Hyperion

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Development of a Decision Support System for Improved Resilience & Sustainable Reconstruction of historic areas to cope with Climate Change & Extreme Events based on Novel Sensors and Modelling Tools

EDITORIAL

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Editorial by HYPERION Project Coordinator, Dr. Angelos Amditis

Dear readers,

I' am very pleased to welcome you to the third and last issue of the HYPERION Magazine! An annual publication created to present the project's major results and achievements, through its third year of activities. During this year, HYPERION consortium had the pleasure to meet again in person after the pandemic outbreak and coordinate to finalize project's research results and carry out our vision to promote the sustainable preservation of cultural heritage around the globe. As Climate Change is becoming more and more a crucial topic globally, HYPERION's research results become even more significant and relevant. Climate Change, ravages of time, intense geological phenomena, extreme weather conditions, all having an impact on historical areas hosting Cultural Heritage sites. Resilience is an essential attribute as we move through this crisis and into the future. In this context, during its last steps, HYPERION drove deeper, launching its final results, aiming to address these challenges, bringing a major impact on improving the conservation-restoration process and safeguarding of tangible cultural wealth. In this magazine, you will have the opportunity to review all HYPERION's research results and significant activities.

A major thank you to all HYPERION partners for contributing to this issue by sharing their research developments but also for the superb cooperation throughout the course of the project. As I often say, Cultural Heritage is not something of the past but it a foundation that fosters our root to the future, let's save it all together.

Thank you.

Welcome message by HYPERION Project Manager, Dr. Antonis Kalis

Dear readers,

Welcome to the third and last issue of HYPERION's annual magazine! HYPERION is a pivotal EU funded project which started in June 2019, and marks the strong concern of the European Commission on preserving Cultural Heritage in times of Climate Change (CC). Project's goal was to create a strong safety net for supporting both the Cultural Heritage structures, and the surrounding communities supporting their resilience. This is of utmost importance in an era of globalization and extreme CC related events, helping in the development of communal bonds, now and in the future. In this issue, we are pleased to present HYPERION's recent results and developments which pave the way for reaching HYPERION's goals towards resilient Cultural Heritage districts.

During HYPERION's course, the consortium worked on innovative methodologies which will help to assess the effect of a multitude of CC or human inflicted threats on the landmarks themselves and launched a Holistic Resilience Assessment Platform, aiming to address multi-hazard risk understanding, ensure better preparedness, faster, adapted and efficient response, and sustainable reconstruction of historic areas. HYPERION also developed and presented a mobile application, a community engagement tool that amplifies community involvement both proactively and reactively to major disrupting events, and business continuity plans to strengthen community responsiveness. Read all about its significant results and activities in the following pages.

Happy reading!

HYPERION's Overall Progress

Throughout its duration, HYPERION has tackled four pilot cities, and achieved progress in diverse fields of science and engineering. The work performed touches upon structural analysis of cultural heritage monuments, hygrothermal assessment, damage analysis of wood and stone materials, seismic and weather hazard assessment, socioeconomic modelling of disaster impact, resilience assessment of urban communities, satellite and unmanned aerial vehicle sensing, photogrammetry, weather mesoscale modelling, wind modelling via computational fluid dynamics, insurance, and numerous other topics. HYPERION's results extend to several emblematic cultural heritage monuments, instrumented and assessed in detail, and to four living and breathing cities with cultural heritage cores that are the lifeblood of their economic activity. By virtue of the HRAP platform, HYPERION offers a user-friendly way to monitor said cities, run what-if and what-is scenarios, and make decisions on their future under the influence of climate change and pertinent external stressors. Most importantly, it delivers innovative financial mitigation tools and proposes reciprocal sector-wide business agreements to assist residents and city officials in protecting their heritage and livelihood for years to come.

1. HYPERION's Scientific Progress

1.1 Conferences

HYPERION project consortium presented the following conference papers & abstracts and conducted presentations in the following Conferences:

39th International Technical Meeting On Air Pollution Modelling And Its Application (ITM 2023) | Chapel Hill, North Carolina, U.S.A. | 22-26 May 2023

HYPERION project will have the opportunity to disseminate its results to the USA, through the presence of team members in the 39th International Technical Meeting On Air Pollution Modelling And Its Application (ITM 2023), with a poster on ***"Dynamic Data Assimilation of meteorological and climate data from sensors"***, (ID 81). The scientific team consists of Eleftherios Chourdakis, George Tsegas, Fotios Barmpas and Nicolas Moussiopoulos.

EGU General Assembly 2023 | Vienna, Austria and Online | 28 April 2023

Luigi Germinario (UNIPD) participated at the General Assembly, 2023, organizing a special session entitled "Cultural heritage and the environment: interaction, vulnerability, past and future changes". The session included the participation of Mrs Alessandra Bonazza, Dr. Antonis Kalis and Beatriz Menéndez. Moreover, the following poster abstract was submitted and accepted:

Smart IoT sensors as part of a holistic solution for improving resilience and sustainable reconstruction of historic areas

(Dr. Antonis Kalis, Nikos Mitro, and Dr. Angelos Amditis)

Abstract

Although Climate Change (CC) has already been reported to have a significant impact on historical areas hosting Cultural Heritage (CH) sites, it is still challenging to assess quantitatively and qualitatively the impact of various climatic and other parameters on the CH sites, since the specific climatic conditions at their vicinity, and the emanating effects on their structure, are difficult to grasp due to cost and regulatory barriers. In the framework of the HYPERION EU project, we address this problem by providing a holistic solution for improving resilience and sustainable reconstruction of historic areas, which integrates the use of smart IoT devices, called Smart Tags, designed to provide environmental measurements close to monuments, with a number of state-of-the-art of technologies, services and tools (e.g. advanced ML, IoT, satellite and terrestrial imaging, social networking, event, material decay and business continuity modelling), in order to develop a single decision support system which aspires to become the cornerstone for resilience and reconstruction planning for historic areas in the future.

3rd International Conference TMM-CH Transdisciplinary Multispectral Modelling and Cooperation for the Preservation of Cultural Heritage | Athens, Greece | 22 March 2023

Dr. Angelos Amditis, HYPERION project coordinator from I-SENSE Group of ICCS, conducted an interesting presentation regarding HYPERION's results and latest achievements at the 3rd International Conference TMM-CH "Transdisciplinary Multispectral Modelling and Cooperation for the Preservation of Cultural Heritage".

The Conference took place on the 22th March 2023. It was organised by the National Technical University of Athens at Eugenides Foundation in Athens, Greece, in cooperation with the Technical Chamber of Greece, under the patronage of H.E. the President of the Hellenic Republic, with benedictions bestowed by His All Holiness, Ecumenical Patriarch, Bartholomew I of Constantinople, and His Beatitude Archbishop Hieronymus II of Athens and All Greece.

3rd European Conference on Earthquake Engineering and Seismology (3ECEES) | Bucharest, Romania | 4-9 September 2022

A preliminary urban seismic risk model for the City of Rhodes Greece

(Karaferi Evdoxia, Melissianos Vasileios, Vamvatsikos Dimitrios)

Keywords: Fragility curves, Vulnerability functions, Ground motion fields, Losses, Cost

Abstract

A first-order model is developed for the seismic risk assessment of the water supply network and the structural integrity of the buildings of Rhodes under spatially correlated seismic loading. For its implementation, in-house software is coded in the object-oriented programming language Python. The water supply network is modelled via a graph theory approach and the vulnerability of the buildings takes advantage of the 2020 European Seismic Risk Model. An event-based probabilistic seismic hazard approach is employed, generating ground motion fields for 10,000 years with the OpenQuake platform. The intensity measures used are the peak ground velocity (PGV) for the water pipelines and Sa(1s) for the buildings. The close correlation of the two allows the creation of spatially cross-correlated PGV and Sa(1s) values that are otherwise not readily available. Results are obtained, per block, for the percentage of people that have no access to water and for the damage of buildings. This is enough to offer a preliminary determination of the disruption caused by each event in terms of available housing and utilities, in support of socioeconomic impact modelling. (Full paper).

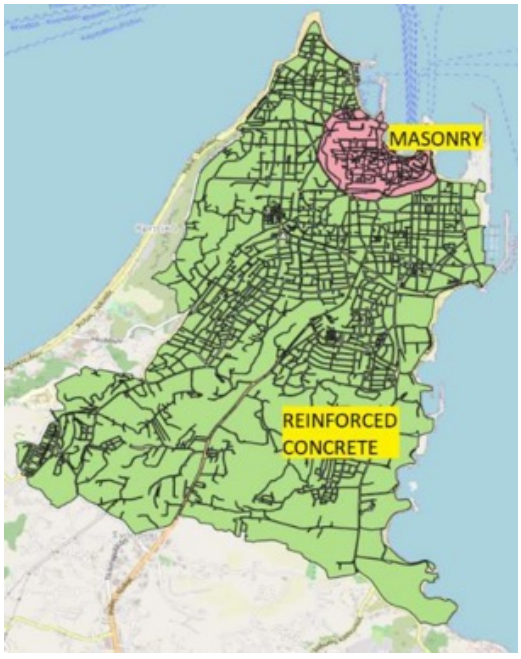

Figure 1: Simplified city model and corresponding classification for the buildings of Rhodes

Tomb raiders of the lost accelerogram: A fresh look on a stale problem

(Dimitrios Vamvatsikos, Christos G. Lachanas)

Keywords: seismic intensity, tombstone, overturning

Abstract

Throughout recorded history, accelerograms have displayed an unfortunate tendency to become unrecorded and lost. Statistically speaking, even after the advent of low-cost accelerometers, the ground motion retains an almost 100% chance of staying unobserved at any given point. One may only place some limits on the peak amplitude of ground motion by observing its effects, or lack thereof. To do so, seismologists run to the mountains, looking for fragile geological features, such as precariously balanced rocks. Structural engineers take a slightly more cinematic and sinister approach. They put on their fedora hats (or tank top and shorts, for video game enthusiasts) and go tomb raiding, searching for rocking rigid bodies that may have survived or toppled in graveyards, tombs, mausoleums, churches, and temples. Yet how is one to best make sense of such low entropy (and sometimes contradictory) uncertain information? Let's have some fun by blowing an old problem to smithereens, perhaps needlessly bringing to bear all the tools of contemporary earthquake engineering, ranging from ground motion prediction models and correlation structures to rocking body fragilities and Bayesian analysis. (Full paper)

SGI-SIMP 2022 Meeting | Torino, Italy | September 19-21, 2022

SGI is the Geological Society of Italy and SIMP is the Italian Society of Mineralogy and Petrography. Claudio Mazzoli, presented the following poster at the Session S5: Sustainability in dimension and ornamental stones industry (from exploitation to application).

Stone recession in cultural heritage investigated by laboratory ageing tests

(Mazzoli C., Salvini S., Coletti C., Germinario L., Maritan L., Massironi M., Pozzobon R.)

Abstract

Carbonate rocks (limestones, marbles) are among the most commonly used building materials (both as dimension and ornamental stones), and are highly vulnerable to weathering, especially in polluted areas. One of the main issues in the evaluation of cultural heritage vulnerability is the quantification of the deterioration rate. With this goal in mind, and in the frame of the HYPERION Project, the water-driven recession of stone in cultural heritage was simulated and measured in the laboratory by exposing a set of carbonate rocks, historically exploited and used in northern Italy, to accelerated ageing tests by immersion in rainwaters with different compositions. The tests were run cyclically in an environmental test chamber, alternating wetting and drying phases; at fixed intervals, the recession of each sample was quantified by bulk weight-loss measurements and surface mapping at the confocal microscope. The relationship between the different mineralogy and texture of the stones and the rate and areal development of their recession was investigated, finding that, besides water pH, calcite grain size is the most important controlling decay factor. Correction coefficients were also calculated for obtaining more reliable recession estimations from recession equations known in the literature. The findings

of this study can be exploited for predicting stone deterioration in cultural heritage constrained by the relevant environmental context and the expected future climate change. (Presentation)

5th Panhellenic Conference on Earthquake Engineering and Technical Seismology | Athens, Greece | 20-22 October 2022

Code-based approach for estimating the seismic fault displacement for the earthquake resistance design of buried pipelines

(Melissianos Vasileios E., Vamvatsikos Dimitrios, Danciu Laurentiu, Basili Roberto)

Abstract (in Greek)
Buried fuel pipelines are vulnerable to ground movements caused by the rupture of the intercepted seismic fault. In such case, pipelines are significantly deformed and stressed as they follow the ground movement. Ensuring the structural and operation integrity of pipelines as critical energy infrastructure is of utmost importance. In contrast to a typical deterministic design approach, where seismicity is not taken into account, the performance-based approach can provide the required balance between safety and economy. In this direction, an approximate methodology for calculating the fault displacement for a given return period was developed. This displacement is suitable for the design of pipelines crossing active seismic faults. Using the catalog of faults in Europe, a large number of probabilistic fault displacement hazard analyses were carried out. The statistical processing of these results led to the development of a set of simplified analytical equations that allow the calculation of the design fault movement based only on the data available to the engineer, without the requirement of specialized geological and seismological studies. The proposed methodology has been adopted as an informative annex in the new version of Eurocode 8 (EN 1998-4). (Full paper in Greek)

3rd International Conference on Natural Hazards & Infrastructure, ICONHIC 2022 | Athens, Greece | 5-7 July 2022

During the 3rd International Conference on Natural Hazards & Infrastructure, ICONHIC 2022, the following six papers were presented, detailed information and the abstracts can be found below:
1) Modular modelling and risk assessment of power transmission lines under extreme weather hazards;
2) Normalized response distribution expressions for ground-supported rigid rocking bodies;
3) The HAPI sensor-aware framework for infrastructure risk and resilience assessment;
4) Simplified Seismic Risk Assessment for the Water Supply Network of Rhodes, Greece;
5) Performance-based assessment of a steel lattice power-transmission tower: A case study in Germany;
6) An integrated model for the seismic risk assessment of an oil refinery;

Modular modelling and risk assessment of power transmission lines under extreme weather hazards

(Gerontati Angeliki, Bilionis V. Dimitrios, Vamvatsikos Dimitrios, Tibolt Mike)

Keywords: risk assessment, power line, failure propagation, lattice towers

Abstract
Power transmission lines are the "highways" of electricity, consisting of conductors supported on steel towers. Transmission towers are categorized as support or angle/dead-end based on their capability to resist along-line loads transmitted by the conductors. They are vulnerable to severe weather and in particular the combination of high winds and ice accretion that could lead to catastrophic failures. It is thus of great interest in the system design to arrest the propagation of a single tower failure that may trigger a series of failures of adjacent ones, considerably lengthening the duration of power outage. A modular multi-span model of a power line is proposed for the assessment of the behavior of the towerline system and the severity evaluation of such failures. Fault tree analysis is employed to examine the failure propagation to adjacent towers under extreme weather hazard, which allows the assessment of consequences at the level of an entire system of interleaved support and angle/dead-end transmission towers. The aggregated economic losses for an operational lifetime of 60 years are investigated using the proposed model versus a simplified approach, where all towers are exclusively characterized as support ones without considering successive failures. (Full paper)

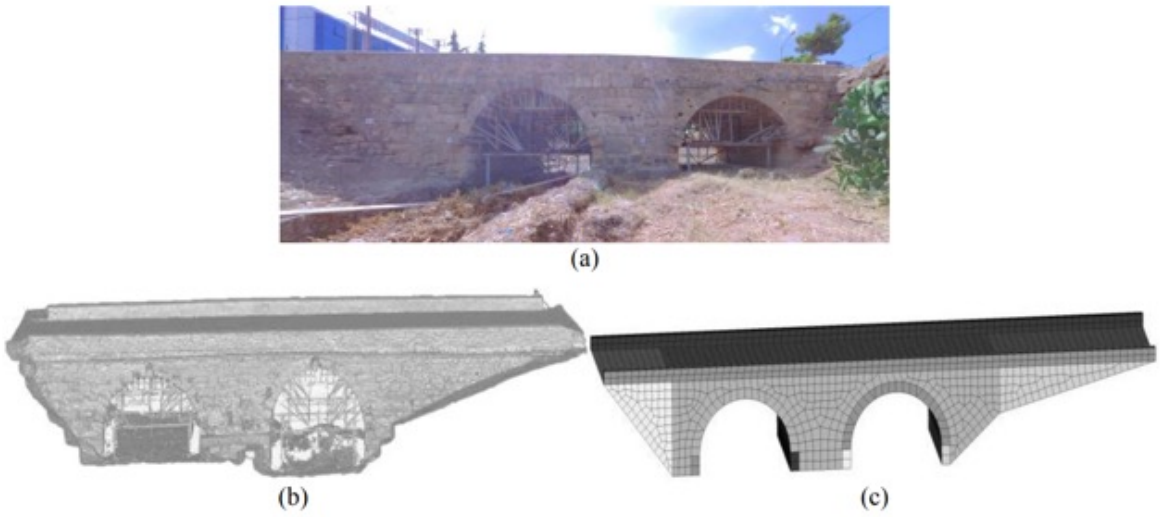

Figure 2: (a) Roman bridge in Greece, (b) 3D light model, and (c) Finite element model

Normalized response distribution expressions for ground-supported rigid rocking bodies

(Athanasia K. Kazantzi, Christos G. Lachanas, Dimitrios Vamvatsikos)

Keywords: rocking response, overturning, seismic response, free-standing contents

Abstract
Estimating the seismic response of ground-supported rocking rigid blocks, is a topic that has attracted significant research interest in the past few decades, since it concerns, among others: (a) several modern structures or ancient monolithic columns that utilize rocking as a seismic protection mechanism and (b) numerous free-standing contents (e.g. museum artefacts) located on the ground floor or lower floors of stiff buildings. In the present research work, by means of a parametric study, utilizing two-dimensional rectangular blocks of varying sizes and ordinary earthquake records, the rocking response at increasing intensity levels was assessed through

Incremental Dynamic Analyses. Following the demand evaluation and in order to allow for an easier utilization of the findings in practical applications, simplified approximate equations have been obtained via nonlinear regression analysis. The proposed equations provide an estimate of the peak rocking response distribution, expressed in terms of the normalized, to the dimensionless slenderness angle Ω, peak rocking angle, at increasing ground motion intensity levels. (Full Paper)

The HAPI sensor-aware framework for infrastructure risk and resilience assessment

(Dimitrios Vamvatsikos, Akrivi Chatzidaki)

Keywords: multi-hazard assessment, risk, climate, earthquake, nowcasting, forecasting

Abstract

The (new) 20's have allowed us to dream big on protecting our infrastructure from natural hazards. Powerful computers, machine learning, terrestrial and airborne sensors are at our disposal to help us quantify the consequences of potential hazardous events that may come in the future, are already unfolding, or have already happened. Owing to its origins in four European projects, namely HY-PERION, ARCHYTAS, PANOPTIS and INFRASTRESS, the HAPI framework has been formulated to perform pre/trans/post-event risk and resilience assessment of diverse infrastructure, comprising different layers of networked, loosely connected or autonomous assets within a city, region or country.

Building upon the well-worn basis of hazard-exposure-vulnerability that underpins practically all insurance risk estimates, HAPI enables assessment of cascading (e.g., mudflow/landslide after earthquake) and cotemporaneous (e.g., extreme precipitation, temperature, ice and wind scenario) hazards, while it offers sensor integration with near-real time updating of predictions based on hazard/asset/

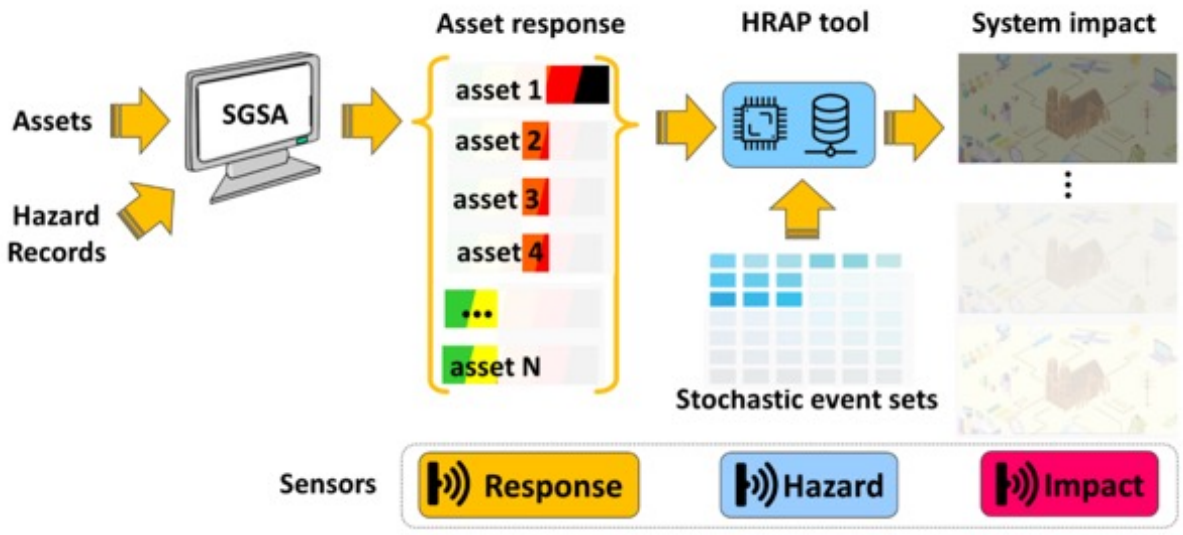

Figure 3: Short-term trans/post-event scenario risk assessment process

consequence information input. Both "static" memoryless hazards (e.g., earthquake), as well as "dynamic" time-dependent hazards (e.g., climate projections) are incorporated in tandem with static/dynamic vulnerabilities, allowing the tracking of complex phenomena, such as climate change, and their effect on the aging/corrosion/fatigue of a diverse set of assets, including buildings, bridges, piping, powerlines, highways and cultural heritage monuments. At the very basis lies a vast database of hazard and asset realization scenarios, employing Total Probability Discrete Event Simulation to explicitly track network interdependencies and propagate uncertainty from our source information to the projected integrated-system functionality and eventual recovery. (Full Paper)

Simplified Seismic Risk Assessment for the Water Supply Network of Rhodes, Greece

(Karaferi Evdoxia; Melissianos E. Vasileios; Vamvatsikos Dimitrios)

Keywords: Risk Assessment, Graph Theory, Seismic Hazard, Water Networks

Abstract

A methodology is developed for the risk assessment of the water supply network of the city of Rhodes under spatially distributed seismic loading. Graph theory is used to implement this methodology by creating in-house software in the object-oriented programming language Python.

