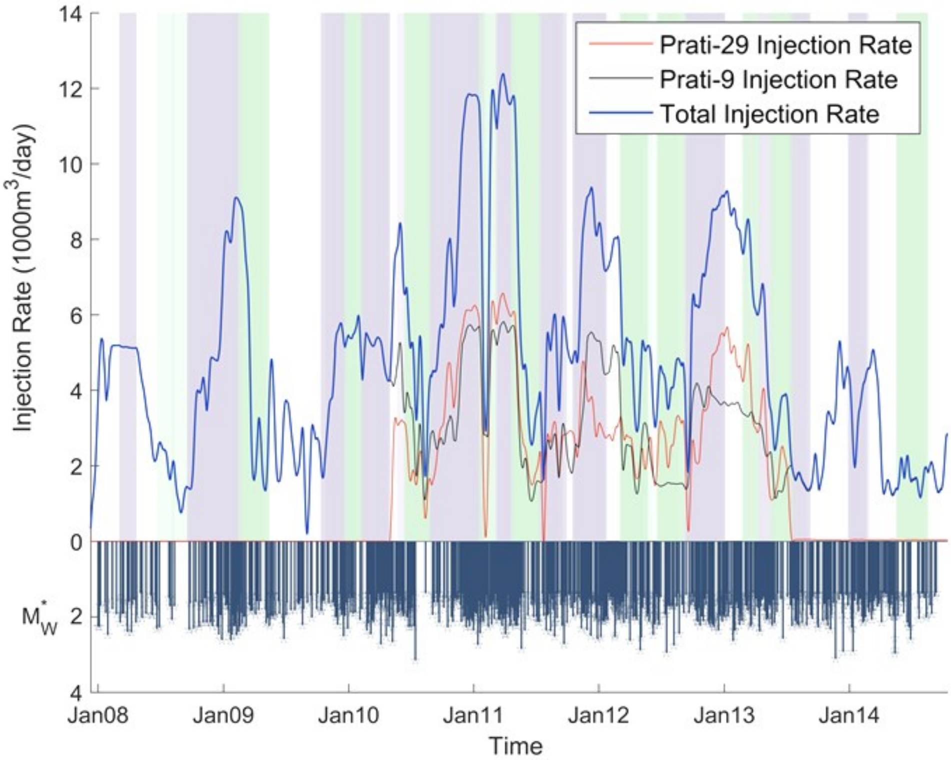
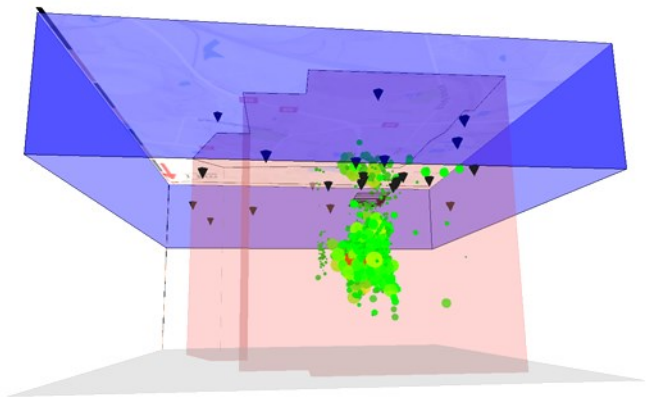


In this figure, 3 different daily injection rates at The Geysers geothermal field are given: total injection rate (blue curve), individual injection rate for the well Prati9 (black curve) and Prati29 (red curve). Below the injection rates, the seismicity rate is given by a blue stem for each event. The vertical bars behind the injection rates indicate time periods of 50 days which have significantly increased (gray bars) or decreased seismicity rates in comparison with the preceding 50 day window. The moving windows overlap. The total amount of data comprises more than 7 years. Figure taken from Leptokaropoulos et al., 2017.

Applications: Apart from the data collection, the platform offers software tools called applications which are ready to use on the chosen data sets. It can be either used to quickly check if the episode is valuable for the study purpose or to run a complete study e.g. the statistical properties of a catalog or the mechanisms of small induced earthquakes. The applications' list comprises software tools for data handling, data processing, resource management and visualization. Figure below shows a 3D visualization of the induced seismicity of Bobrek Coal Mine in the region of Silesia, southern Poland.