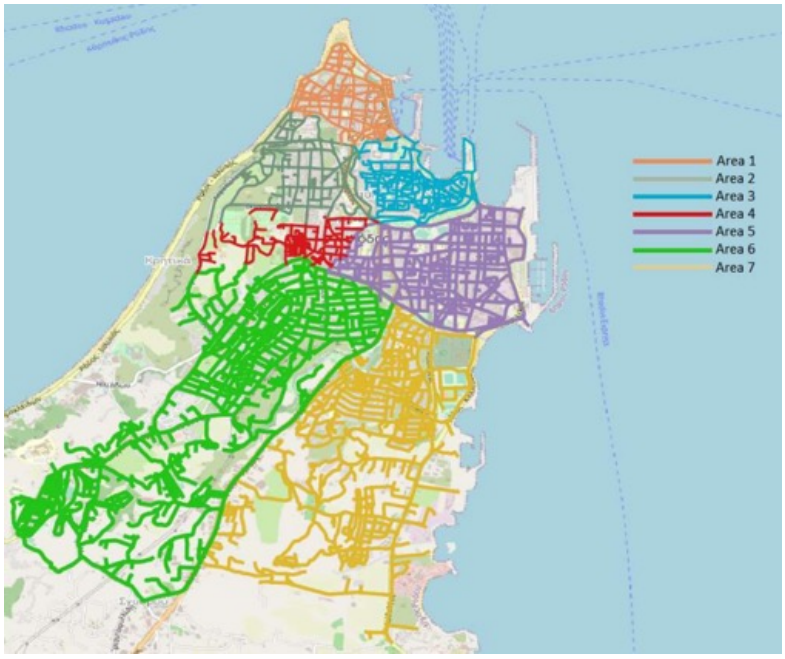

Figure 4: Partitioning of the water distribution system on the city of Rhodes, Greece into seven areas based on the age and the material of the pipes

Multiple seismic events are employed that have been generated with a probabilistic approach for a 10,000 year period using the OpenQuake platform and the 2013 European Seismic Hazard Model. The intensity measure used is the peak ground velocity (PGV). Since a direct generation capability for ground motion fields with spatial correlation is not readily available for PGV, the spatial distribution of the spectral acceleration at a period of 1s was employed, which is strongly correlated with the ground velocity. Results are obtained for the length of the pipes that will break for each event. The complex topology of the network is efficiently tackled via the graph theory to track which pipes cannot supply water and which need repair. The outcomes of the analysis indicate the percentage of the customers that are left without water in each building block of the city, to assess the population that has no access to water after a destructive event. Finally, curves of the mean annual frequency of exceeding given values of the damaged pipe length and the number of pipe breaks are produced, and the average annual losses are estimated. (Full paper)

Performance-based assessment of a steel lattice power-transmission tower: A case study in Germany

(Bilionis V. Dimitrios; Vlachakis Konstantinos; Bezas Marios-Zois; Tibolt Mike; Vamvatsikos Dimitrios; Vayas Ioannis)

Keywords: Power transmission tower, Wind, Ice, Steel lattice tower, Corrosion

Abstract

Power transmission towers are tall steel lattice structures used for supporting the conductors of a power transmission line, constituting essential parts of an entire power network. Past experience has shown that even a failure of a single tower can cause cascading effects to its adjacent towers leading to a total collapse of a whole line. Transmission towers are susceptible to severe weather conditions including low temperatures, snow and high winds. Specifically, high winds in combination with ice accumulation increase the lateral and vertical loads to levels causing damages ranging from local failures to global collapse. This effect is even more intense in case of aged towers with members weakened by corrosion effects. Herein, the focus is on a single suspension transmission tower widely used in Central Europe and designed according to the EN 50341-1:2012 and EN 50341-2-4:2016 assuming installation in Germany. The structure's fragility In both initial and corroded state against wind and icing loads was estimated via nonlinear dynamic analyses. The climatic hazard was estimated by deriving the joint probability of wind speed and ice thickness based on meteorological data obtained for Central-East Germany. Finally, the assessment of the structure's risk for each of the two states considered was made by combining the tower's fragility results with the climatic hazard. Assessing the risk of a single tower is a precursor of estimating the reliability of an entire power transmission network, offering a useful decision-support tool on the need to maintain or upgrade a power line network. (Full Paper)

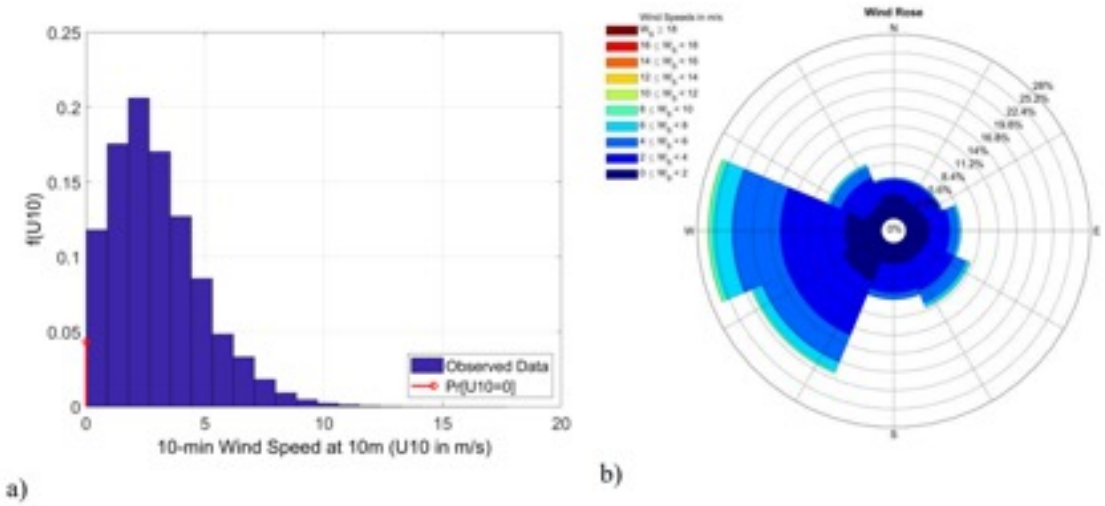

Figure 5: Distributions of a) Wind Speed and b) Wind Direction (Wind Rose) for Marienberg

An integrated model for the seismic risk assessment of an oil refinery

(Melissianos E. Vasileios, Karaferis D. Nikolaos, Kazantzi K. Athanasia, Konstantinos Bakalis, Vamvatsikos Dimitrios)

Keywords: Oil refinery, seismic hazard, risk assessment, exposure model

Abstract

Oil refineries play a key role in the energy supply chain. Safeguarding the integrity of such high-importance facilities against natural hazards is crucial because a potential failure may result in a sequence of unwanted events, spanning from business disruption to uncontrolled leakage and/or major accidents. Despite the strict criteria enforced during the design, construction, maintenance, and operation of an oil refinery, Natural Technological events caused by earthquakes still occur. Oil refining is a complex process that involves a variety of structural typologies, such as buildings, tanks, chimneys, pipe-racks, pressure vessels, and process towers.

These structures have fundamentally different dynamic properties and seismic responses. A comprehensive seismic risk assessment framework is thus required to account for the refinery as an integrated system and provide information about both the structural and operational integrity of the individual assets and the system. In the present study, a virtual crude oil refinery is examined as a case study to demonstrate the steps of a preliminary seismic risk assessment framework, consisting of the seismic hazard calculation, the development of the exposure model, the analysis of the structures at risk, and the damage assessment of the facility. Scenario-based results are presented for the refinery and the critical assets are identified. (Full Paper)

AIAr 2022 | Padova, Italy | 29 June – July, 2022

During AIAr 2022, the following three abstracts were presented:
1) Mapping stones and deterioration morphologies distribution at the Torre dell' Orologio (St. Mark square – Venice) in the frame of the Hyperion EU project
2) Assessing climate change risk to cultural assets by monitoring and quantifying the decay of heritage materials and its environmental constraints
3) Decay assessment and 3D surface modelling of historical brick masonries in Venice

Mapping stones and deterioration morphologies distribution at the Torre dell' Orologio (St. Mark square – Venice) in the frame of the Hyperion EU project

(Rebecca Piovesan, Elena Tesser, Lara Maritan, Gloria Zaccariello, Claudio Mazzoli Fabrizio Antonelli)

Abstract
The Torre dell' Orologio (clock tower) in Venice is an early Renaissance (1499) building in Lombard style overlooking the entrance to the Mercerie on the north side of St. Mark's square. Its historical and artistic importance in the city as well as in the general landscape of the Italian Renaissance, is undeniable, as it is the representative expression of the architectonic stone materials most in vogue in that historical period. As part of the European project HYPERION (Horizon 2020), which is dealing with resilience and sustainable reconstruction of historical areas, the main façade of this elegant monument was mapped in order to obtain an overview of the composition of the building, its state of conservation and the history of its restoration. The mapping of deterioration morphologies was carried out following the ICOMOS-ISCS glossary of decay forms together with a quantification of the same inspired by the work of Fitzner and Heinrich (2001). To support the drafting of the maps, in-depth investigations were carried out on a series of micro-samples of both stone and deterioration products following a multi-analytical approach including petrographic and biological analyses by optical and scanning electron (SEM-EDS) microscopy, as well as through powder X-ray diffraction, ion chromatography and infrared spectrometric investigations using FTIR. The final output was the production of a series of monographic maps: one concerning the building materials, a series of maps focused on the five macro-categories of deterioration morphologies as defined in ICOMOS/ISCS (i.e. cracks and deformations, detachment, features induced by material loss, discoloration and deposit, biological colonisation). A further map was produced to graphically summarise the total state of decay of the building by reporting a Total Decay Index (TDI). In general, the most abundant and/or intense forms of deterioration detected were black crusts, patinas, discoloration and patterns related to erosion processes.

The stones used in the façades are: regional (Rosso Verona and Scaglia Rossa) and extra-regional limestones as well as a series of marbles and stones already used in classical times: three crystalline marbles (Carrara and Pavonazzeto Toscano from the Apuan Alps; Proconnesian from the micro-Asiatic island of Marmara), the Rouge de Languedoc (a French limestone in Italy called Rosso di Francia), and the famous Egyptian volcanite known as Porfido rosso antico. (Presentation)

Assessing climate change risk to cultural assets by monitoring and quantifying the decay of heritage materials and its environmental constraints

(Luigi Germinario, Chiara Coletti, Fabrizio Antonelli, Petros Choidis, Dimitrios Kraniotis, Lara Maritan, Rebecca Piovesan, Raffaele Sassi, Elena Tesser, Laura Tositti & Claudio Mazzoli)

Abstract

The EU-funded project Hyperion aims at developing a "decision support system for improved resilience and sustainable reconstruction of historical areas" facing the impact of climate change and extreme weather events, with the aid of sensor-based and modelling tools. An essential part of the project involves the quantification of the current decay of cultural heritage, which may shed light on how heritage materials interact with the environment, react to microclimate stresses, and resist to future climate change in weathering models and simulations. To that purpose, a novel experimental method based on the long-term monitoring of historical building materials, their deterioration, and the relevant environmental parameters in different geographic contexts, was designed. A selection of stone and wood materials historically used in different European countries are exposed outdoors to natural weathering, in the urban environment of Italy (Padova and Venice) and Norway (Tønsberg). In every location, the same set of samples are exposed at different orientations (North, South, and horizontal plane) and their surface microclimate parameters are being monitored with temperature and moisture sensors. The microclimate data series are compared with the climate data provided by both the complementary weather stations installed in each monitoring site and the stations of the official regional agencies of environmental monitoring. At the same time, the material decay is being measured by monitoring the changes in surface topography/recession, chemical composition, and color of each building material, that is, comparing the maps acquired before and during the exposure tests by 3D optical profilometry, micro X-ray fluorescence, and colorimetry. This investigation is expected to provide a solid base for developing models of future deterioration of cultural heritage and prediction of its endurance in a changing climate. (Presentation)

Decay assessment and 3D surface modelling of historical brick masonries in Venice

(Chiara Coletti, Luigi Germinario, Enrique Hernández Monte, Luisa María Gil-Martín, Lara Maritan, Jacopo Nava, Matteo Massironi, Simone Dilaria, Gianmario Guidarelli, Stefano Castelli & Claudio Mazzoli)

Abstract

In many noteworthy buildings in Venice we can observe a strong loss of material at the bottom of the façades (usually in the 1-2 meters from the soil level). Capillary rise, water condensation-evaporation sub-florescence of salts can induce scaling and cracking in bricks with a subsequent reduction of the thickness of the wall section and therefore of its load-bearing capacity. This work proposes a new approach to assess the vulnerability of historical brick masonry patrimony, the most used in Venice. This new approach provides for three main steps: i) the minero-petrographic characterization of the materials (bricks and mortars); ii) the 3D photogrammetric survey and the measurements of the cross-sections of brick walls; iii) the decay assessment. For this purpose, the Church of Santa Maria dei Servi (Cannaregio, 14th century) was selected as case of study. Color, mineralogy and texture of the bricks and mortars, and secondary weathering products were studied by means spectrophotometry, X-ray diffraction, optical and scanning electron microscopy, and hyperspectral analysis. 3D surface modelling by empirical descriptions based on photogrammetry was used for understanding the effects of water and salts interaction in the bricks wall of the main façade. Results will be useful to provide previsions of long-term deterioration of that monument and they can be implemented in other brick buildings in Venice, which have the same decay pattern. (Presentation)

The 8th European Congress on Computational Methods in Applied Sciences and Engineering, ECCOMAS Congress 2022 | Oslo, Norway | 5-9 June 2022

During the 8th European Congress on Computational Methods in Applied Sciences and Engineering, the following two abstracts/papers were presented:
1) Pros and cons of various equivalent frame models for nonlinear analysis of URM buildings;
2) Vulnerability assessment of cultural heritage structures;

Pros and cons of various equivalent frame models for nonlinear analysis of URM buildings

(Shabani A. and Kioumarsi M.)

Keywords: Equivalent frame methods, Macroelements, Nonlinear analysis, DM-MVLEM

Abstract
Masonry is considered as an old construction material. Several cultural heritage assets including churches, towers, and fortifications are made of unreinforced masonry (URM) which is susceptible to earthquake due to the brittle behavior. Equivalent frame method (EFM) is a nonlinear modelling method which has been widely utilized for the seismic analysis of URM buildings with lower computational efforts compared to finite element method. Various macroelements consisting of nonlinear shear or flexural springs, nonlinear fiber beam column elements have been developed to simulate the URM structural components [1]. Unified method (UM) is considered as the simplest method in this study. In UM each perforated or unperforated URM wall is simulated with a macroelement consisting of a nonlinear shear spring. Composite spring method (CSM) is the second EFM that each pier is simulated with a nonlinear shear spring that connect to the linear spandrel elements. However, as the most detailed approach, each pier and spandrel are modeled using the double modified multiple vertical line element (DM-MVLEM) model element considering the effect of axial moment interaction [2]. In this study three EFM macroelements have been utilized to model three case studies with different configurations of openings. DM-MVLEM is accurate enough for the prediction of load bearing behavior and damage pattern of perforated URM walls compared to CSM and finite element method. It is investigated that the CSM cannot reflect the weak spandrel elements and conservative results are concluded from the seismic analysis of the models developed using UM compared to CSM and DM-MVLEM. (presentation)

Vulnerability assessment of cultural heritage structures

(M. Kioumarsi, V. Plevris and A. Shabani)

Keywords: Vulnerability Assessment, Cultural heritage, Digital twin, Finite element

Abstract
Cultural heritage (CH) assets are the legacy of a society that are inherited from the past generations and can give us lessons for contemporary construction. Not only the formally recognized CH assets but also the non-CH structures and infrastructure, and the inter-connection between them are crucial to be considered in a vulnerability assessment tool for the sustainable reconstruction of historic areas. Since most CH assets were not designed based on robust design codes to resist natural hazards such as earthquakes,

vulnerability assessment and preservation are pivotal tasks for the authorities. For this aim, HYPERION, an H2020 project (Grant agreement No 821054), was formed in order to take advantage of existing tools and services together with novel technologies to deliver an integrated vulnerability assessment platform for improving the resiliency of historic areas. Geometric documentation is the first and most important step toward the generation of digital twins of CH assets that can be facilitated using 3D laser scanners or drone imaging. Afterward, the finite element method is an accurate approach for developing the simulation-based digital twins of cultural heritage assets. For calibration of the models, the result of the operational modal analysis from the ambient vibration testing using accelerometers can be utilized. Structural analysis for the prediction of the structural behavior or near real-time analysis can be carried out on the calibrated models. However, the full finite element analysis needs a lot of computational effort, and to tackle this limitation, equivalent frame methods can be utilized.

EGU General Assembly 2022 | Vienna, Austria and Online | 23–27 May 2022

During the EGU General Assembly the following three abstracts were presented:
1.A Communities Engagement Mobile Application for Assessing the Resilience and Deterioration of Cultural Heritage Monuments;
2.Bridging urban development, resilience planning, and heritage management for Climate Neutral and Resilient Historic Urban Districts;
3.Developing a new method for long-term monitoring of the weathering of historical building materials;

A Communities Engagement Mobile Application for Assessing the Resilience and Deterioration of Cultural Heritage Monuments

(Maria Krommyda, Nikos Mitro, Katerina Georgiou, Vassillis Nousis, and Angelos Amditis)

Abstract
Climate change has been proved to have negative impacts on historic areas hosting cultural heritage sites and monuments, which in turn yields significant adverse impacts on local economies, societies, and even politics. The first and necessary step of the process of confrontation of this challenge is the early detection and recording of the on-site inflicted damage by a monitoring tool. In order to achieve that, we developed a dedicated mobile application that aims to assist the assessment of the resilience and the deterioration of the historic areas and the potential impacts due to various hazards. Citizens and local authorities worldwide can directly use the developed application on their mobile phones to acquire photos of on-site damages and submit short reports based on them. This software component has been designed and developed in the context of the European project entitled "HYPERION", which aims to deliver an integrated resilience assessment platform, addressing multi-hazard risk understanding, faster and efficient response, and sustainable reconstruction of historic areas. With this application, we aim to create a user-friendly application with the latest user interface and usability issues/trends which is focused on museum enthusiasts and active citizens' or travelers' needs. It's important to put the users of this targeted group at the center of our efforts and by understanding their needs to create an intuitive application for them and at the same time a useful tool for the local authorities. Users download the application from the Google or Apple App store and they log in or create an account in the application through the PLUGGY platform, which was developed in the context of the "PLUGGY" European project. The main function of the application is to create and post an asset using PLUGGY's REST API. An Asset is an elementary unit of

content in PLUGGY, a media file with an identified owner, a title, a description, a set of tags, and a license, which specifies how this file can be reused. Initially, the user's location is detected via GPS and corrected in case of miscalculation. The user is then prompted to select a photo (or directly to take a snapshot) that depicts the damage of a monument. To complete the creation of the asset, the user will also need to select a title that will accompany the photo, and some tags, not only for a better description of the event but also for correlation with other assets or exhibition points that already exist in PLUGGY. The developed mobile application gives voice to citizens and encourages them to provide direct feedback to the relevant cultural authorities, in order to assist them in assessing the deterioration of the cultural heritage sites and determining the needed reconstruction actions. As a result, the communities can have a major role in the safeguard of their cultural heritage. (Presentation)

Bridging urban development, resilience planning, and heritage management for Climate Neutral and Resilient Historic Urban Districts

(Ioannis Karaseitanidis, Antonis Kalis, Aitziber Egusquiza Ortega and Katharina Milde)

Abstract

Climate change is one of the biggest challenges that our planet is currently facing. From seasonal shifts in climate, with droughts, heatwaves, floods and storms, the impacts of climate change are global in scope and unprecedented in scale. Cities are heavily affected by the climate change consequences, with most of Europe's population living in cities and urban areas and projections for 2050 predicting even larger shares (Nabielek, Hamers, & Evers, 2016). At the same time, cities generate up to 80% of a country's GDP (United Nations Human Settlements Program, 2011), but also consume 75% of the natural resources and account for 60-80% of greenhouse gas emissions. That is, urbanisation and cities' economic growth are the biggest contributors to climate change.

Heritage, as a sensitive and valuable element of the living environment, is being affected by the increase in frequency and intensity of climate-related events, posing new challenges and needs to conservators and heritage managers. But improving the resilience of the historic urban districts, adapting to urbanisation, climate change, and other social, economic, and security trends is a challenging endeavour for cities and prone to potential conflicts of interest. It requires managing tasks like accommodating a growing – and in many cases aging – population, providing the required services, fostering social, environmental, and economic sustainability, and keeping the city liveable and attractive. But a liveable, sustainable, and, above all, resilient city is not just a product of organised and well-functioning services; other crucial elements are the places that make up the city, along with their communities. Sites of significant cultural and historical value and significance have an important role to play in fostering location-based identity and social cohesion. With the increased recognition of the threats that heritage faces from climate change, but also the role heritage can play in driving climate actions, all those connected to heritage face both a profound opportunity and a challenging responsibility. (ICOMOS Climate Change and Cultural Heritage Working Group, 2019).

As a response to these threats, a bridge is needed to fill the gap between urban development, resilience planning, and heritage management to boost collaboration among all involved stakeholders and make our cities more climate neutral and resilient. This should be based on a vision to stimulate and promote development for wider adoption of solutions for climate change mitigation and adaptation in historic urban districts. This process will promote constructive dialogue, development, and exchange of best practices for achieving better integration between resilient urban planning and heritage management. Moreover, it will aim to increase awareness of the role of historic areas – with their unique value and importance – play in stimulating the general public to actively contribute to coordinated efforts on climate resilience in accordance with protection and preservation of heritage both within local environments as well as

nationally and internationally.
In the long-term, the goal is to make historic urban districts and their communities' climate neutral and resilient, but also branch out to issues of contemporary urban districts to build and nurture more synergies.

Developing a new method for long-term monitoring of the weathering of historical building materials

(Luigi Germinario, Chiara Coletti, Petros Choidis, Dimitrios Kraniotis, Lara Maritan, Raffaele Sassi, Laura Tositti, and Claudio Mazzoli)

Abstract
This contribution presents the work of research and technical development for designing a novel method for monitoring and predicting the weathering of cultural heritage, in particular of stones and timber used historically as building materials.
An apparatus for long-term field tests was designed in its hardware and software components with a twofold application:

- Exposure of a set of selected stone and wood specimens to natural weathering, at different orientations (North, South, and horizontal plane) and environmental settings (Italy and Norway).
- Non-stop acquisition of microclimate data series at different resolutions, down to the scale of the specimen surface, completed by datasets of regional stations of environmental monitoring.

Complementary laboratory analyses aim at setting a reference point for the state of conservation of each material before the exposure tests, and monitoring the changes of surface recession/topography (by 3D optical profilometry), thus reconstructing the relevant deterioration trends.
Within the framework of the EU-funded project HYPERION, this novel experimental approach is expected to help assessing the interaction of building materials with the environment and their weathering constrained by microclimate and climate variability; combining climate model simulations, the stresses brought about by climate change can also be assessed. The findings might represent a source of precious information for the activities and decision-making protocols of the stakeholders involved in the protection of cultural heritage.

Japan Geoscience Union Meeting | Chiba, Japan & Online | 22 May 2022

Deterioration effects on bricks masonry in the Venice lagoon cultural heritage. Study of the main façade of the Santa Maria dei Servi Church (XIV century)

(Chiara Coletti, Jacopo Nava, Ludovica Pia Cesareo, Lara Maritan, Matteo Massironi, Claudio Mazzoli)

Abstract
In the November 2019 the city of Venice (Italy) was hit by high tides (more the 150 cm), with the highest tide peaked at 187 cm. According to government statistics (reports, graphs and data of flooding since the year 1860), it is the worst flooding in Venice since 1966, when the city was hit by tides of up to 194 centimeters (76 inches). In addition, in the last century the Venetian air quality has been strongly affected by the industrial activity in the near city of Porto Marghera and by the proximity presence of the Marco Polo Airport, which enriched the atmosphere in the CO2, SOx, NOx airborne composites. The present study addresses these issues by proposing a study of 23 brick samples collected on the main façade of the Santa Maria dei Servi Church (XIV century), one of the historical buildings hit by the high tide's events in 2019.
The façade is characterized by bricks of different color (yellow, pink and red) with an advanced decay conservation state due to the history of the monument and the environmental conditions. Color, mineralogy and texture of these samples were studied using standard methods such as, Spectrophotometry, Powder X-Ray Diffraction (PXRD), Polarized Optical Microscopy (POM) and Field Emission Scanning Electron Microscopy (FESEM-EDS). The presence of carbonates (calcite and dolomite) and new silicate phases (e.g. gehlenite and diopside) provided indications of the temperatures reached during firing and suggested the absence of a good standardization in the production process. While, X-ray diffraction and hyperspectral analysis (in the SWIR range) detected gypsum, halite and mirabilite as the main weathering products due to the salt decay process that affects monuments in Venice and in the overall lagoon environment.

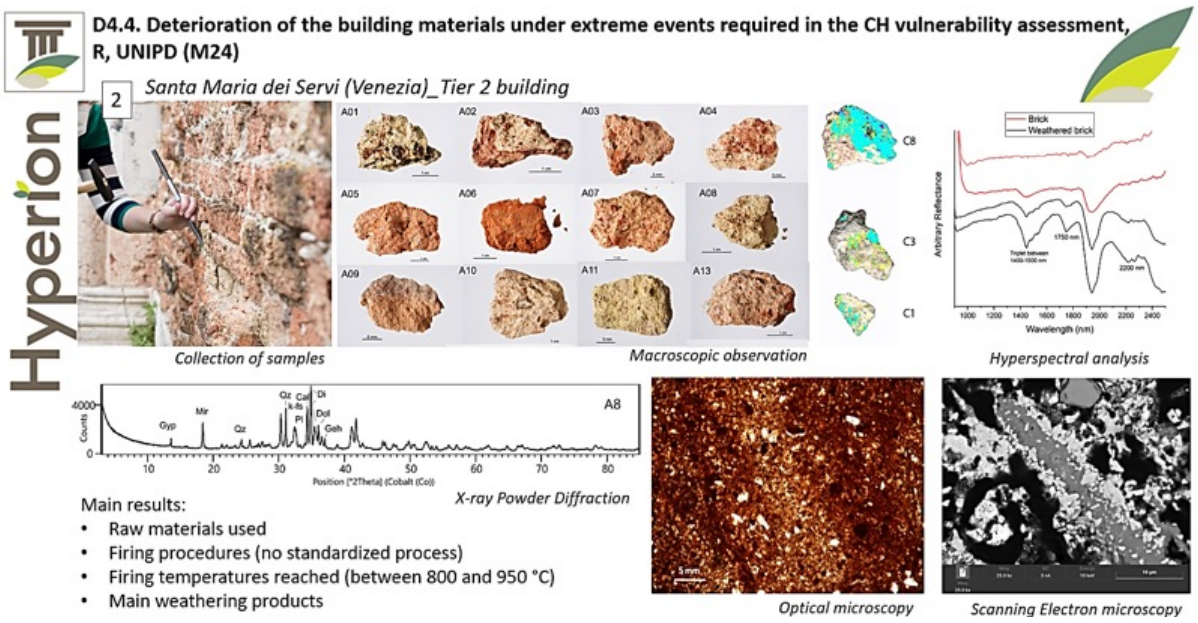

Figure 6: Deterioration of the building materials under extreme events required in the CH vulnerability assessment

This work aims to increase the awareness in the decay process occurring on the historic Venetian urban texture to fix new planning tools and to achieve multiple goals oriented to a sustainable transformation of the city, leading it to more resilient solutions.

17th World Conference on Earthquake Engineering (17WCEE) | Sendai, Japan and Online | 27 September - 2 October 2021

During the 17th World Conference on Earthquake Engineering the following two papers were presented by the HYPERION researchers:
1) A comparative study on the initial in-plane stiffness of Masonry walls with opening;
2) Seismic risk assessment of the ancient temple of Aphaia in Greece;

A comparative study on the initial in-plane stiffness of Masonry walls with opening

(Shabani, V. Plevris, M. Kioumarsi)

Keywords: Initial stiffness, masonry walls, in-plane stiffness, analytical methods, finite element analysis

Abstract

Masonry buildings have been used for centuries in various locations around the world, including areas with high seismicity. Studies about the behavior of masonry structural components subjected to lateral loadings and retrofitting techniques for improving their performance have gained much attraction lately. Various simplified methods have been presented in the literature for the seismic

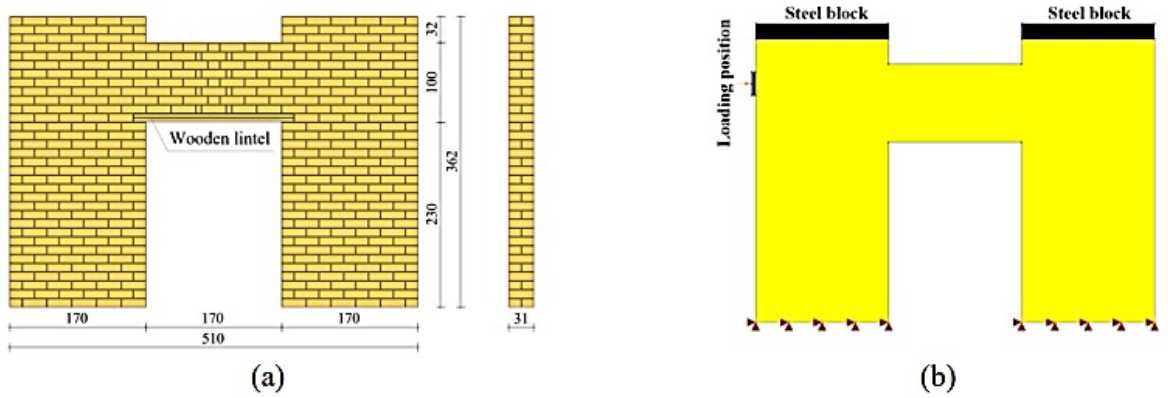

Figure 7: (a) Geometry and (b) FE model of the test wall (Dimensions in cm).

vulnerability assessment of masonry buildings. The initial in-plane stiffness of masonry walls is a key parameter which significantly affects the nonlinear backbone curve of the masonry walls as well as their ultimate in-plane strength. Different simplified analytical methods have been proposed for deriving the initial in-plane stiffness of masonry buildings with regular or irregular openings by considering the flexible spandrels that can translate and rotate under lateral load and flexible piers' endings. In the analytical methods, the initial in-plane stiffness of each pier will be computed from the equations by considering the geometry of each component as input. Each structural component is considered as a spring and the stiffness of the whole system is computed based on equations of springs in series or in parallel. The finite element method is considered as a reliable tool for verifying the analytical methods. For this purpose, a homogenization method has been employed for modelling the masonry walls and lateral loads have been applied on the walls with the assumption of linear material to derive the initial in-plane stiffness of the walls. For this purpose, three categories of masonry walls have been considered with one, two, and three openings where the openings' geometries also vary to investigate the effect of opening placements and irregularities on the initial in-plane stiffness of the walls. Afterwards, the stiffnesses computed from the analytical methods are compared with the stiffnesses that have been derived from the finite element analysis to investigate the accuracy of the analytical methods. It is shown that the analytical methods can be utilized for deriving the initial in-plane stiffness of masonry walls with openings, providing fast and accurate solutions in comparison to more detailed and time-consuming finite element implementations. (Full paper)

Seismic risk assessment of the ancient temple of Aphaia in Greece

(V.E. Melissianos, M.-E. Dasiou, D. Vamvatsikos)

Keywords: ancient temple; seismic hazard; discrete element modelling; risk assessment

Abstract

The protection of cultural heritage against natural hazards has attracted significant research efforts and funding during the last decades, recognizing its importance in humanity's history and raising public awareness on this issue. In Greece, there are numerous monuments that have been exposed to environmental actions, and, consequently, many are classified as deteriorating structures. In addition, earthquakes pose a significant threat to their structural integrity and contribute to the accumulation of damage. The evaluation of the seismic performance of such heritage assets is a complex computational problem, especially as their structural elements are either not rigidly connected, or connected by weak mortar, and thus prone to rocking due to the seismic excitation. Research on the seismic assessment of monuments is quite limited to the estimation of the structural behavior, thus excluding the incorporation of pertinent uncertainties. The aim of the study is to contribute to the seismic risk assessment of monuments. The framework of Performance-Based Earthquake Engineering is applied, comprising of four successive and interconnected steps: (1) the European seismic source model is used to estimate the seismic hazard in terms of a scalar intensity measure, (2) the structure is modeled with a discrete element approach. The rocking and/or sliding of the individual stone blocks are accurately addressed by the software since, during the calculation, it locates each contact and computes the motion of each block from the forces that are developed at the joints. Results in terms of maximum displacements are obtained from the analysis and related to damage states. (3) The limit-state and the aleatory

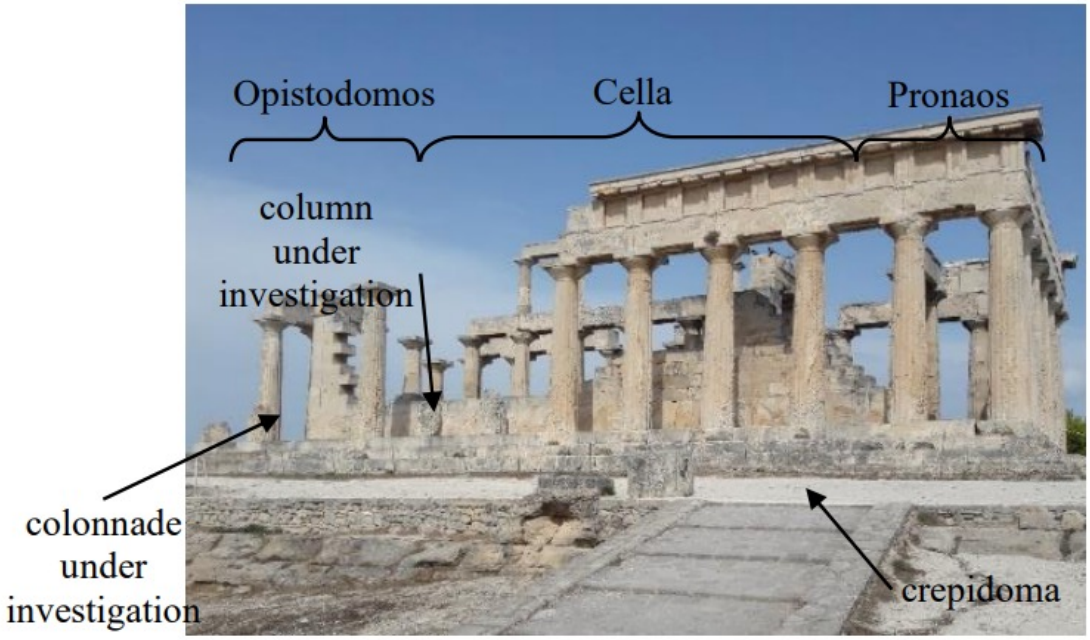

Figure 8: North view of Temple of Aphaia

and epistemic uncertainties are defined for the determination of discrete damage states and the associated fragility curves, and (4) the seismic risk is calculated in terms of the mean annual frequency of exceeding each limit state. The aforementioned methodology is applied to a free-standing column and a colonnade of two columns with an architrave at the ancient Temple of Aphaia, located on the Greek island of Aegina and built between 510 and 470 BC, comprising a significant example of the Archaic architecture. (Full paper)

Attribute-driven fragility curve through class disaggregation

(A.K. Kazantzi, D. Vamvatsikos)

Keywords: fragility; building class; loss assessment

Abstract

Fragility curves are an important ingredient in the seismic loss assessment process. For a regional scale loss estimation, to reduce to reasonable levels the computational burden associated with determining the seismic demands for individual buildings, analytical seismic fragilities are instead evaluated on a broad building class basis. The latter process essentially involves representing a population of buildings having similar characteristics with a set of characteristic "index" buildings to avoid analyzing every single building within this

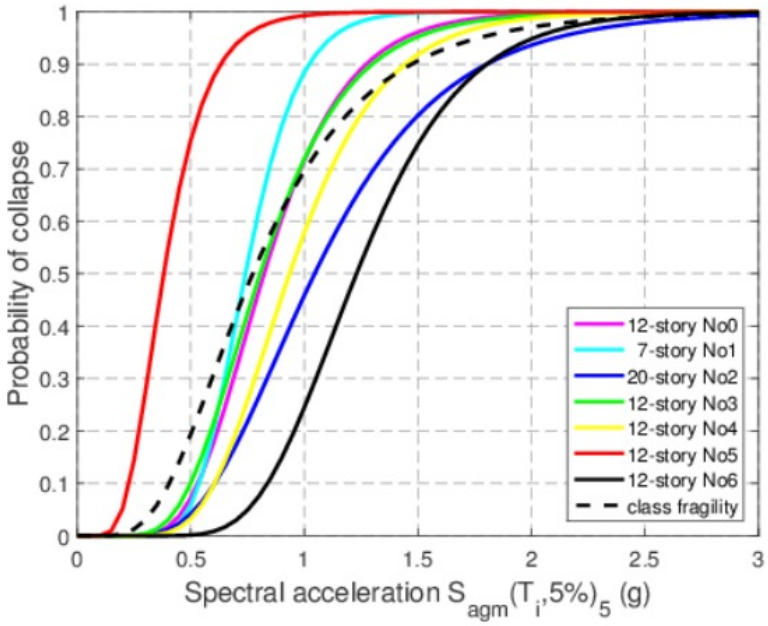

Figure 9: Collapse fragility curves for the seven high-rise RC index buildings along with the class fragility curve

population. For the definition and modelling of index buildings, two main options are currently available, these being (a) defining a limited number of index buildings to represent the class and modelling them with relatively complex, yet more accurate, MDOF systems, and (b) defining numerous index buildings to represent the class and modelling them with simplified approximate SDOF systems. Apparently, the dilemma of defining the optimal way to sample the index buildings comes down to the use of few MDOFs or many SDOFs. Despite the fact that the use of many SDOFs is a rather attractive option, given that they are an easy and computationally inexpensive choice in terms of both modelling and analysis, they are often a bad approximation of the actual problem. This is the case, for example, of tall or irregular buildings, where non-negligible higher modes render the SDOF approximation ineffective.

Then, the more expensive and accurate MDOF option has to be employed. However, using a limited number of MDOFs to represent the class of interest inherently offers very little flexibility towards capturing individual buildings that might belong to that class yet their salient features do not necessarily match those of the "average" index building. Aggregating the results of all index buildings into a single class fragility means that one cannot provide a more accurate answer than the mean class fragility plus some dispersion, even if the building in question actually closely matches one of the underlying index ones. This may not matter for estimating long-term average losses over a region, but it becomes increasingly important as the size of the portfolio is reduced and individual structures stand out. To resolve the aforementioned issue, we propose here a method for adding substance back to the class fragility and consequently obtaining fine-grained attribute-driven fragility estimates. The term attribute-driven is key in our approach, since it implies that the process explicitly accounts for the specific characteristics of the building in question. It is essentially a meso-scale approach that stands between the building-specific FEMA P-58 style approach (micro-scale) and the building-class approach (macro-scale). Our testbed is a population of modern high-rise reinforced concrete buildings, represented by seven index buildings, for which we have evaluated fragility functions. With this information at hand, our proposed approach employs statistical methodologies for effectively disaggregating the index building fragility functions, to provide attribute-aware response and collapse fragility spot estimates for individual sample buildings, other than the index ones, that belong to the same class. (Full paper)

4th International Conference on Protection of Historical Constructions (PROHITECH 2021) | Athens, Greece | 25-27 October 2021

Structural Model Updating of a Historical Stone Masonry Tower in Tønsberg, Norway

(Amirhosein Shabani, Agon Ademi, Mahdi Kioumarsi)

Keywords: Finite element model, Numerical modelling, Historical towers, Masonry tower, 3D laser scanner, Accelerometer, Operational modal analysis

Abstract

Conservation of historical structures plays a pivotal role in every nation, and numerical modelling of historic buildings is an essential part of a conservation methodology. Since deriving the mechanical properties of construction materials using destructive tests is usually not allowed, and most of the cultural heritage assets are so complicated in architecture, numerical modelling of historic buildings is challenging for the analysts. Therefore, in this study, a non-invasive approach for numerical simulation of historic structures has been proposed and applied on a historical stone masonry tower (Slottsfjell tower) in the city of Tønsberg, Norway. Two types of sensors were utilized for finite element modelling of the stone masonry tower. Firstly, three-dimensional (3D) laser scanners were used as a fast and precise tool to provide a finite element model of the case study with and without considering soil-structure interaction. Secondly, operational modal analysis (OMA) was performed using accelerometers to derive the tower's dynamic characteristics. Finally, as a preliminary result of the case study in the context of a European project, the produced finite element models' mechanical properties are updated based on the OMA results, and the effect of considering soil-structure interaction has been investigated. (Full paper)