3D visualisation of induced seismicity (green dots) in Bobrek Coal Mine. The purple volume is reflecting the velocity model, the rose colored volume encompasses the mining area. Black cones mark the seismologicalstation sites.

Workspace: In order to apply software tools to selected data sets, everything has to be transferred to the user's workspace. The episode data transferred to the workspace can be downloaded to the user's personal IT hardware. The user can also upload own data for tests and analysis with the platforms' applications. Another important feature of the workspace is that it simplifies and supports collaboration among users in common research projects. A share function facilitates the exchange of data and results via notifications through the email accounts of the participating users.

The IS-EPOS platform provides VA access to the platform resources which were granted and available at the time when the SERA grant agreement was signed[1]. However, the platform's resources have been continuously growing since then and the platform administration is opening access to everything that is possible. Below, some technical facts about the current status of the platform are given:

* Data Centers: Polish eNODE – CIBIS (Warsaw), French eNODE – CDGP (Strasbourg), collaborating Data Center KNMI.
* Data Providers: in total 28 episodes are on the platform from institutions of 10 different countries.
* Applications: 35 tested applications are available for users of the platform.
* Users: 878 users from 152 institutions worldwide use the platform. ■

[1] *These resources resulted from the IP-EPOS Polish national Project, 2013-2015 (Co-financed by the European Regional Development Fund (ERDF) as part of the Operational Programme Innovative Economy (OP-IE), Intermediate Body – The National Centre for Research and Development, Operational Programme Innovation 2007-2013, Priority Axes 2 – Infrastructure of R+D Sphere, Measure 2.3 – Investments connected with development of IT infrastructure of science.*

Access to data and services for engineering seismology: strong-motion records, macroseismic data and seismogenic fault data

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Engineering seismology is the study and application of seismology for engineering purposes. On the one hand, this involves understanding the source, the size, and the mechanisms of individual earthquakes, as well as the frequency of occurrence of earthquakes over time. On the other hand, it also involves the understanding of how the ground motion propagates from the source to the site of interest, the characteristics of ground motion at that site, and how the ground motion must be evaluated for engineering design. Therefore, it is a link between earth science and civil engineering. A fundamental task for engineering seismologists is to access the information that lays behind seismic hazard and risk models. In the past decades, the amount of open-access data has dramatically increased thanks to the advances in information technology and the momentum gained by European and national projects in developing infrastructures to host data and promote their interoperability. These circumstances resulted in significant improvements of dedicated thematic repositories and of the tools that facilitate the user to access data and services.

It was not until few years ago that any study related to engineering seismology needed the construction of project-related datasets which implied lookup procedures into local, often offline if not even on paper, repositories. Data lacked metadata, so that it was not easy to get familiar with their format before starting to use them. Data collection used to be very time consuming. Moreover, data were not standardized so that an additional work of format conversion was often necessary, which implied a waste of resources.

SERA-VA3 aims to overcome these difficulties of the past and wants to bring the data at the users' fingertips. It offers access to reliable and extensive data sets and services for the community of engineering seismologist and other specialists. They include the European Strong Motion Database (ESM), the European Archive of Historical Earthquake Data (AHEAD), and the European Database of Seismogenic Faults (EDSF).

European Strong Motion Database (ESM)

ESM is a centralised collector of European strong motion data, with a magnitude threshold of seismic events equal to 4. It archives the waveforms recorded since 1969 by about 50 European seismic networks and provides end-users with quality-checked and manually processed waveforms. The database is updated daily with new waveforms and metadata. The service is distributed and regulated under the umbrella of ORFEUS (Observatories & Research Facilities for European Seismology, www.orfeus-eu.org/) and is one of the pillars of EPOS-seismology (WP8 - waveform distribution). Data are accessible through a user-friendly web interface, whereas peak motions are accessible through a dedicated web-service (e.g. USGS peak values).