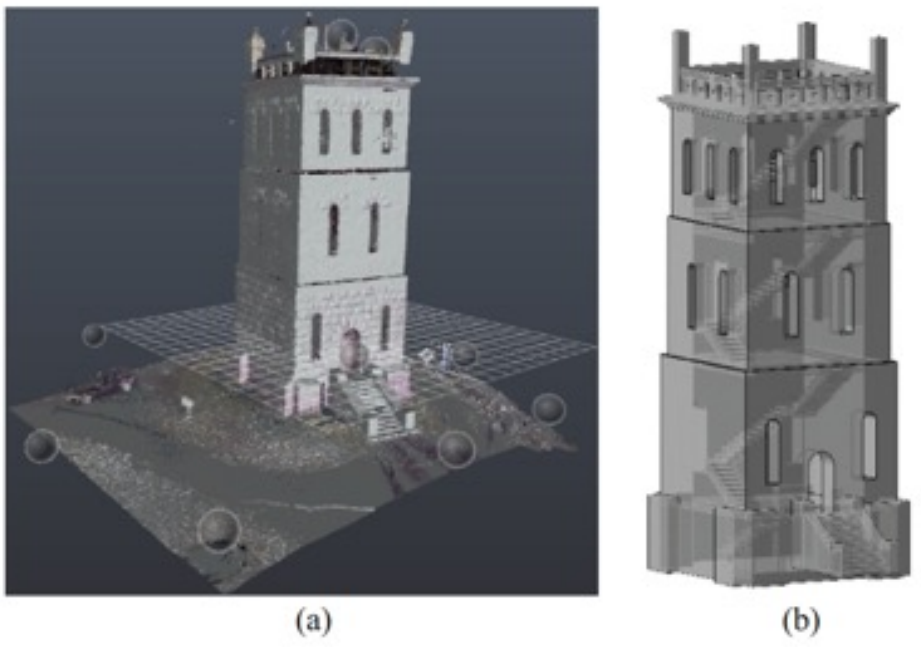

Figure 10: (a) Point clouds derived from the 3D laser scanner and position of the scanners during the data acquisition and (b) 3D drawing of the tower

ICSEA 2021, 16th International Conference on Software Engineering Advances | Barcelona, Spain | 3-7 October 2021

A Communities Engagement Tool for Assessing the Resilience and Deterioration of Cultural Heritage Sites

(Nikolaos Tousert, Antonis Kalis, Maria Krommyda, Nikos Frangakis, Spyridon Nektarios Bolierakis, Angelos Amditis)

Keywords: deterioration, hazards, cultural heritage sites, communities' engagement tool, monuments

Abstract

Climate change and geo-hazards (such as landslides and earthquakes) may have a negative impact on historic areas hosting Cultural Heritage (CH) sites and monuments, which in turn yields significant adverse impacts on economies, politics and societies. The deterioration of CH sites is one of the biggest challenges that needs to be addressed through structural responses, preventive measures, restoration strategies, resilience and adaptation methodologies. In order to assess the resilience and deterioration of the historic areas and also the potential impacts due to various hazards through a community-based participatory environment, a web tool has been developed, entitled "Communities' Engagement Information and Communication Technology (ICT) Tool". This paper presents the aforementioned tool which aims at engaging cultural heritage aware communities through a web platform. This specialized software is an advanced application that will encourage citizens to give direct feedback to the relevant cultural authorities in order to assist them in assessing the deterioration of the cultural heritage sites and determining the needed reconstruction needs and expectations. (Full paper)

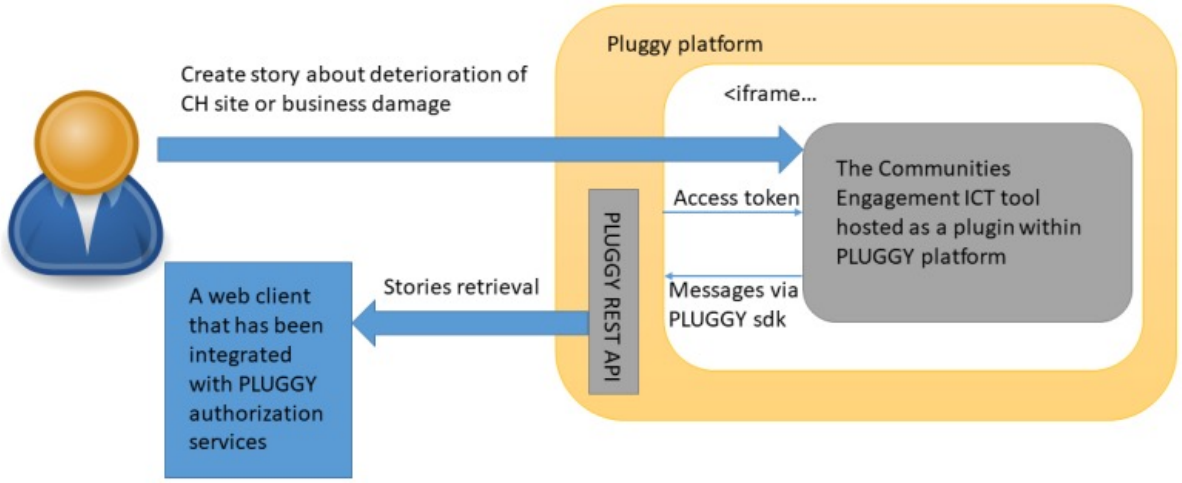

Figure 11: Integration of the Engagement Tool within PLUGGY platform

31st European Safety and Reliability Conference | Angers, France | 19-23 September 2021

Updating structural FE models of cultural heritage assets based on probabilistic tools

(María L., Jalón, Juan, Chiachío, Luisa M, Gil-Martín, Manuel, Chiachío, Enrique, Hernández-Montes Rubén, Rodríguez-Romero Víctor, Compán-Cardiel)

Keywords: Ambient vibration test, Bayesian system identification, cultural heritage buildings, finite element models, global sensitivity analysis, operational modal analysis.

Abstract

The deterioration of Cultural Heritage assets due to the climatic change and natural hazards is a pressing issue in many countries. In this sense, the assessment of their actual structural integrity based on higher-scale structural responses is key to assess the resilience of these important assets.

This paper proposes a rational methodology to integrate modal vibration data into structural FE models based on probabilistic tools. The methodology is based on solid Bayesian probabilistic principles thus allowing uncertainty quantification in the assessment. A real case study for a sixteenth century heritage building in Granada (Spain) is presented. The results show the efficiency of the proposed methodology in identifying the probability density functions of basic material parameters such as the Bulk modulus of the building stones or the modulus of soil reaction among others. (Full paper)

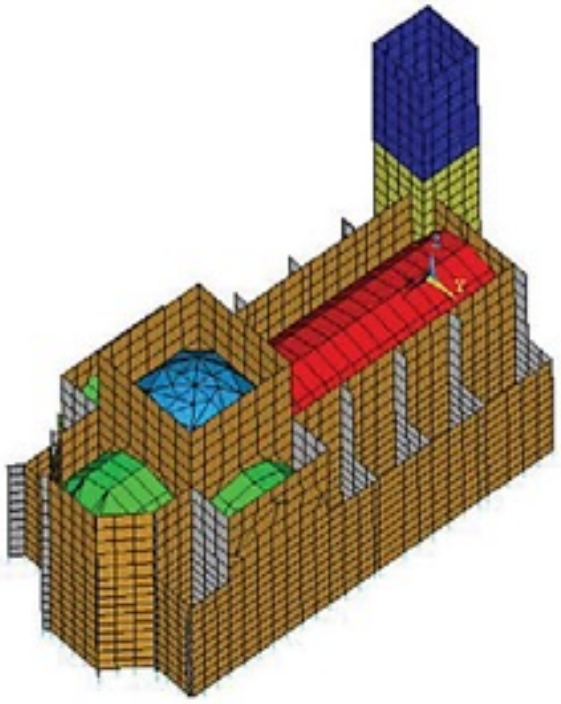

Figure 12: FE model and mesh details of San Jerónimo Monastery (Granada, Spain).

4th International Conference on Structural Integrity | Funchal, Madeira, Portugal | 30 August – 1 September 2021

3D simulation models for developing digital twins of heritage structures: challenges and strategies

(A. Shabani, M. Kioumarsi, M. Skamantzari, S. Tapinaki, A. Georgopoulos, V. Plevris)

Keywords: 3D geometric documentation; cultural heritage; digital twins; 3D laser scanner; photogrammetry; finite element model

Abstract

Structural vulnerability assessment of heritage structures is a pivotal part of a risk mitigation strategy for preserving these valuable assets for the nations. For this purpose, developing digital twins has gained much attention lately to provide an accurate digital model for performing finite element (FE) analyses. Three-dimensional (3D) geometric documentation is the first step in developing the digital twin, and various equipment and methodologies have been developed to facilitate the procedure. Both aerial and terrestrial close-range photogrammetry can be combined with 3D laser scanning and geodetic methods for the accurate 3D geometric documentation. The data processing procedure in these cases mostly focuses on developing detailed, accurate 3D models that can be used for the FE modelling. The final 3D surface or volumes are produced mainly by combining the 3D point clouds obtained from the laser scanner and the photogrammetric methods. 3D FE models can be developed based on the geometries derived from the 3D models using FE software packages. As an alternative, developed 3D volumes provided in the previous step can be directly imported to some FE software packages. In this study, the challenges and strategies of each step are investigated by providing examples of surveyed heritage structures. (Full paper)

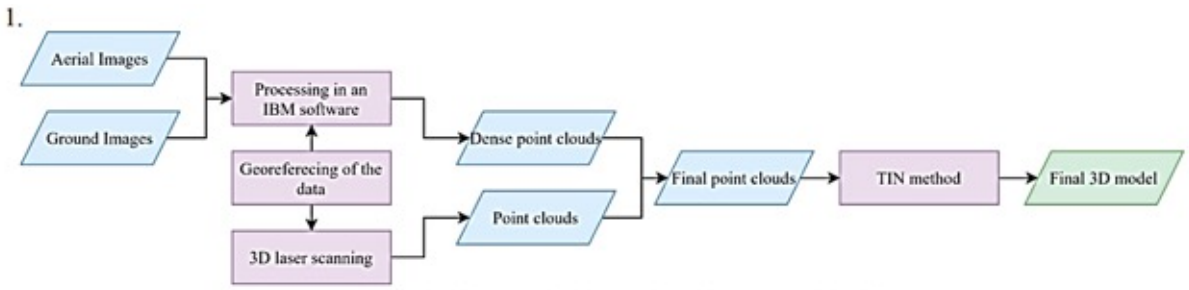

Figure 13: Workflow of the holistic methodology for developing 3D models of the CH assets

Japan Geoscience Union Meeting 2021| Online | 5 June 2021

Luigi Germinario from the Department of Geosciences of the University of Padova organized a Special Session at the at the Japan Geoscience Union Meeting (Session M-IS09) entitled "Weathering and conservation of cultural heritage and geosites". The following abstract presentation was conducted regarding HYPERION by Chiara Coletti from the Department of Geosciences of the University of Padova.

HYPERION: understanding and quantifying the effects of climate change on cultural heritage

(Chiara Coletti, Luigi Germinario, Antonio Galgaro, Lara Maritan, Matteo Massironi, Jacopo Nava, Raffaele Sassi, Claudio Mazzoli Rebecca Piovesan, Elena Tesser, Fabrizio Antonelli, and Renzo Bertoncello)

Abstract

Climate change is one of the most critical global challenges of our time. During the last century, the anthropic activity had a great impact not only on the environment, affecting even the conservation of cultural heritage. This is becoming a mandatory issue to be tackled by international and local administrations and heritage stakeholders.

Stone is one of the natural materials most utilized in historical monuments. Although stone decay phenomena have been broadly investigated in the past, only few studies are moving towards the understanding and quantification of the short- and long-term effects of climate change. This research direction, however, is essential for supporting sustainable mitigation plans and the city management. The HYPERION project aims to fill this gap, improving the knowledge of measurable material- and climate-based parameters that influence stone decay rate. The project includes simulations of future scenarios and potential effects of changing climate patterns and air quality, extreme climate events, and multi-hazard circumstances in the historical urban context.
In this contribution, we present the preliminary results of the study of selected building stones used in four European demonstration sites, in Italy (Venice), Greece (Rhodes), Spain (Granada), and Norway (Tønsberg). The basic petrographic and physical-mechanical investigation of the materials is combined with accelerated ageing tests under different environmental stresses (cycles of salt crystallization and freeze-thaw and interaction with rainwaters with different compositions) and field-exposure tests. The expected results will help refining adequate material-specific models of stone surface recession and support structural and hygrothermal simulations about the future decay of cultural heritage. (Full paper)

9th Turkish Conference on Earthquake Engineering | Istanbul, Turkey | 2-4 June 2021

A Dürüm Döner view of seismic risk assessment

(Dimitrios Vamvatsikos)

Keywords: risk, earthquake, dürüm döner, interface variable

Abstract
A dürüm döner (DD) is a magnificent culinary invention, without which any visit to Turkey would never be complete. Its excellent combination of bread and meat, with the occasional mix of tomato, onions and mayonnaise, is readily available to complement any walk around the sokaks and plazas of any Turkish city and town. The experience is inherently addictive, and Dr. V is no stranger to it. Contemplating a sabbatical in Turkey comes with an increased hazard of ample DD availability, and heightened risk of high calorie intake. When a powerful stakeholder (Mrs. V) steps in to question this sabbatical plan, how is Dr. V to show that he will be able to conduct research while safeguarding his enviable cuddly figure? Three nearby vendors of excellent but highly variable DDs, one exposed yet enterprising researcher, and one tough uncompromising stakeholder come together in a nail-biting risk assessment drama to play out in view of the Bosporus.

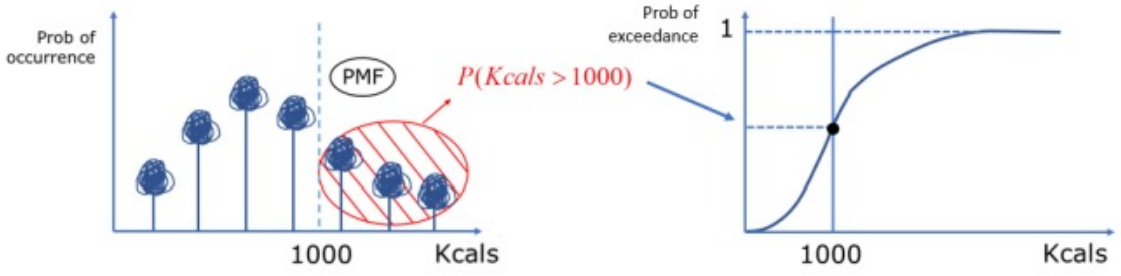

Figure 14: Probability mass function (left) and cumulative distribution function (right) of DD calories, indicating the limit-state threshold of interest.

Chapter in the Book "Protection of Historical Constructions"

The conference presentation **"Structural Model Updating a Historical Stone Masonry Tower in Tønsberg, Norway"** by Amirhosein Shabani, Agon Ademi, Mahdi Kioumarsi was included in the book "Protection of Historical Constructions", which is Part of the Lecture Notes in Civil Engineering book series (LNCE, volume 209). pp. 576-585 by Springer-Verlag (https://doi.org/10.1007/978-3-030-90788-4_45) on December 04, 2021. The above mentioned content was at first presented at the conference "PROHITECH 2021" under the same title.

M.Sc. Thesis

One M.Sc. thesis was presented during the last year in Greece, under the title ***«Design and Implementation of DAG-based workflows. Application of the interdependencies according to the existing data and tasks for an H2020 project»***. The M.Sc. student Angelos Koutanis under the supervision of Prof. Panayotis Yannakopoulos reviewed the field of Data Engineering to implement a data pipeline for the Hyperion Community Engagement Tool. The thesis was presented at the University of West Attica in October 2021.

Keywords: Data pipelines, Workflow Management Systems, Process Scheduling, Workflow Orchestration Platforms, Data processing

Abstract

In recent years the amount of data that companies and organisations are managing is enormous. Usually, these data belong to numerous data sources and can have different formats. It is important that these data will be processed and validated before feeding other systems. In order to make this happen, the orchestration and execution of tasks is necessary. These tasks are retrieving the data from all these sources, processing them and delivering them to the appropriate destination. This set of processes assembles a data pipeline. For the implementation and monitoring of data pipelines there are numerous open-source Workflow Orchestration platforms available. This thesis reviews the field of Data Engineering regarding the fundamentals of data pipelines, as well as, investigates some of the most famous Workflow orchestration platforms. Additionally, the most suitable Workflow Orchestration Platform is picked to implement a data pipeline for the Hyperion Community Engagement Tool. This tool is part of Hyperion Project, a real-life project that helps to protect cultural heritage sites. Finally, before the implementation of the data pipeline; the analysis and definition of requirements for each task is taking place and then the procedure continues further with the implementation of the data pipeline according to the most suitable workflow orchestration platform.

1.2 Journal Publications

During 2023 four journal papers were published with regards to HYPERION project while in 2022 twenty papers were published. Two of them were included in our previous Annual Magazine II. These are: "State of the art of simplified analytical methods for seismic vulnerability assessment of unreinforced masonry buildings" and "A Modelling Approach for the Assessment of Climate Change Impact on the Fungal Colonization of Historic Timber Structures". On the other hand, four publications were published during the second year of the project but did not appear in our previous issue. The journals are presented in reverse chronological order below:

Seismic fragility analysis of low-rise unreinforced masonry buildings subjected to near- and far-field ground motions

Amirhosein Shabani, Maria Zucconi, Delaram Kazemian, Mahdi Kioumarsi
Results in Engineering (2023), 18, 101221, Science Direct

Keywords: Low-rise buildings, Seismic fragility, Unreinforced masonry, Near-field ground motions, Pulse-like ground motions

Abstract

Unreinforced masonry (URM) is considered one of the most cost-effective structural typologies for low-rise buildings in seismic regions. Near-field (NF) ground motions are sometimes characterized by high-velocity pulses that are typically more destructive than far-field (FF) seismic events. Therefore, a seismic fragility analysis of low-rise URM building typologies subjected to NF and FF seismic events was performed. Four URM walls were chosen, and nonlinear models of the walls were developed based on the double-modified, multiple vertical line element model (DM-MVLEM). The zero-moment coefficient was used to determine the effective uncracked section length of a pier. This parameter must be calculated for each pier of a perforated URM wall to derive the maximum shear strength of the piers using a nonlinear model development process. A simplified analytical method was proposed to obtain the zero-moment coefficient factor of piers by performing linear static analysis on nine perforated walls and regression analyses of the results. Subsequently, nonlinear pushover analysis was performed to derive the capacity curves, and the damage limit states were defined for each model according to the Eurocode 8 standard. Subsequently, incremental dynamic analysis (IDA) was performed for each case study by applying FF and NF ground motions. Finally, fragility curves were developed based on the IDA results for each damage limit state. The susceptibilities of one- and two-story URM walls subjected to FF and NF seismic events were investigated by examining the derived fragility curves.

To download the full issue or read more, visit the following link: https://doi.org/10.1016/j.rineng.2023.101221

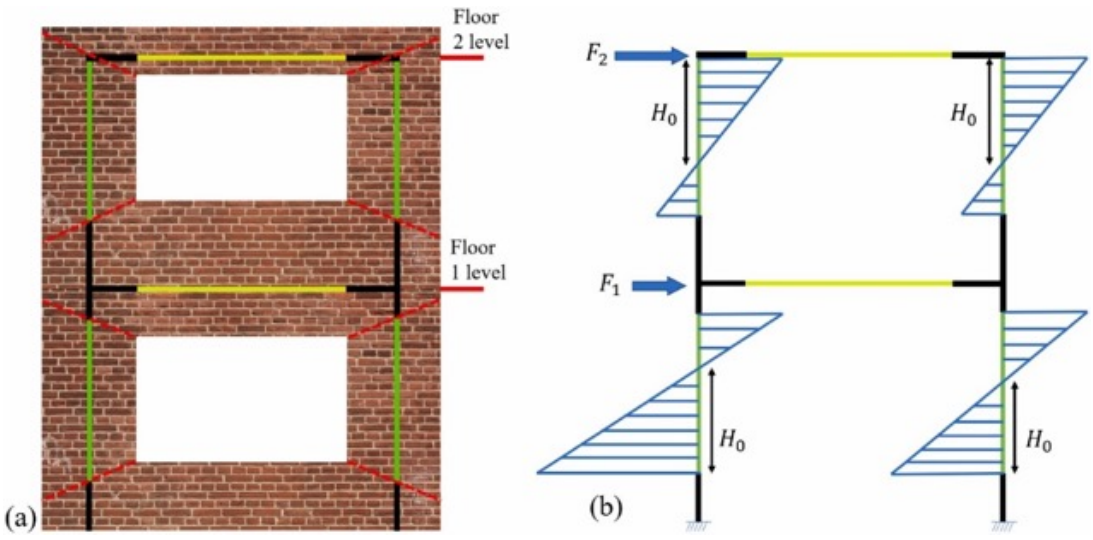

Figure 15: Features induced by material (a) A perforated two-story URM wall and (b) the moment diagram of the wall subjected to lateral loadings and definition of H_0.

The Relationship between Concrete Strength and Classes of Resistance against Corrosion Induced by Carbonation: A Proposal for the Design of Extremely Durable Structures in Accordance with Eurocode 2

Luisa María Gil-Martín, Luisa Hdz-Gil, Emilio Molero and Enrique Hernández-Montes
Sustainability (2023), 15(10), 7976, MDPI

Keywords: carbonation front; minimum cover; reinforced concrete structures

Abstract
The new Eurocode 2 provides valuable information on the required concrete cover to protect reinforcement against corrosion induced by carbonation, for two design service life values of 50 and 100 years. However, to design structures with an even longer service life and assess existing ones, additional tools are necessary. The 'square root of time' relationship is a well-established method for estimating the penetration of the carbonation front, making it useful for long-term design and assessment purposes. In this article, we propose a new function that adjusts the evolution of the carbonation front to the Eurocode 2 values. This function is a powerful tool for designing extremely durable structures and assessing existing ones. To demonstrate its effectiveness, we provide two examples of its application.

To download the full issue or read more, visit the following link: https://doi.org/10.3390/su15107976

Mapping of stones and their deterioration forms: The Clock Tower, Venice (Italy)

Rebecca Piovesan, Elena Tesser, Lara Maritan, Gloria Zaccariello, Claudio Mazzoli, Fabrizio Antonelli
Heritage Science, (2023), 11:108, Springer

Keywords: Torre dell' Orologio, Ancient stones and marbles, Deterioration forms, Weathering, Total Deterioration Rank

Abstract
The HYPERION EU project aims to develop a Decision Support System to improve resilience and sustainable reconstruction of historic areas faced with climate change and extreme events. In this context, Venice presents an outstanding example of urban and architectural complexity and richness. The mapping of the ornamental stones of the façade of the Venice Clock Tower (Torre dell' Orologio) and their deterioration patterns acts as a milestone on which to build the knowledge-acquisition process of the system as regards stone artefacts and their decay products. The Clock Tower is an early Renaissance building (1499) in Lombardesque style and stands over the entrance to the Mercerie on the northern side of St. Mark's Square. Detailed surveys and mapping of both building materials (mainly stones) and deterioration patterns were carried out, the latter following the glossary of weathering forms, coupled with an easy-to-use scale of evaluation of their intensity. The data output consists of several monothematic maps which can be handled separately, each one focusing on precise lithological or specific deterioration aspects. This study also proposes a simple approach to summarizing the total state of deterioration of the building in the form of a Total Deterioration Rank (TDR) and its representation. The stones used in the façade are regional (Ammonitico Rosso and Scaglia Rossa) and extra-regional limestones (Istrian Stone), as well as Mediterranean white and coloured marbles and stones already used in antiquity (i.e., Fior di Pesco or marmor chalcidicum, lapis porphyrites, a volcanic rock from the Egyptian Eastern Desert, Proconnesian marble from the Island of Marmara, Pavonazzetto toscano and white Carrara marble from the Italian Apuan Alps). The most frequent forms of deterioration detected are black crusts, patinas, discoloration and patterns linked to erosion processes. The interrelation of different mappings led to a number of useful considerations concerning differences in the effectiveness of maintenance procedures between public and private management of the monument.

To download the full issue or read more, visit the following link: https://doi.org/10.1186/s40494-023-00909-4

Figure 15: Features induced by material loss: a, b differential erosion on Ammonitico Rosso from Verona slabs (eastern façade), c microkarst on Istrian Stone small columns (western façade). Discoloration and deposit: d black crusts on Istrian-stone Corinthian capitals (southern façade); e soiling on Scaglia Rossa slabs (western façade); f efflorescence on Istrian Stone small columns (western façade); g greenish staining on Istrian Stone (western façade); h yellowish patinas (southern façade)

Statistical property parameterization of simple rocking block response

Lachanas G. Christos; Vamvatsikos Dimitrios; Dimitrakopoulos G. Elias
Earthquake Engineering Structural Dynamics, (2023), 52 (2): 394-414, Wiley

Keywords: incremental dynamic analysis, response statistics, rigid rocking blocks, seismic demands

Abstract

The parametric representation of rocking fragilities is statistically investigated. Initially, the potential normalization of the rocking parameters to reduce the problem's dimensionality is tackled by undertaking comparisons both on a single-record and a sample-of-records basis. It is found that the slenderness angle can be normalized out when probabilistically considering the rocking response of simple rocking blocks with the same semi-diagonal length. Then, the robustness of the lognormal distribution for characterizing the rocking motion is investigated. Sets of pulse-like and ordinary ground motions are employed to test the lognormal fit for the full range of rocking response when the peak ground acceleration or the peak ground velocity are employed as intensity measures. In both cases, the lognormal distribution offers an adequate, but often imperfect, baseline model of the rocking fragility curves. Instead, a shifted lognormal that accounts for the absence of response below the rocking initiation intensity is an enhanced solution that can form the basis for offering simplified response model surrogates.

To download the full issue or read more, visit the following link: https://doi.org/10.1002/eqe.3765

Bayesian structural parameter identification from ambient vibration in cultural heritage buildings: The case of the San Jerónimo monastery in Granada, Spain

Enrique Hernández-Montes, María L. Jalón, Rubén Rodríguez-Romero, Juan Chiachío, Víctor Compán-Cardiel, Luisa María Gil-Martín
Engineering Structures, (2023), 284, 115924, Elsevier

Keywords: deterioration rate, cultural heritage buildings, climate factors, surface recession assessment, photogrammetry

Abstract

The deterioration of Cultural Heritage assets caused by the natural hazards is a pressing issue in many countries. Therefore, reliable models based on the large-scale structural response of the assets is key to assess their resilience. However, reliable models such as large and detailed Finite Element (FE) models, require a large number of data and input parameters. This paper proposes a Bayesian learning approach to identify the main parameters of a FE model with quantified uncertainty based on ambient vibration data. As a novelty when compared with other Bayesian structural parameter identification methods from ambient vibration data, here the likelihood function is formulated in a principled way considering information from both frequencies and modes using a probabilistic version of the Modal Assurance Criterion for the modes. This method is embedded into a parameterised computational model to automate the simulation process, and a real case study for a sixteenth century heritage building in Granada (Spain) is presented. The results show the suitability and effectiveness of the proposed Bayesian approach in identifying the most plausible values of the uncertain model parameters in a rigorous probabilistic way, but also in obtaining the modelled frequencies and the modal assurance criterion values with quantified uncertainty.

To download the full issue or read more, visit the following link: https://doi.org/10.1016/j.engstruct.2023.115924

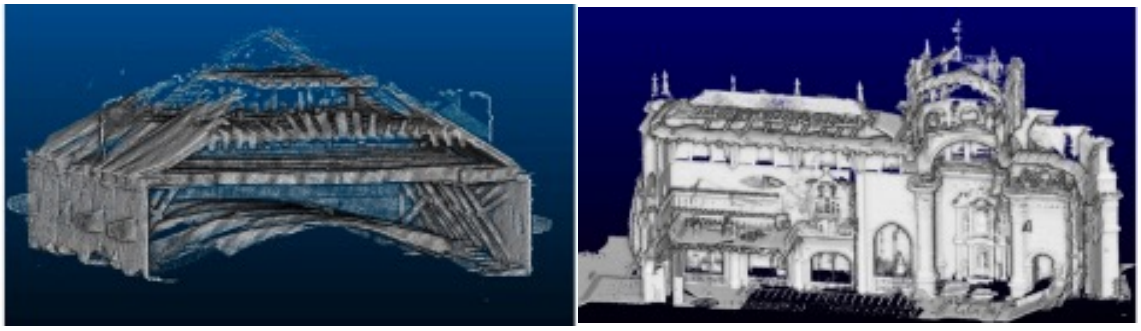

Figure 16: Geometrical 3D data: (left) point cloud of roof's support, (right) point cloud of the interior

Deterioration Effects on Bricks Masonry in the Venice Lagoon Cultural Heritage: Study of the Main Façade of the Santa Maria dei Servi Church (14th Century)

Coletti, Chiara, Cesareo, Ludovica Pia, Nava, Jacopo, Germinario, Luigi, Maritan, Lara, Massironi, Matteo, Mazzoli, Claudio
Heritage, (2023), 6:1277–1279, MDPI

Keywords: bricks; cultural heritage; decay; weathering process; damage; historical building; construction materials; firing process; salt crystallization; Venice lagoon

Abstract

Tidal exchange, capillary rise, water condensation-evaporation cycles, and crystallization of salts are the main causes of damage in historic brick buildings in Venice. The present study addressed these issues by proposing a study of twenty-three brick samples collected on the main façade of the Santa Maria dei Servi Church (14th century). The color, mineralogical composition, and texture of these samples were studied using standard methods such as spectrophotometry, X-ray powder diffraction (XRPD), optical microscopy (OM), and field emission scanning electron microscopy (FESEM). The presence of carbonates (calcite and dolomite) and newly formed silicate phases, such as gehlenite and diopside, provided indications of the temperatures reached during firing and suggested the absence of a good standardization in the production process. Meanwhile, XRPD and hyperspectral analysis (HA) detected sulfates (e.g., gypsum and mirabilite) as the main weathering products due to the salt decay process that affects monuments in the Venice lagoon environment. Moreover, secondary phases, such as Mg- and Ca-zeolites, occurred in bricks where the groundmass observed by OM was more vitri-

ficated, and the XRPD patterns displayed the highest amorphous content. On-site mapping of sulfates and chlorophyll by HA was also performed on the main façade of the Church, highlighting the large presence of salts and biodeterioration.

To download the full issue or read more, visit the following link: https://doi.org/10.3390/heritage6020070

Figure 17: Details of the main façade of the ruins of Santa Maria dei Servi Church: (a) the external main portal; (b) the internal main portal; (c) exfoliation of red Verona marble used in the portal; (d) detail of ornamental Istrian stone use in the portal with black crusts in sheltered areas; (e) detail with Proconnesian marble (grey) and the tondo in Cipollino marble (red); secondary plants (ficus carica) growth is also visible.

Prediction Model for the Evolution of the Deterioration of Bricks in Heritage Buildings in Venice Caused by Climate Change

Enrique Hernández-Montes, Luisa Hdz-Gil, Chiara Coletti, Simone Dilaria, Luigi Germinario and Claudio Mazzoli

Heritage (2023), 6:483–491, MDPI

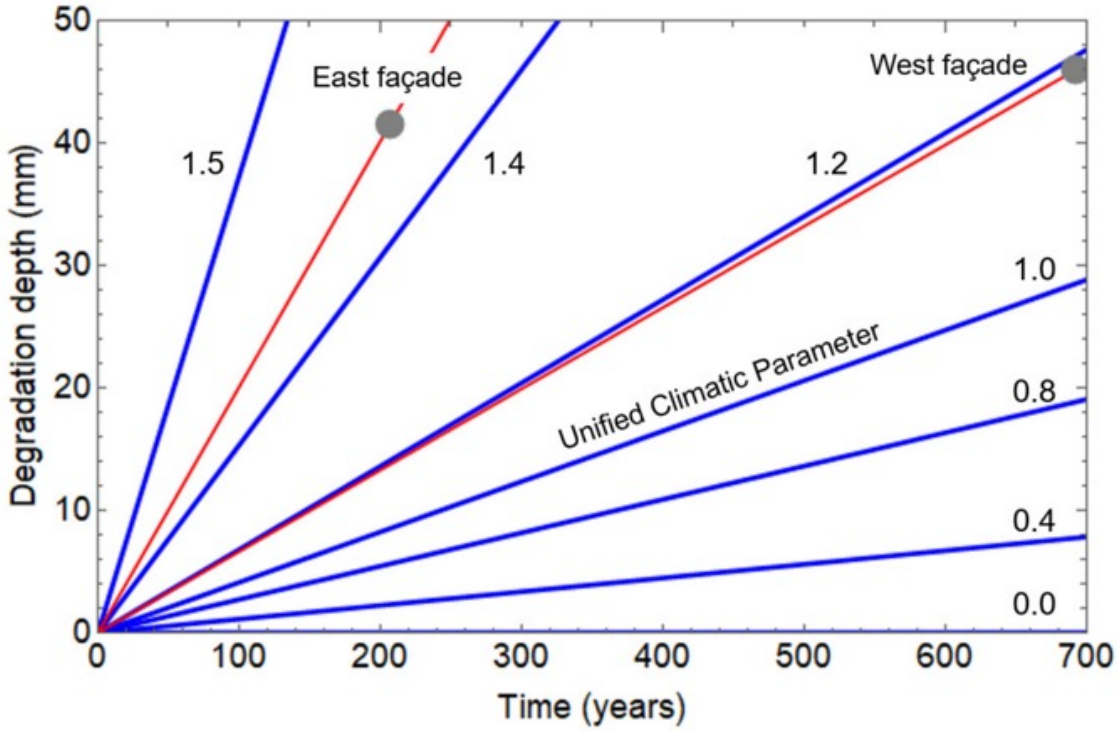

Figure 18: Deterioration Evolution Diagram (DED) of the bricks depending on the exposure times of the façades and the Unified Climatic Parameter, which accounts for the different orientations of the two sides of the main façade of Santa Maria dei Servi church in Venice (grey circles), facing west and east, respectively.

Abstract

This work presents a methodology for obtaining a quantitative expression of the superficial deterioration of bricks affected by climatic conditions. The method combines in situ measurements with laboratory data. Input data on material recession were obtained from photogrammetric observations, the material properties were derived from laboratory tests or the relevant literature, and climate data were provided from regional environmental monitoring service. The climatic parameters considered in this study are: relative humidity, number of freeze-thaw cycles (i.e., mean number of days per year with temperatures below zero), and peak sun hours per day. The methodology proposed estimates the deterioration rate of brick façades under variable climate conditions over time. As a conclusion of this research, a new tool for the structural evaluation of brick walls is presented.

To download the full issue or read more, visit the following link: https://doi.org/10.3390/heritage6010025

Optimal placement of coupling elements of RC shear walls using endurance time method

Ali Kheyroddin, Reza Arabsarhangi, Amirhosein Shabani, Mahdi Kioumarsi
Procedia Structural Integrity, (2022), 42, 210-217, Elsevier

Keywords: Endurance time method; RC shear walls; Coupling beams

Abstract

Shear wall is one of the common lateral bracing systems in reinforced concrete structures. A coupling beam can be used due to architectural limitations for connecting two or multiple separate walls. Coupling beams are the most vulnerable elements of coupled shear wall systems. Therefore, beams could be designed to act as replaceable fuses in the system. This paper investigates the application of viscoelastic coupling dampers (VCD) and replaceable steel coupling beams in a high-rise building in a high seismicity region. A parametric study has been performed to determine the most effective number and location of the dampers to acquire enhanced seismic performance of the structure. The endurance time analysis method has been utilized to compare the seismic performance of a conventional steel coupled wall building to alternative designs incorporating VCD. The results show that the structure with positioning the coupling beams of P2 in which 25% of coupling beams are VCD has had 21% less inter-story drift ratios compared to P1, where all coupling beams are replaceable steel coupling beams (RSCBs). VDCs allow the natural period of the structure to enhance. By replacing the RCSB with less stiff VCDs, the lateral stiffness of the structure is reduced and the natural period is shifted beyond the predominant periods of regular earthquakes. The added damping provided by using the VCDs dissipates seismic energy and efficiently controls excessive drifts.

To download the full issue or read more, visit the following link: https://doi.org/10.1016/j.prostr.2022.12.026

Climate change impact on the degradation of historically significant wooden furniture in a cultural heritage building in Vestfold, Norway

Petros Choidis, Akriti Sharma, Giulia Grottesi, and Dimitrios Kraniotis
E3S Web of Conferences, (2022), 362, EDP Sciences

Abstract

Climate change is expected to significantly affect the interior climate of old, leaky buildings without HVAC systems. As a result, the items of cultural significance that are hosted indoors will experience new ambient conditions, which will affect their degradation. In the current research, the impact of climate change on the biological, mechanical, and chemical degradation of a cabinet and a storage trunk which are made of wood and have paintings on their outer surface is investigated. These two items are found in two different rooms of a historic timber building in Vestfold, Norway. Data from the REMO2015 driven by the global model MPI-ESM-LR are used in order to account for past, present, and future climate conditions. In addition, climate data from ERA5 reanalysis are used in order to assess the accuracy of the MPI-ES-LR_REMO2015 model results. Whole building hygrothermal simulations are employed to calculate the temperature and the relative humidity inside the rooms that host the items of interest. The transient hygrothermal condition and certain characteristics of the timber surfaces are used as inputs in models that describe their degradation. The biological degradation is examined by using i) the updated VTT mould model and ii) the Growing Degree Days (GDD) for temperature and humidity dependent insects. The mechanical deterioration is assessed by the method proposed by Mecklenburg et al. (1998). The concept of the Lifetime Multiplier (LM) is used in order to assess the chemical deterioration of the furniture. Results reveal a significant mechanical degradation risk and a very high chemical deterioration risk. The biodeterioration risk remains at acceptable levels. Moreover, it could be possible that the storage trunk would be damaged by certain insects in the future. It is then suggested that both items should be moved to a

room with proper conditions in order to minimize their chemical and mechanical deterioration risk and extend their life span. Finally, the significance of implementing bias correction in the data from climate models is underlined.

To download the full issue or read more, visit the following link: https://doi.org/10.1051/e3sconf/202236211003

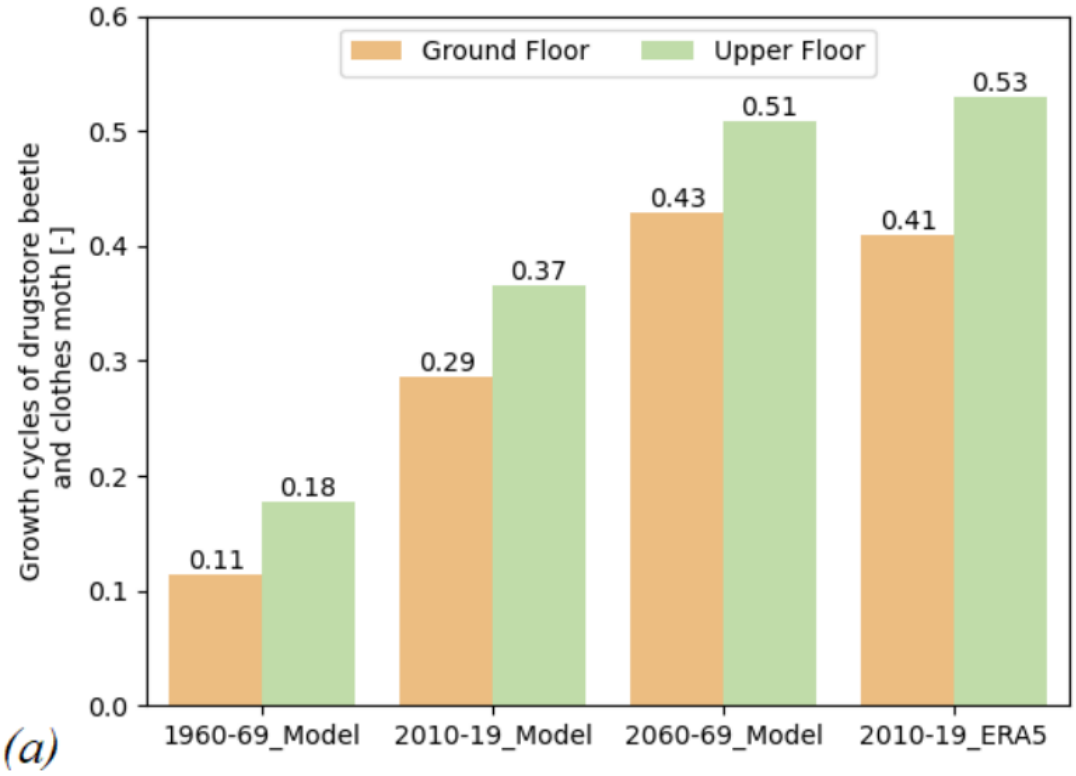

Figure 19: Average annual growth cycles for (a) drugstore beetle and clothes moth

Hyperomet: An OpenSees interface for nonlinear analysis of unreinforced masonry buildings

Amirhosein Shabani, Mahdi Kioumarsi
SOFTWARE X, (2022), 20, 101230, Elsevier

Keywords: Unreinforced masonry, Numerical modelling, Double modified MVLEM, Unified method, Nonlinear analysis, OpenSees

Abstract

Seismic vulnerability assessment of historical unreinforced masonry (URM) buildings is crucial for the authorities due to the high sus-

ceptibility of historical URM buildings to earthquakes. Open system for earthquake engineering simulation (OpenSees) is a well-known, powerful, and versatile seismic analysis platform. In a lack of a free graphical user interface (GUI) for seismic analysis of URM buildings, Hyperomet was designed to bridge the gap between nonlinear analysis of URM buildings and OpenSees platform. The Hyperomet GUI includes an accurate enough macroelement representing the nonlinear behavior of URM components. The structures can be modeled based on the double-modified multiple vertical line element model (DM-MVLEM) and the Unified method (UM) using the GUI. Calculators for deriving the mechanical properties are provided to minimize the modelling time. Furthermore, the ability to perform various analysis types including incremental dynamic analysis (IDA) is facilitated.

To download the full issue or read more, visit the following link: https://doi.org/10.1016/j.softx.2022.101230

Optimal sensor placement techniques for modal identification of historical masonry structures

Amirhosein Shabani, Mahdi Kioumarsi
Procedia Structural Integrity, (2022), 42:147-154, Elsevier

Keywords: Optimal sensor placement; Structural health monitoring; Historical masonry structures.

Abstract

Since destructive tests are not allowed for historical structures, numerical model updating using accelerometers has gained a lot of attraction in the last decade. Furthermore, another application of structural health monitoring is damage detection for near-real time monitoring of cultural heritage assets of infrastructures such as masonry bridges. However, high cost is the main problem that discourages the use of large-scale structural health monitoring systems, and a modal pretest analysis is required to plan and optimize the modal tests procedure. For this purpose, various optimal sensor placement (OSP) techniques have been developed to derive the operational modal analysis results with a minimum number of sensors, leading to a lower cost. In this study, various OSP techniques have been applied to optimize sensor placement in two selected case studies. The first case study is a two-span masonry arch bridge in Rhodes, Greece and the second is a stone masonry tower located in Tønsberg, Norway. Baseline finite element models were developed before performing the ambient vibration tests and model updating process. The optimum sensor locations were detected using various techniques, and a comparative study was conducted on the results. Furthermore, the effect of considering soil structure interaction on the OSP results was investigated.