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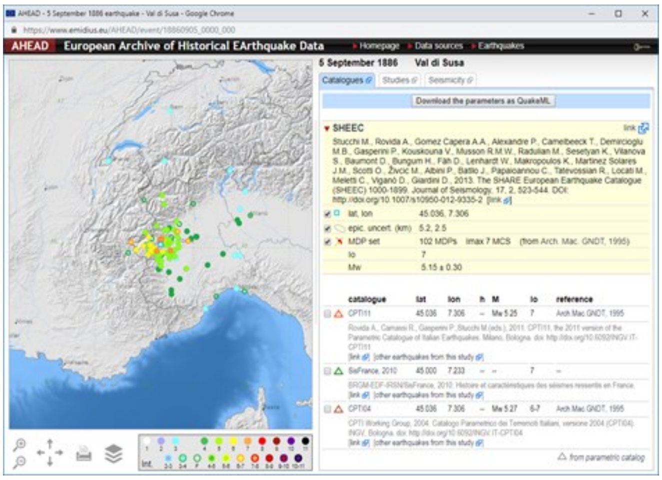
European Archive of Historical Earthquake Data (AHEAD)

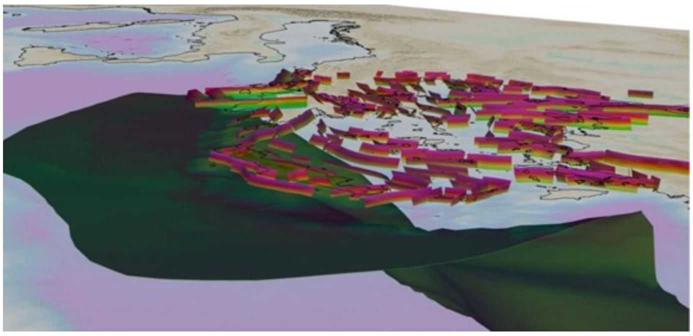
AHEAD collects and distributes bibliographic, macroseismic, and parametric data on nearly 5000 European earthquakes from 1000 to 1899 CE, as provided by regional and national data-centres and the literature, with more than 200 data sources (available as PDF or links). All the data are accessible through a dedicated, user-friendly web interface, and through standard and documented web services (FDSN-event, OGC WMS, OGC WFS). AHEAD also provides the parameters, together with the macroseismic data at their basis, of the European catalogue used for the ESHM (European Seismic Hazard Model) 2013, and its 2020 version that is being developed in the framework of SERA.



AHEAD. Web interface example for the earthquake parameters (left) and macroseismic data (right) available for the earthquake occurred on 5th of September 1886 at border between Italy and France.

European Database of Seismogenic Faults (EDSF)

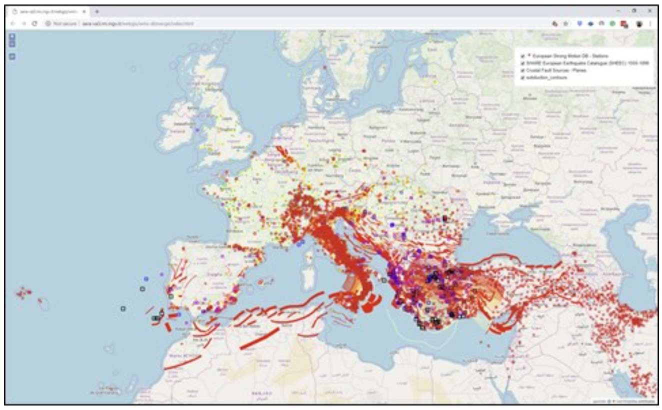
EDSF was designed, developed, and compiled by many geoscientists in the framework of the EU FP7 Project SHARE (Seismic Hazard Harmonization in Europe). EDSF includes faults that are deemed capable of generating earthquakes of M≥5.5 and aims to ensure a homogenous input for earthquake hazard assessment in the Euro-Mediterranean area. EDSF distributes data about crustal faults and subduction zones. The current version of the database counts 1128 records, totalling 63775 km of crustal faults, from Iberia to Anatolia, and three subduction zones, known as Calabrian Arc, Hellenic Arc, and Cyprus Arc in the central and eastern Mediterranean Sea. All the data and metadata are accessible through a dedicated, user-friendly web interface, and through documented web services (WFS, WMS, CSW) following the OGC standard protocols.