To download the full issue or read more, visit the following link: https://doi.org/10.1016/j.prostr.2022.12.018

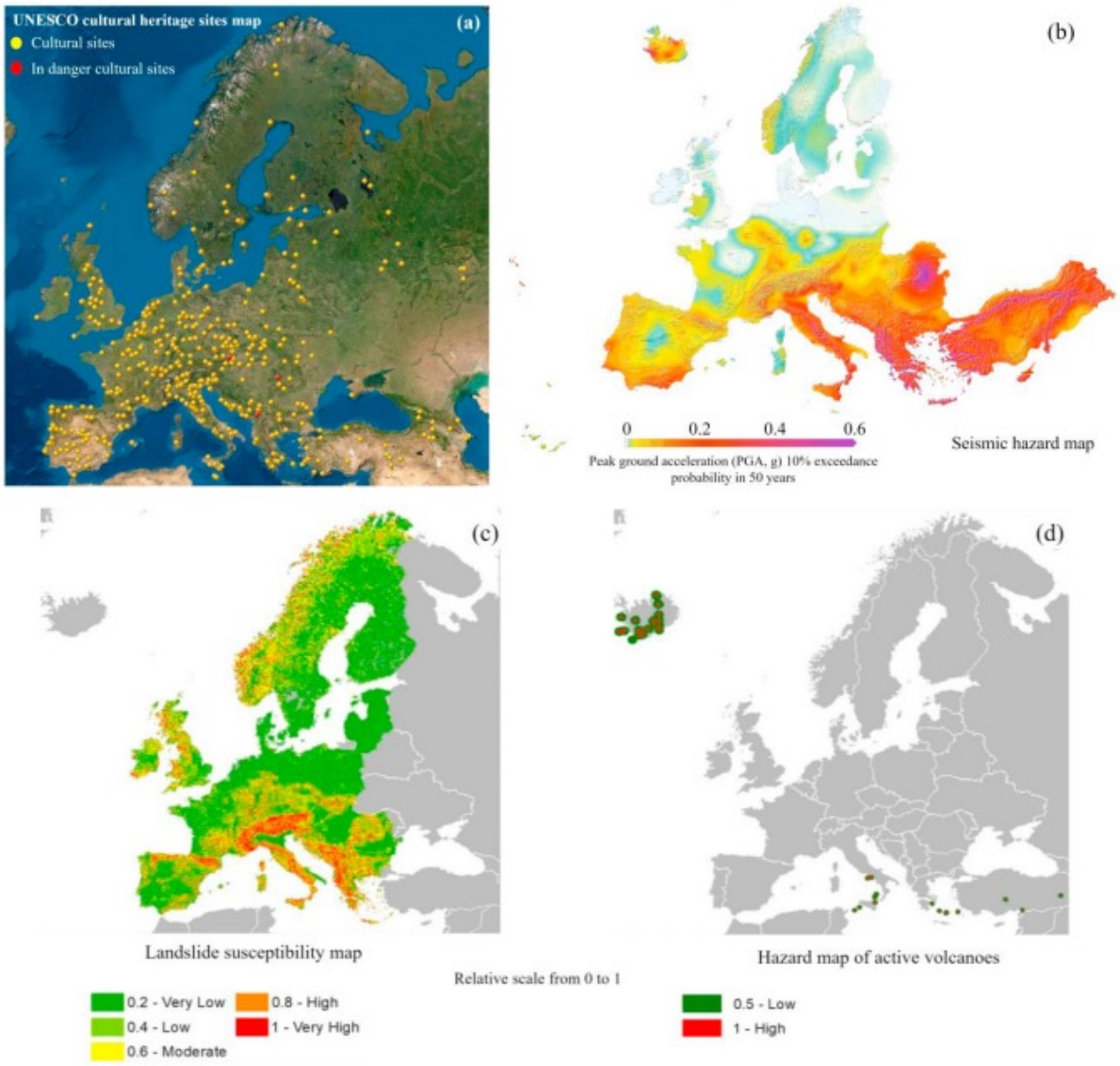

Figure 20: (a) The UNESCO cultural heritage sites map (adapted from https://whc.unesco.org/), (b) seismic hazard map developed by Danciu et al. (2021), (c) landslide susceptibility map presented by Günther, Van Den Eeckhaut, et al. (2014) and (d) hazar

Fragility Curves for Historical Structures with Degradation Factors Obtained from 3D Photogrammetry

Luisa María Gil-Martín 1, Luisa Hdz.-Gil, Mohsen Kohrangi, Esperanza Menéndez and Enrique Hernández-Montes
Heritage, (2022), 5(4), 3260–3279, MDPI

Keywords: degradation pattern; photogrammetry; fragility curve; FE modelling

Abstract

The influence of the effects of the degradation of materials on the seismic fragility of Cultural Heritage buildings in Granada (Spain) is investigated. The degradation of the material, which mainly happens at the lower levels of the façades, is obtained by using 3D photogrammetry data. Fragility curves for three cultural heritage constructions in Granada are calculated by using FE nonlinearamic analyses for both non-deteriorated and deteriorated geometries. The Finite Elements (FE) models, based on the macro-modelling technique, are subjected to ground motions for the city of Granada, which were selected by considering Probabilistic Seismic Hazard Analysis (PSHA) methodology with their probability of occurrence. The response of each model is analyzed for different seismic Intensity Measure (IM) levels, which, in this study, correspond to average pseudo-acceleration. The procedure is applied to three monuments in Granada that were built with two different constructions materials: calcarenite and rammed earth. The damage mechanisms considered are roof displacement or maximum compressive principal stress, depending on each case. The results show that the restoration works that have been carried out has prevented structural failures in the rammed earth construction studied, and that, during future seismic events, special attention must be paid to the level of compressive strength reached in the Santa Pudia calcarenite used at the San Jerónimo monastery.

To download the full issue or read more, visit the following link: https://doi.org/10.3390/heritage5040167

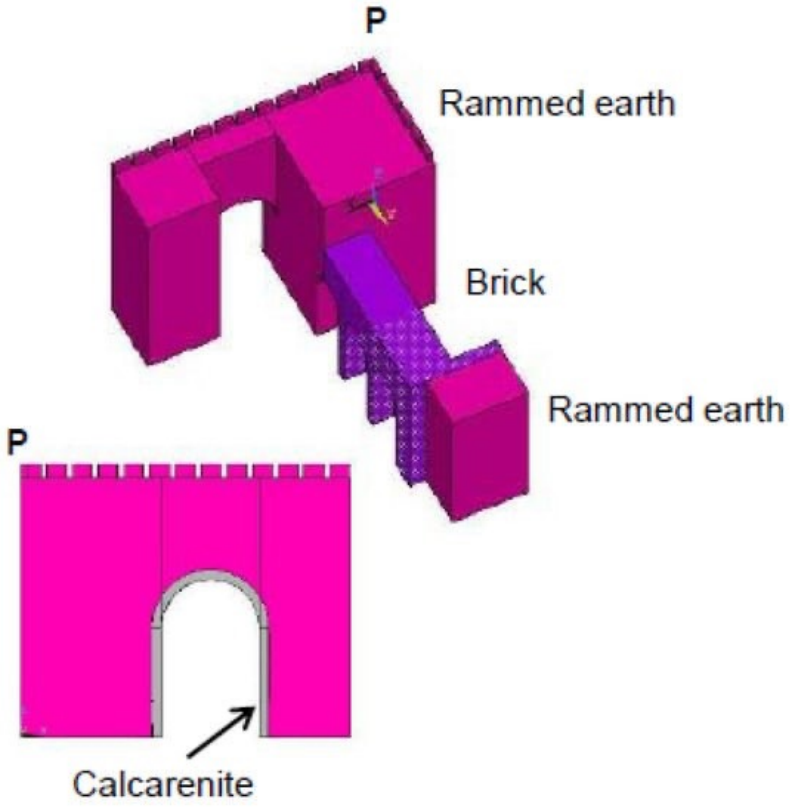

Figure 21: FE model of Puerta Elvira

Microclimate and Weathering in Cultural Heritage: Design of a Monitoring Apparatus for Field Exposure Tests

Germinario, Luigi; Coletti, Chiara; Girardi, Giampaolo; Maritan, Lara; Praticelli, Nicola;
Heritage, (2022), 5(4), 3211–3219, MDPI

Keywords: building material; long-term monitoring; stone deterioration; wood decay; microclimate sensor; surface temperature; surface moisture; climate change; risk assessment

Abstract

An innovative experimental method for the long-term monitoring of outdoor microclimate and material decay at cultural heritage sites was developed to aid the formulation of new damage functions and models for climate-change risk assessment. To that end, an apparatus for field exposure tests was designed to monitor a variety of historical building materials in different environmental settings. The data series acquired, i.e., surface temperature and moisture, are compared with the corresponding meteorological datasets on a local and regional scale. The apparatus is designed for supporting also the monitoring of the physical and chemical changes caused by weathering. This novel method is expected to provide insights into the interaction between historical materials and the environment, which can be exploited for the protection and conservation of cultural heritage.

To download the full issue or read more, visit the following link: https://doi.org/10.3390/heritage5040165

Figure 22: The stone materials selected (the short side of each photo is 4 cm).

Yield displacement charts for performance based seismic design

Enrique Hernández-Montes, María L. Jalón, Juan Chiachío, Luisa María Gil-Martín
Bulletin of Earthquake Engineering, (2023), 21:237–255, Springer

Keywords: Performance-based design, Yield displacement, Yield frequency spectra, Preliminary design

Abstract
A new tool for seismic design is presented, called Yield Displacement Charts (YDC). As with its predecessors, the Yield Point Spectra (YPS) and the Yield Frequency Spectra (YFS), the YDC concept takes advantage of the simple features of yield displacement (uy), to use uy in a performance-based design instead of a force-based period-dependent approach. A self-contained and comprehensive approach to YPS and YFS is presented, enabling the novel aspect of YDC to be introduced: a tool for a multi-performance objective design that only depends on the location of the structure to be designed. Once the yield displacement chart has been calculated for a particular place, it can be used for the preliminary design of any structure. For a given value of yield displacement, the YFS are obtained from the Yield Displacement Chart. The suitability of the methodology proposed is illustrated by means of a simple case study of a concrete bridge pier.

To download the full issue or read more, visit the following link: https://doi.org/10.1007/s10518-022-01534-5

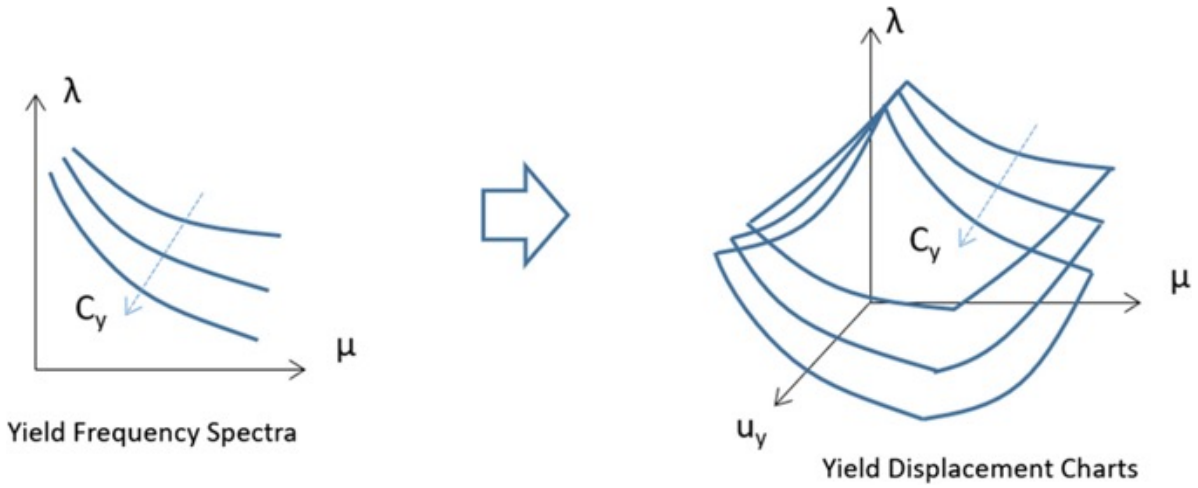

Figure 23: Yield displacement charts

Risk Assessment of Rehabilitation Strategies for Steel Lattice Telecommunication Towers of Greece under Extreme Wind Hazard

Dimitrios V. Bilionis, Konstantinos Vlachakis, Dimitrios Vamvatsikos, Maria-Eleni Dasiou, Ioannis Vayas, Konstantinos Lagouvardos
Engineering Structures, (2022), 267, 114625, Elsevier

Keywords: telecommunication tower, steel lattice tower, performance-based wind engineering, risk assessment, wind hazard

Abstract
The risk and losses associated with the wind-induced failure of existing steel lattice telecommunication towers are assessed for a number of upgrade/replace/redesign schemes. Specifically, a performance-based wind engineering framework is employed for assessing a

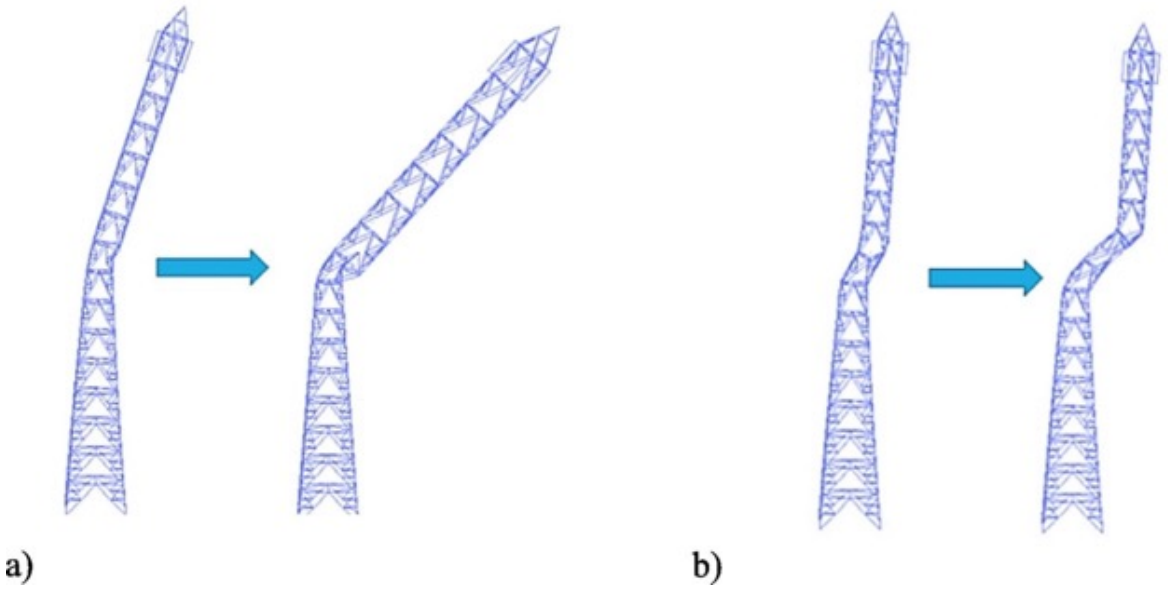

Figure 24: Failure modes revealed by pushover analysis: a) Leg buckles first, b) Vertical bracing member buckles first.

typical tower topology used by EU telecommunication network operators over four different cases: a conventional design, its corroded version after 60 years, a strengthened version of the corroded tower by applying fibre-reinforced polymer plates, and a redesign with high-strength steel. Multiple potential sites of installation were considered throughout coastal and mainland Greece, comprising two different groups of design wind speed. Mischaracterization of the site-specific wind distribution is by far the most important risk factor, with corrosion coming right behind. Still, selecting a rehabilitation approach does not depend only on site and tower characteristics, but also on the projected direct and indirect losses. By considering service to different populations, even after 60 years of corrosion, the "Do Nothing" approach may still be competitive when serving few residents and for short projected lifetime, while an upgrade is considered optimal for larger towns, or wherever higher revenue is on the line.

To download the full issue or read more, visit the following link: https://doi.org/10.1016/j.engstruct.2022.114625

Recession rate of carbonate rocks used in cultural heritage: Textural control assessed by accelerated ageing tests

Salvini Silvia, Bertoncello Renzo, Coletti Chiara, Germinario Luigi, Maritan Lara, Massironi Matteo, Pozzobon Riccardo, Mazzoli Claudio
Journal of Cultural Heritage, (2022), 57:154-164, Elsevier

Keywords - Recession rate Ageing tests, Rainwater simulation, Confocal microscopy, Grain-size Carbonate rocks

Abstract

In this study, the recession rate of eleven carbonate stones widely used in the cultural heritage of northeastern Italy and differing in their textural features and mineralogical composition was investigated. Samples of stones known as Vicenza (Nanto and Costozza varieties), Carrara marble, Verona (Red and Brown varieties), Asiago, Istria (Orsera variety), Aurisina, Chiampo (Ondagata and Paglierino varieties), and Botticino were subjected to accelerated ageing tests in an environmental test chamber for simulating the effect of rainfall, using two different water compositions corresponding to rainwater chemistry in the cities of Bologna (pH- 7) and Stresa (pH - 6) in Italy. Bulk stone recession was evaluated considering sample weight loss as a function of the number of wetting cycles. Moreover, direct measurements of recession were performed by confocal microscopy, which allowed 3D surface reconstruction of the stone surface and evaluation of differential recession as a function of calcite grain size. The results also allowed the definition of correction coefficients for calculating more precisely the recession rate of carbonate rocks using known recession equations from the literature. This pilot study illustrates a rapid and efficient methodological approach that can be used for providing reliable estimates of future stone deterioration in cultural heritage, related to specific environmental conditions and expected climate scenarios, which can be exploited for evaluating risk-based protection measures of a variety of historical artifacts and structures.

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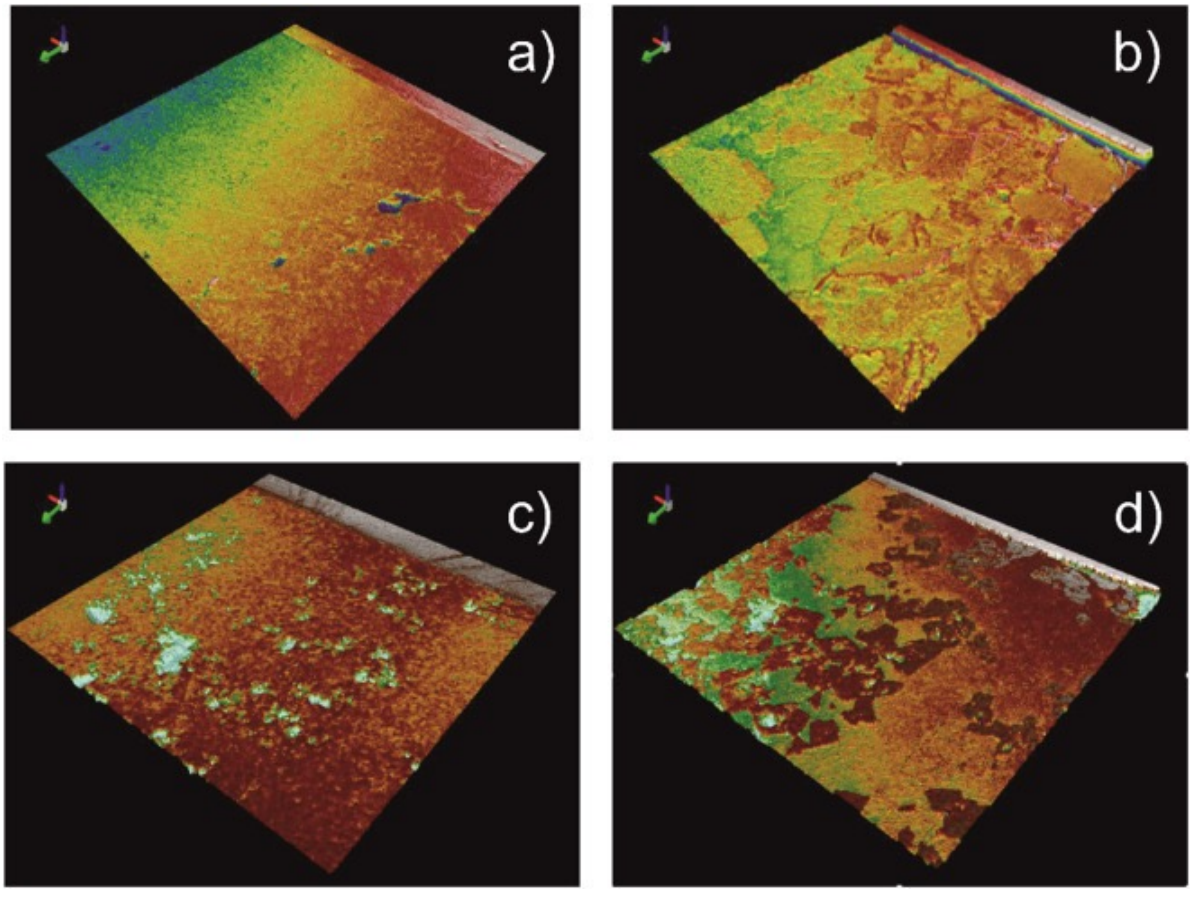

Figure 25: 3D surface model of a sample of Chiampo Paglierino stone (a and b) and of Botticino stone (c and d) before the ageing test (left) and after 240 immersion cycles in the Stresa water (right). The side of the scanned area is about 3 mm. On the opposite side is the stainless still plate used as a reference in the evaluation of stone recession.

Mechanical characterization and elastic stiffness degradation of unstabilized rammed earth

Luisa María Gil-Martín, Manuel Alejandro Fernández-Ruiz, Enrique Hernández-Montes
Journal of Building Engineering, (2022), 56, 104805, Elsevier

Keywords: Rammed earth, Creep, Compressive strength, Mechanical properties, Instantaneous response after creep

Abstract

Rammed earth is attracting renewed interest due to its sustainability. In this work, a mechanical characterization of unstabilized rammed earth is presented. Compressive strength, Young's modulus, and Poisson's ratio were determined, with the first of these being the most representative mechanical property of rammed earth. Stress – strain curves were obtained from uniaxial compression tests. Creep is of great importance in the long-term assessment of historical buildings and in the design of new ones. Samples of rammed earth were subjected to a constant load for 15 days to study their creep behavior. In order to simulate the long-term behavior of the material, different rheological models were fitted to the experimental results. The instantaneous deformation of rammed earth samples caused by a sudden additional load (maintaining a previous service load level) was also studied. This is the first time that this phenomenon, called elastic stiffness degradation, has been studied for rammed earth material.

To download the full issue or read more, visit the following link: https://doi.org/10.1016/j.jobe.2022.104805

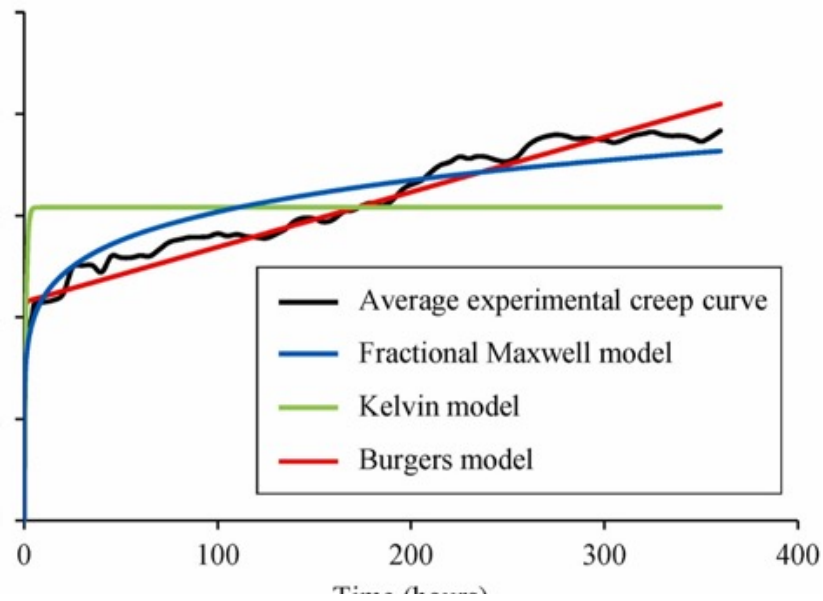

Figure 26: Fitting average experimental creep curve to three rheological models

Onshore Buried Steel Fuel Pipelines at Fault Crossings: A Review of Critical Analysis and Design Aspects

Vasileios E. Melissianos

Journal of Pipeline Systems Engineering and Practice, (2022),13(4), ASCE

Keywords: buried pipeline, fault crossing, design fault displacement, numerical modelling, protection measure

Abstract

Onshore buried steel pipeline infrastructure is a critical component of the fuel supply system. Pipeline failure due to seismic actions is socially, environmentally, and economically unacceptable and thus the design of pipelines at geohazard areas, such as fault crossings, remains a hot topic for the pipeline community. There is an intense research effort on the evaluation of the pipeline mechanical behavior and the strength verification at fault crossings. Still, some aspects need in-depth consideration concerning practical applications. A state-of-the-art review is presented on three critical analysis and design aspects, namely the calculation of the design fault displacement via deterministic and probabilistic methods, the effect of numerical modelling parameters such as soil spring properties, and the alternative pipe protection measures in terms of availability, efficiency, and selection process. The critical review offers a thorough insight on what is available and how to employ it in design, assisting engineers and pipe operators in improving pipe safety.

To download the full issue or read more, visit the following link: https://doi.org/10.1061/(ASCE)PS.1949-1204.0000661

Reduced-order models for the seismic assessment of plan-irregular low-rise frame buildings

Ruggieri Sergio, Chatzidaki Akrivi, Dimitrios Vamvatsikos, Uva Giuseppina

Earthquake Engineering Structural Dynamics, (2022), 51(14): 3327-3346, Wiley

Keywords: Reduced-Order Models, Asymmetric-Plan Buildings, Class-Level Assessment, Fragility Functions, Seismic Performance

Abstract

A procedure is presented for deriving low-complexity structural models to predict the global response of asymmetric-plan low-rise frame buildings for purposes of class-level assessment. As a compromise between employing a full-scale multi-degree-of-freedom structural model versus an equivalent single-degree-of-freedom one, the challenge is to create an idealized 3D structure with few degrees-of-freedom that can match the inelastic response of a building for which full knowledge of geometrical and mechanical properties is available. Such a 3D reduced-order model can offset the computational cost related to performing multiple nonlinear dynamic analyses within the framework of Performance-Based Earthquake Engineering. To this goal, rules and equations are proposed for achieving equivalence among the linear and nonlinear properties (e.g., mass, stiffness, strength) of the building analysed and the related 3D reduced-order model. The procedure is applied on a sample of 15 existing reinforced-concrete frame school buildings, from the province of Foggia in Southern Italy, for which the full numerical models are available. Both calibrated and uncalibrated reduced-order models are created, exploring the limitations of the proposed order-reduction in a real-life case study.

To download the full issue or read more, visit the following link: https://doi.org/10.1002/eqe.3725

Figure 27: Concept of 3D reduced-order model by means of a two-story tavolino structure, applied on the BIO case study building

Seismic fragility assessment of building-type structures in oil refineries

Karaferis D. Nikolaos, Kazantzi Athanasia, Melissianos E. Vasileios, Bakalis Konstantinos, Vamvatsikos Dimitrios
Bulletin of Earthquake Engineering, (2022), 20:6877–6900, Springer

Keywords: oil refinery; critical infrastructure; seismic fragility; buildings.

Abstract

A seismic fragility assessment methodology is presented for equipment-supporting reinforced concrete and steel buildings that are typically encountered in oil refineries. Using a suite of hazard-consistent ground motions and reduced-order models, incremental dynamic analysis is performed to obtain the seismic demand of the structural systems examined. Appropriate drift- and floor acceleration-sensitive failure modes are considered to define the limit state capacities of the supporting structure and the nested non-structural process equipment. Special care is exercised on the demand and capacity representation of structural and non-structural components, offering a transparent roadmap for undertaking analytical fragility assessment for equipment-supporting buildings typical to an oil refinery. The findings and the proposed methodology can be exploited by designers and facility managers for mitigating the risk of failure prior to the occurrence of an earthquake event, for designing the pertinent structures and their non-structural components by means of a risk-aware performance-based methodology, or as feed data in early warning systems.

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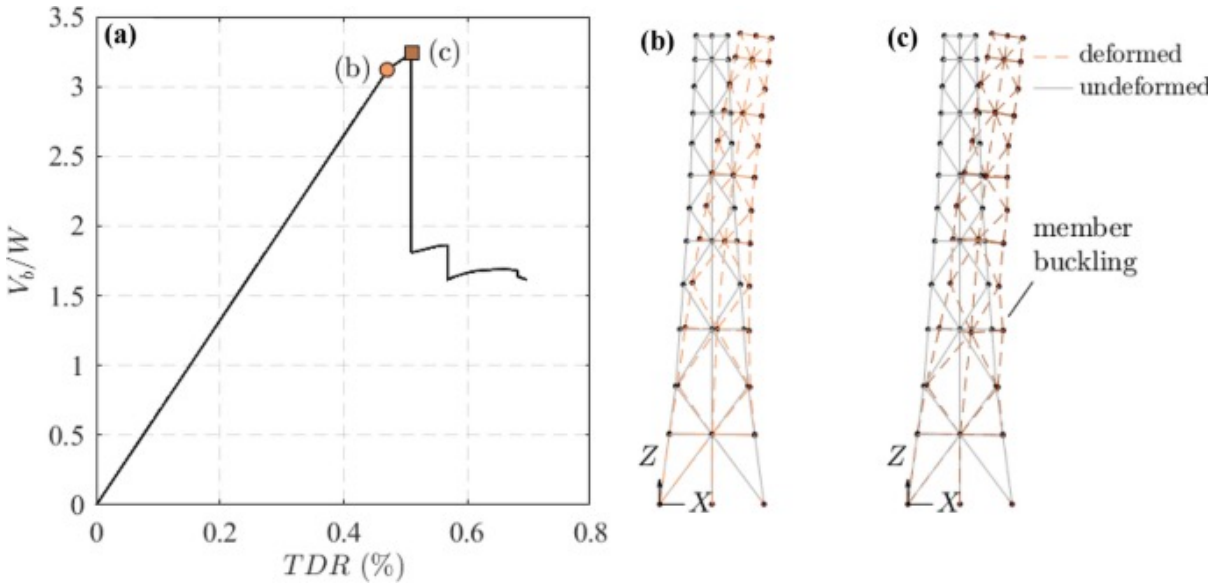

Figure 28: Flare: a) Static Pushover analysis curve; illustration of damage progression, featuring b) yielding and c) member buckling

Seismic response distribution expressions for rocking building contents under ordinary ground motions

A.K. Kazantzi, C. G. Lachanas & D. Vamvatsikos
Bulletin of Earthquake Engineering, (2022), 20: 6659–6682, Springer

Keywords: Earthquake engineering, Rocking, Building contents, Floor motions, Seismic fragility

Abstract
Analytical expressions are proposed for predicting the rocking response of rigid free-standing building contents subjected to seismic-induced floor excitations. The study considers a wide range of rigid block geometries and seismic floor acceleration histories that were recorded during actual earthquakes in instrumented Californian buildings, so as to cover, in a fully probabilistic manner, the entire spectrum of potential pure rocking responses, i.e. from the initiation of rocking up to the block overturning. Contrary to past observations on anchored building contents (prior to any failure in their anchorage system that could alter their response and mode of failure), it is shown that the response of free-standing blocks is not influenced by the predominant period of the supporting structure. The proposed set of equations can be utilised for estimating the response statistics and consequently for undertaking an analytical seismic fragility assessment on rocking building contents.

To download the full issue or read more, visit the following link: https://link.springer.com/article/10.1007/s10518-022-01424-w

Mechanical Characterization and Creep Behavior of a Stone Heritage Material Used in Granada (Spain): Santa Pudia Calcarenite

Luisa María Gil-Martín, Manuel Alejandro Fernández-Ruiz & Enrique Hernández-Montes
Rock Mechanics and Rock Engineering, (2022), 55:5659–5669, Springer

Keywords: Calcarenite, Creep, Temperature, Compressive strength, Instantaneous response after creep

Abstract
Santa Pudia calcarenite was one of the most commonly used building materials in the construction of historical buildings in the city of Granada (Spain). As a result, Santa Pudia calcarenite has been mainly studied from a petrographical point of view in previous works. In this work, the mechanical properties of Santa Pudia calcarenite are studied. The main mechanical properties (compressive strength, elastic modulus and Poisson's ratio) were determined using the corresponding tests. Samples of Santa Pudia calcarenite were heated at 550 °C to study the effect of high temperatures on its compressive strength. Two different cooling methods were considered: air-cooling and water-cooling. Stress–strain curves of heated and non-heated samples were obtained from uniaxial compression tests. Creep is of great importance in the long-term structural assessment of historical buildings. To study the creep behaviour of Santa Pudia calcarenite, samples were subjected to uniaxial compressive tests at constant stress until the stabilization of the recorded strains was reached. Different rheological models were adjusted to the experimental results to simulate the long-term behaviour of the material studied. The instantaneous response to additional loadings on the samples (maintaining the long-term loading and deformation) were also studied. Results show that a Santa Pudia calcarenite specimen subjected to dead loads will suffer a higher instantaneous deformation against a sudden load than a non-preloaded specimen. This degradation effect can be particularly important in the case of a seismic evaluation of historical buildings.

To download the full issue or read more, visit the following link: https://doi.org/10.1007/s00603-022-02946-0

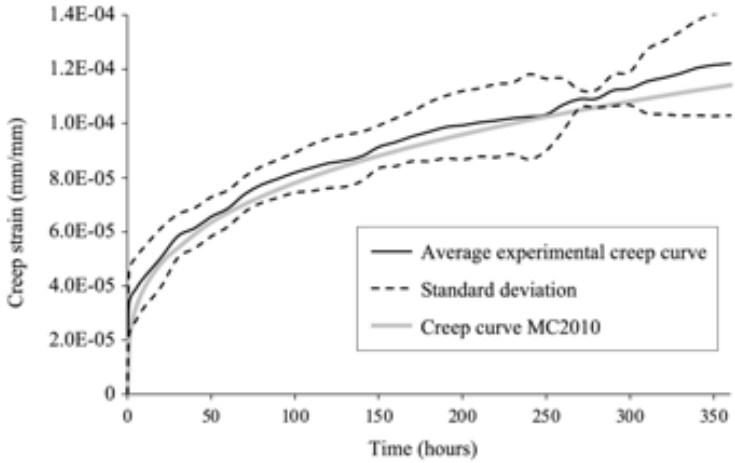

Figure 29: Average experimental creep curve (continuous black curve, dashed black curves correspond to the standard deviation) and creep curve proposed by MC2010 (gray line)

A risk-based evaluation of direct displacement-based design

Luke van der Burg, Mohsen Kohrangi, Dimitrios Vamvatsikos, Paolo Bazzurro
Bulletin of Earthquake Engineering, (2022), 20:6611–6633, Springer

Keywords: Direct displacement-based design, Seismic risk, Performance-based earthquake engineering · Seismic hazard

Abstract

Recent seismic design approaches developed under the umbrella of performance-based earthquake engineering (PBEE) pursue pre-defined performance objectives in terms of structural response, economic losses, or casualties. The earlier PBEE methods were mainly concerned with the deterministic evaluation of performance at a single ground motion intensity level. This premise, however, provides little insight into the long-term risk-based performance of a structure, and limits the ability to make informed design decisions. Given the inherent sources of uncertainty in all aspects of seismic design, probability theory needs to be employed to enable reliable design solutions. However, applying a risk-oriented design approach is not currently feasible for most practitioners, making it essential to understand how the current deterministic applications of these intensity-based PBEE approaches perform in terms of risk. Specifically, the aim is to investigate the capability of the direct displacement-based design (DDBD) method in producing reliable, risk-consistent designs. A probabilistic PBEE assessment framework is applied as the benchmark to determine the risk of exceeding performance objectives for multiple DDBD-based reinforced-concrete-wall and dual reinforced-concrete-wall/steel-frame buildings located at three different sites. The significant variation in the achieved risk estimates related to the limit states of damage limitation, life safety and global collapse for the buildings considered, questions the ability of DDBD-or any other intensity-based design method that does not account for uncertainty-to offer risk consistency.

To download the full issue or read more, visit the following link: https://doi.org/10.1007/s10518-022-01447-3

Model updating of a masonry tower based on operational modal analysis: The role of soil-structure interaction

Amirhosein Shabani, Mohyeddin Feyzabadi, Mahdi Kioumarsi
Case Studies in Construction Materials, (2022), 16: e00957, Elsevier

Keywords: Digital twins, Model updating, Soil-structure interaction, Masonry tower, Operational modal analysis, Resonance effect

Abstract

Vibration-based finite element model (FEM) updating of cultural heritage assets is gaining so much attraction these days since destructive tests are usually not allowed to be performed. In this study, a framework for developing three-dimensional (3D) FEMs is proposed using 3D laser scanners and applied on Slottsfjell tower, a stone masonry tower in Tønsberg, Norway. Operational modal analysis (OMA) was done based on the ambient vibration testing (AVT) data to define the frequency values and corresponding mode shapes of the tower. Mechanical properties of the tønsbergite stone were utilized to derive the base values of the material properties of the homogenized masonry for performing sensitivity analysis and FEM updating. To investigate the effect of the soil-structure interaction (SSI) on the FEM updating results, three FEMs are developed. The fixed-base model is the FEM without considering the SSI effects, and two other FEMs are developed using the substructure and direct methods for simulating the SSI effects. Sensitivity analysis was performed to investigate the effective parameters on the dynamic characteristics of the models. FEM updating was conducted on the three FEMs, and results are compared to each other to show the role of the SSI on the FEM updating results. The resonance effect can cause damages to buildings located even in low seismicity zones. For this aim, the risk of resonance effect has been evaluated for the tower. Finally, linear dynamic analysis was performed on the three calibrated models, and the results were compared to each other.

To download the full issue or read more, visit the following link: https://doi.org/10.1016/j.cscm.2022.e00957

Figure 30: (a) Point clouds derived from the 3D laser scanner and position of the scanners during the data acquisition, (b) imported dense 3D point to the Revit Autodesk software, and (c) 3D drawing of the tower in the Revit Autodesk software.

Change Detection in VHR Imagery With Severe Co-Registration Errors Using Deep Learning: A Comparative Study

Viktoria Kristollari and Vassilia Karathanassi IEEE Access, (2022), 10:33723-33741, IEEE

Keywords: Change detection algorithms, artificial neural networks, very high-resolution imagery, image registration, land cover monitoring, buildings.

Abstract

Change detection (CD) through Earth observation techniques can offer very significant information for monitoring tasks in a time-efficient manner. Very high-resolution (VHR) images can display objects in fine detail, thus making it possible to rapidly perceive isolated changes. However, this is a challenging task because of the increased within-class variance and geometric registration errors caused by different satellite view directions and angles. Lately, deep learning (DL) CD methods have proven very appealing for the CD problem because of their flexibility to combine and process different types of information along with the increased availability of higher processing power systems. Even though previous research has developed several notable DL methodologies, it has mostly focused on images with minor co-registration errors. Based on that, the goal of this study is to evaluate the performance of five state-of the-art DL CD methods, two unsupervised and three supervised, on VHR images with severe co-registration errors. The methods are implemented on four urban European areas of versatile morphology. In addition, before applying the CD process, four popular automatic co-registration methods were evaluated because of the importance of this pre-processing step for the successful output of the CD problem. It was shown that phase correlation used on the Fourier-Mellin Transform produced the most satisfactory co-registration results and STANet detected building-related changes most successfully. Its success can be attributed to its particular attention mechanism and its training dataset. The rest of the co-registration and CD methods showed low performance.

To download the full issue or read more, visit the following link: https://doi.org/10.1109/ACCESS.2022.3161978

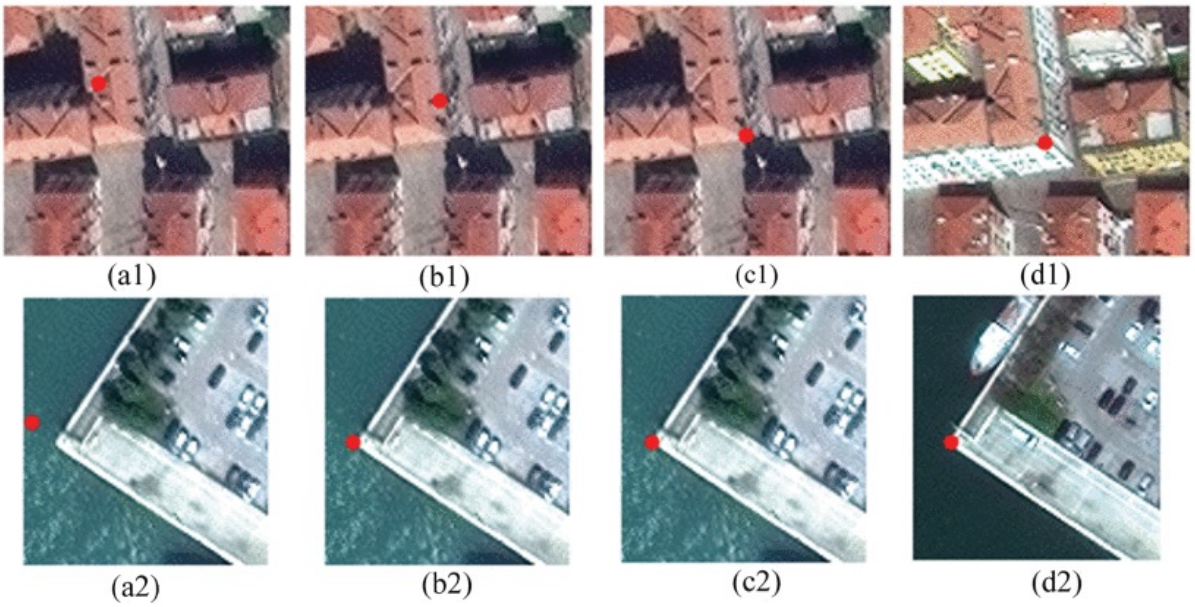

Figure 31: Comparison of Fourier-Mellin Transform and manual co-registration (Example outputs in Venice). (a1, a2) Image collected on 13/5/2018 by WV-2. (b1, b2) Co-registered output of Fourier-Mellin Transform. (c1, c2) Manually co-registered output. (d1, d2) Image collected on 4/5/2013 by GE01. The red bullet shows the position for a point

The influence of the vertical component of ground motion on the probabilistic treatment of the rocking response of free-standing blocks

Christos G. Lachanas, Dimitrios Vamvatsikos, Michalis F. Vassiliou

Earthquake Engineering & Structural Dynamics Journal, (2022), 51(8):1874-1894, WILEY

Keywords: multi-stripe analysis, response statistics, rigid rocking blocks, seismic demands, vertical component

Abstract

The influence of the vertical component of ground motion is investigated for assessing the distribution of the seismic response of unanchored rigid blocks. Multiple stripes of site-hazard-consistent ground motions are employed for calculating the seismic response of rigid rocking blocks with and without the inclusion of the vertical component. The comparison of the resulting response is being made both for single records and full suites, employing a paired record versus an ensemble-statistics comparison, respectively. It is shown that on a single record basis, the vertical component may have a non-negligible but highly variable influence on the rocking response, sometimes detrimental, sometimes beneficial. Still, when considering any large ensemble of records, the effect becomes statistically insignificant, except for the very specific case of rocking uplift for stocky blocks. To this end, for cases where the appearance of uplift is associated with damage, closed-form expressions are proposed to modify the lognormal fragility function of rocking initiation given the block slenderness and the ratio of the peak vertical over the peak horizontal ground acceleration.