EDSF. Oblique view (looking to northwest) of the Aegean region showing a selection of crustal faults and the slab of the Hellenic Arc subduction. This view was made by performing a spatial query on EDSF and importing the selected data on a desktop software.

These three databases are intrinsically diverse and were originally conceived as separate entities, therefore coordination and optimization efforts are being carried out in the framework of SERA VA3 to blend them together.

The starting point of the integration of the three services was the construction of a web portal that works as a unified access point (http://sera-va3.rm.ingv.it/) to the data and services. This portal not only guides the visitors to the three original database portals, but it is also meant to provide an enhanced navigation experience through the data. The webpages feature a glossary of technical terms that are commonly encountered within the domains of the offered services, whose definitions spread on all webpages and appear in a tooltip message when hovering the mouse on highlighted words. Integrated access to the data will also be provided through a map viewer.



Map view of the three integrated services (ESM, AHEAD, and EDSF) through a prototyped WebGIS.

Finally, in order to facilitate the creation and sharing of information, ideas, and career opportunities we attempt to create a virtual community using social media (Twitter: @sera_va3) to advertise new releases of data and services, and useful information about conferences or workshops. ■

Orfeus: Observatories and Research Facilities for European Seismology

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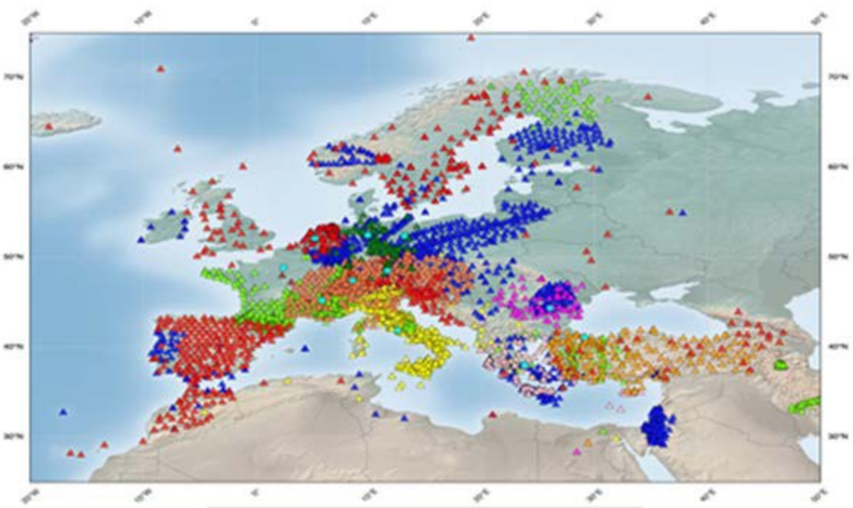
ORFEUS (www.orfeus-eu.org/) is a collaborative non-profit foundation that promotes seismological knowledge in the Euro-Mediterranean area through the collection, archival and distribution of digital seismic waveform data, metadata and derived products. ORFEUS is one of the largest infrastructures in the world that provides seismological waveform data to the scientific research community in strong collaboration with European seismological observatories. The ORFEUS infrastructure is built around a networked system of European seismological observatories, data archives and services. ORFEUS is one of the three pillars of the Thematic Core Service for Seismology within the European Plate Observing System (EPOS Seismology).

Two Service Management Committees (SMCs) are established within ORFEUS to manage, operate and develop (a) the European Integrated waveform Data Archive (EIDA; www.orfeus-eu.org/data/eida/); and (b) the European Strong-Motion databases (SM; www.orfeus-eu.org/data/strong//).

EIDA transparently connects (currently 10) large data centers in Europe, including the ORFEUS Data Center. This unique, federated archive serves seismological data from permanent (>100) and temporary (>100) networks of broad-band sensors and strong motion sensors deployed in Europe and beyond through dedicated services.



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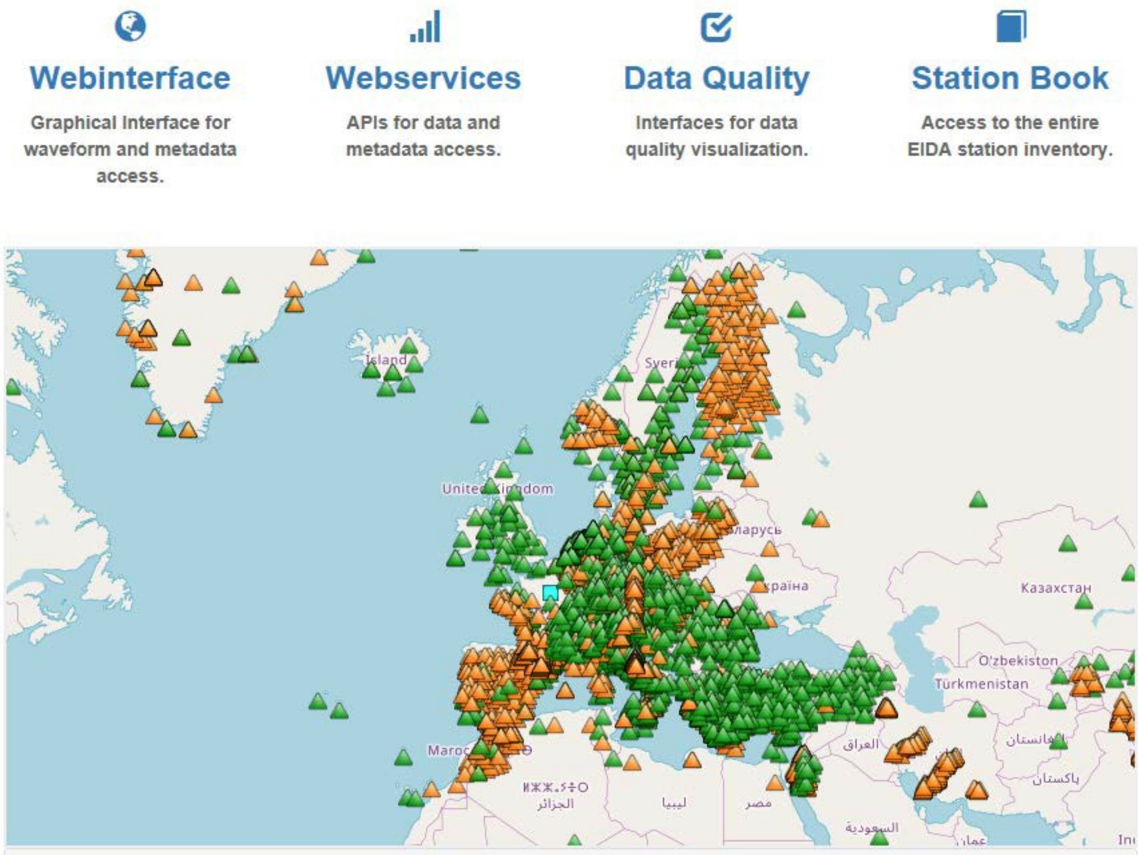

Access to waveform data is secured by services: a web interface, standardized webservices, data quality services and the Station Book.

The ORFEUS strong-motion databases provide high-quality automatic (RRSM) and manually processed (ESM) waveforms, peak-motions and engineering parameters for any earthquake occurring in the Euro-Mediterranean region, starting from M>=3.5 for automatic processing. Virtual access to seismological waveform data is provided through webservices, interactive services and clients.

Webservices:

* fdsnws-dataselect - FDSN standardized webservice for mini-SEED waveform data.
* fdsnws-station - FDSN standardized webservice for station metadata.
* eidaws-routing - EIDA standardized webservice for routing between EIDA services.
* eida-wfcatalog - EIDA standardized webservice for waveform metadata.
* EIDA federator - webservice for collecting data without a-priori knowledge of where data is hosted.
* EIDA authentication - webservice to provide tokens from a central authentication system for EIDA.

Interactive services:

* ORFEUS website - the landing pages for all information concerning ORFEUS, EIDA and services.
* EIDA GUI - the web interface to interactively search for and download data from EIDA.
* StationBook - the GUI to access all (available) information on seismic stations across EIDA.
* RRSM GUI - the webinterface to search for and collect strong motion products in near real time.

Clients:

ORFEUS Data Center developed a number of specific clients (www.orfeus-eu.org/data/odc//) to display features like data latency, event waveforms and data quality parameters. ■