To download the full issue or read more, visit the following link: https://doi.org/10.1002/eqe.3643

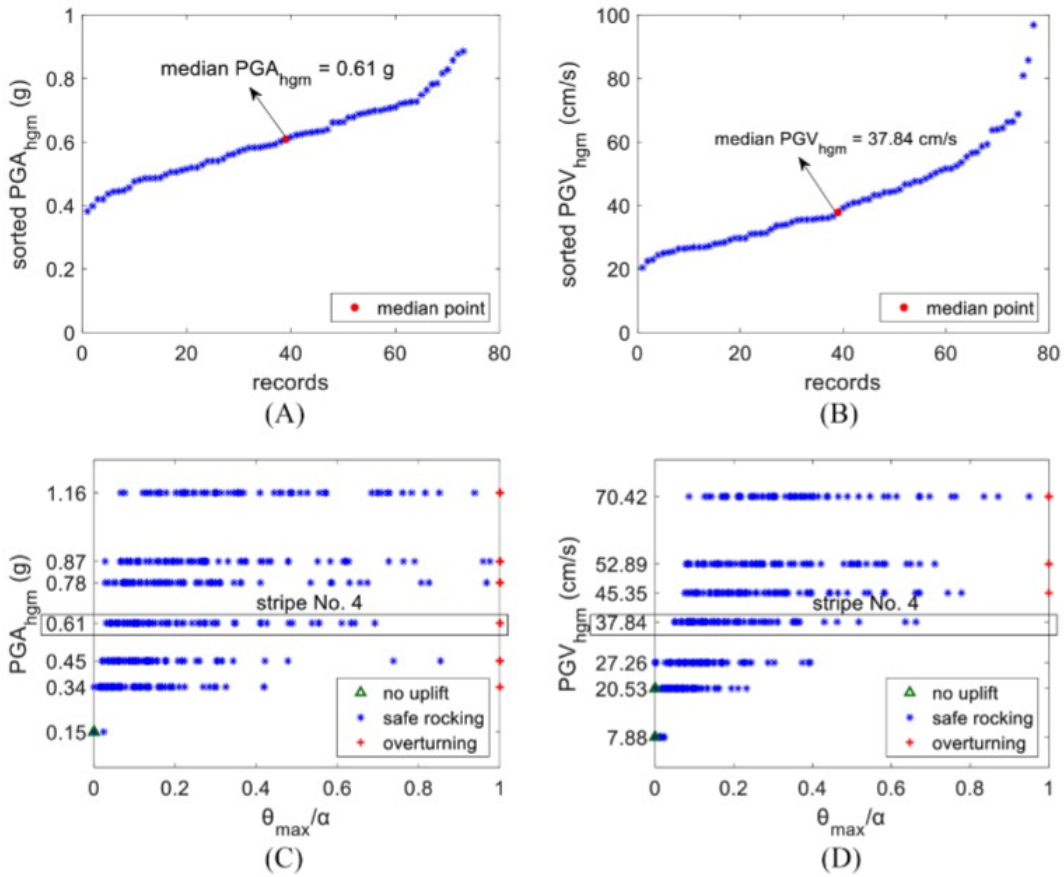

Figure 32: Example of intensity measure (IM) conversion from Sahgm(0.3 s) to PGAhgm and PGVhgm for the 4th IM level: (A) sorted values of PGAhgm corresponding to the 4th level of Sahgm(0.3 s); (B) sorted values of PGVhgm corresponding to the 4th level of Sahgm(0.3 s). Example MSA results for Block C without the vertical component, showing how the rescaled records form stripes at the median (C)PGAhgm and (D)PGVhgm values.

3D simulation models for developing digital twins of heritage structures: challenges and strategies

Amirhosein Shabani, Margarita Skamantzari, Sevi Tapinaki, Andreas Georgopoulos, Vangelis Plevris, Mahdi Kioumarsi
Procedia Structural Integrity, (2022), 37: 314-320, Elsevier

Keywords: 3D geometric documentation; cultural heritage; digital twins; 3D laser scanner; photogrammetry; finite element model

Abstract

Structural vulnerability assessment of heritage structures is a pivotal part of a risk mitigation strategy for preserving these valuable assets for the nations. For this purpose, developing digital twins has gained much attention lately to provide an accurate digital model for performing finite element (FE) analyses. Three-dimensional (3D) geometric documentation is the first step in developing the digital twin, and various equipment and methodologies have been developed to facilitate the procedure. Both aerial and terrestrial close-range photogrammetry can be combined with 3D laser scanning and geodetic methods for the accurate 3D geometric documentation. The data

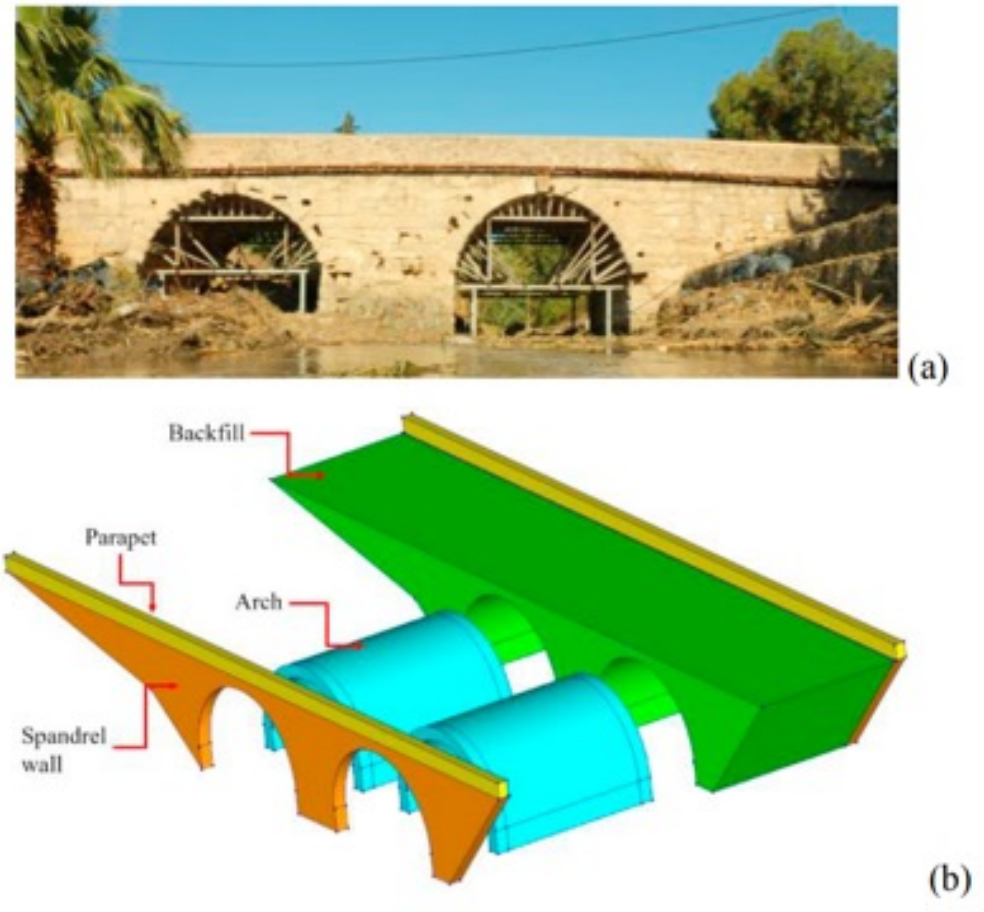

Figure 33: a) The Roman bridge in Rhodes, Greece; (b) Different parts of the 3D FE model of the bridge

processing procedure in these cases mostly focuses on developing detailed, accurate 3D models that can be used for the FE modelling. The final 3D surface or volumes are produced mainly by combining the 3D point clouds obtained from the laser scanner and the photogrammetric methods. 3D FE models can be developed based on the geometries derived from the 3D models using FE software packages. As an alternative, developed 3D volumes provided in the previous step can be directly imported to some FE software packages. In this study, the challenges and strategies of each step are investigated by providing examples of surveyed heritage structures.

To download the full issue or read more, visit the following link: https://doi.org/10.1016/j.prostr.2022.01.090

Smart Tags: IoT Sensors for Monitoring the Micro-Climate of Cultural Heritage Monuments

Nikos Mitro, Maria Krommyda and Angelos Amditis
Applied Sciences, (2022), 12(5):2315, MDPI

Keywords: IoT network; micro-climate sensors; smart sensors; cultural heritage; monument deterioration; environmental monitoring; IoT visualization

Abstract

The building materials of Cultural Heritage monuments are subjected to continuous degradation throughout the years, mainly due to their exposure to harsh and unexpected weather phenomena related to Climate Change. The specific climatic conditions at their vicinity, especially when there are local peculiarities such as onshore breeze, are of crucial importance for studying the deterioration rate and the identification of proper mitigation actions. Generalized models that are based on climate data can provide an insight on the deterioration but fail to offer a deeper understanding of this phenomenon. To this end, in the context of the EU-funded HYPERION project a distributed smart sensor network will be deployed at the Cultural Heritage monuments in four study areas as the solution to this problem. The developed system, which is demonstrated in this paper, includes smart IoT devices, called Smart Tags, designed to provide environmental measurements close to monuments, a middle-ware to facilitate the communication and a visualization platform where the collected information is presented. Last but not least, special focus is given to the device's NB-IoT connectivity and its power efficiency by conducting various tests and extract useful conclusions.

To download the full issue or read more, visit the following link: https://doi.org/10.3390/app12052315

Figure 34: Smart Tag User's Interface

A novel macroelement for seismic analysis of unreinforced masonry buildings based on MVLEM in OpenSees

Amirhosein Shabani and Mahdi Kioumarsi
Journal of Building Engineering, (2022), 49, 104019, Elsevier

Keywords: Seismic analysis, Unreinforced masonry buildings, Equivalent frame method, Macroelement model, MVLEM element

Abstract

Unreinforced masonry (URM) buildings are susceptible to extraordinary actions such as earthquakes compared to steel or reinforced concrete buildings. Various methods have been developed for the computational analysis of URM buildings in the last few decades. The

equivalent frame method (EFM) is one of the numerical modelling approaches widely used for the nonlinear analyses of URM buildings. Different macroelements in the context of the EFM have been proposed. However, there is still a need for an efficient modelling approach in the computational effort that can predict the real behavior of URM structural components with sufficient agreement and available in opensource structural analyses software packages. For this purpose, a new macroelement based on the multiple vertical line element method (MVLEM) element has been developed in this study. The MVLEM is available in the OpenSees software platform comprising vertical uniaxial macro-fibers and a shear spring as an efficient macroelement for nonlinear analysis of flexure-dominated reinforced concrete walls. The novel macroelement, double modified MVLEM (DM-MVELM) element has been proposed consisting of two modified MVLEM elements tied with a nonlinear shear spring at the middle with a trilinear backbone behavior. DM-MVLEM can capture the axial-flexural interaction with lower computational effort than finite element models and fiber beam-column elements. The DM-MVLEM has been validated against the test results at the structural components level and a full-scale perforated URM wall. Unified method (UM) and composite spring method (CSM) are two existing EFMs that are presented in this study. A study is performed by comparing the seismic behavior of the perforated URM walls modeled using the UM, CSM, and DM-MVLEM modelling strategies. Results show that the DM-MVLEM can predict the damage patterns, and nonlinear behavior of spandrels can be simulated that was usually modeled with linear behavior in EFMs.

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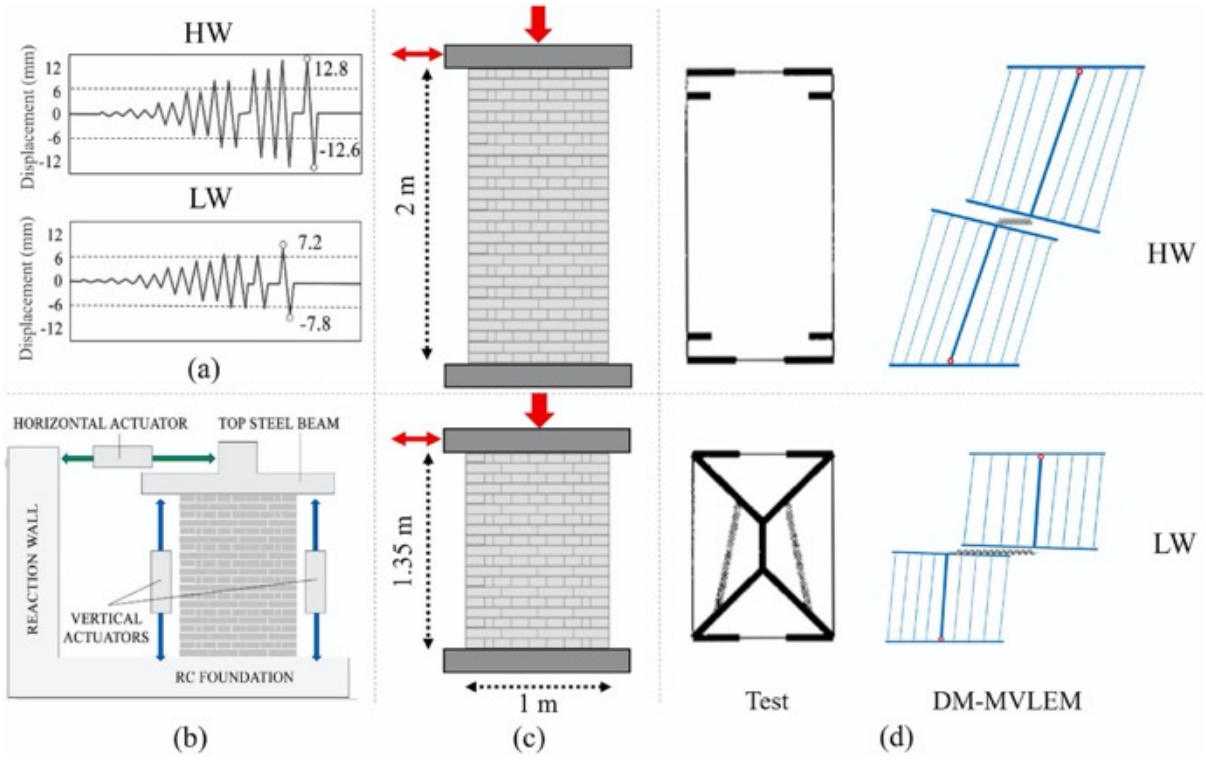


Figure 35. (a) Displacement protocols applied to the HW and LW specimen, (b) experimental test setup, (c) geometry of the HW and LW, (d) the crack patterns (failure mode) based on the test results and kinematics of the DM-MVLEM models of the walls.

Rocking incremental dynamic analysis

Christos G. Lachanas and Dimitrios Vamvatsikos
Earthquake Engineering and Structural Dynamics, (2022), 51(3):688-703, WILEY

Keywords: incremental dynamic analysis, response statistics, rigid rocking blocks, seismic demands

Abstract

The seismic response assessment of rocking systems via Incremental Dynamic Analysis (IDA) is investigated, focusing on the issues that arise in the analysis and postprocessing stages. Rocking IDA curves generally differ from those of hysteretic structural systems due to (i) the frequent appearance of resurrections; (ii) their highly weaving non-monotonic behavior; and (iii) their overall high variability. Hence, including or ignoring analysis results above the first resurrection level, deriving statistics given a response level versus an intensity measure level, as well as selecting an adequate number of ground motion records and runs per record, become challenging issues with non-trivial impact on the probabilistic characterization of rocking response. This necessitates a fresh view on analysis choices and post-processing techniques, aiming to assure the accuracy and fidelity of rocking IDA results. As an example, the effect of different choices and techniques are showcased on two-dimensional rigid blocks that are assumed to represent simplified models of monolithic ancient columns of different slenderness.

To download the full issue or read more, visit the following link: https://doi.org/10.1002/eqe.3586

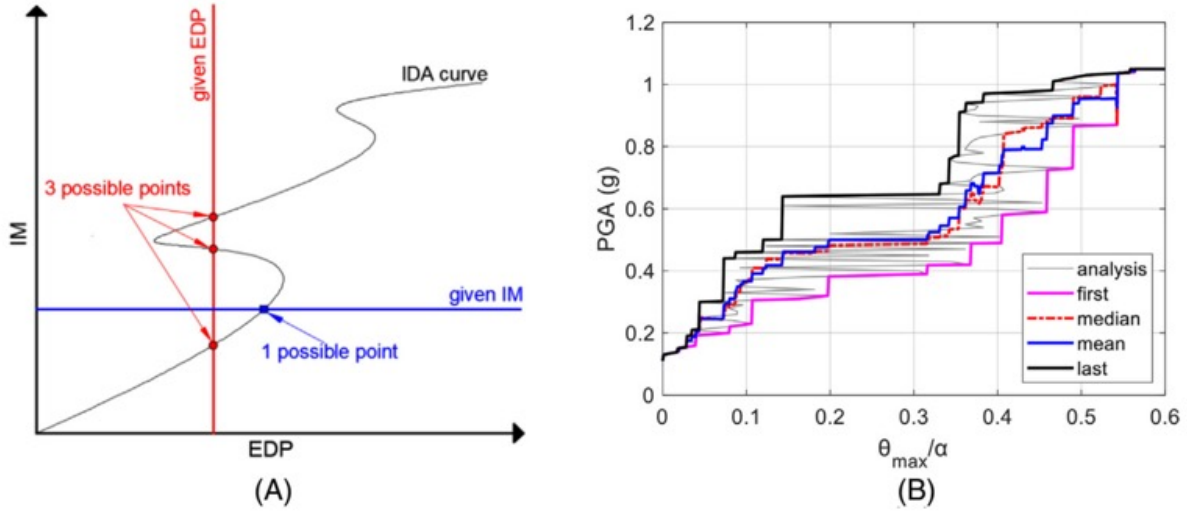


Figure 36: (A) IM|EDP versus EDP|IM for a weaving rocking IDA curve, (B) Different techniques for the inversion of the weaving IDA curve, comparing the first/median/ mean/last-point choices

Structural Model Updating of a Historical Stone Masonry Tower in Tønsberg, Norway

Amirhosein Shabani, Agon Ademi, Mahdi Kioumarsi
Protection of Historical Constructions (LNCE), (2022), 209:576-585, Springer

Keywords: Finite element model, Numerical modelling, Historical towers, Masonry tower, 3D laser scanner, Accelerometer, Operational modal analysis

Abstract

Conservation of historical structures plays a pivotal role in every nation, and numerical modeling of historic buildings is an essential part of a conservation methodology. Since deriving the mechanical properties of construction materials using destructive tests is usually not allowed, and most of the cultural heritage assets are so complicated in architecture, numerical modeling of historic buildings is challenging for the analysts. Therefore, in this study, a non-invasive approach for numerical simulation of historic structures has been proposed and applied on a historical stone masonry tower (Slottsfjell tower) in the city of Tønsberg, Norway. Two types of sensors were utilized for finite element modeling of the stone masonry tower. Firstly, three-dimensional (3D) laser scanners were used as a fast and precise tool to provide a finite element model of the case study with and without considering soil-structure interaction. Secondly, operational modal analysis (OMA) was performed using accelerometers to derive the tower's dynamic characteristics. Finally, as a preliminary result of the case study in the context of a European project, the produced finite element models' mechanical properties are updated based on the OMA results, and the effect of considering soil-structure interaction has been investigated.

To download the full issue or read more, visit the following link: https://link.springer.com/chapter/10.1007/978-3-030-90788-4_45

Seismic Vulnerability Assessment and Strengthening of Heritage Timber Buildings: A Review

Shabani A., Alinejad A., M. Teymouri, Costa Nascimento A., Shabani M., and Kioumarsi M.
Buildings, (2021), 11(12): 661-685, MDPI

Keywords: heritage timber buildings; nonlinear numerical modelling; vulnerability assessment; strengthening techniques; seismic analysis; literature review

Abstract

Recent studies highlight the potential impact of earthquakes on cultural heritage sites and monuments, which in turn yield significant adverse impacts on economies, politics, and societies. Several aspects such as building materials, structural responses, and restoration strategies must be considered in the conservation of heritage structures. Timber is an old organic construction material. Most of the historic timber structures were not designed to withstand seismic forces; therefore, the seismic vulnerability assessment of heritage timber structures in areas with high seismic hazard is essential for their conservation. For this purpose, different strategies for the numerical modelling of heritage timber buildings have been developed and validated against tests results. After performing seismic analysis using detailed analytical methods and predicting the susceptible structural components, strengthening techniques should be utilized to mitigate the risk level. To this aim, various methods using wooden components, composite material, steel components,

SMA etc., have been utilized and tested and are reviewed in this study. There are still some gaps, such as full-scale numerical modelling of strengthened buildings and investigating the soil–structure interaction effects on the seismic behavior of buildings that should be investigated.

To download the full issue or read more, visit the following link: https://doi.org/10.3390/buildings11120661

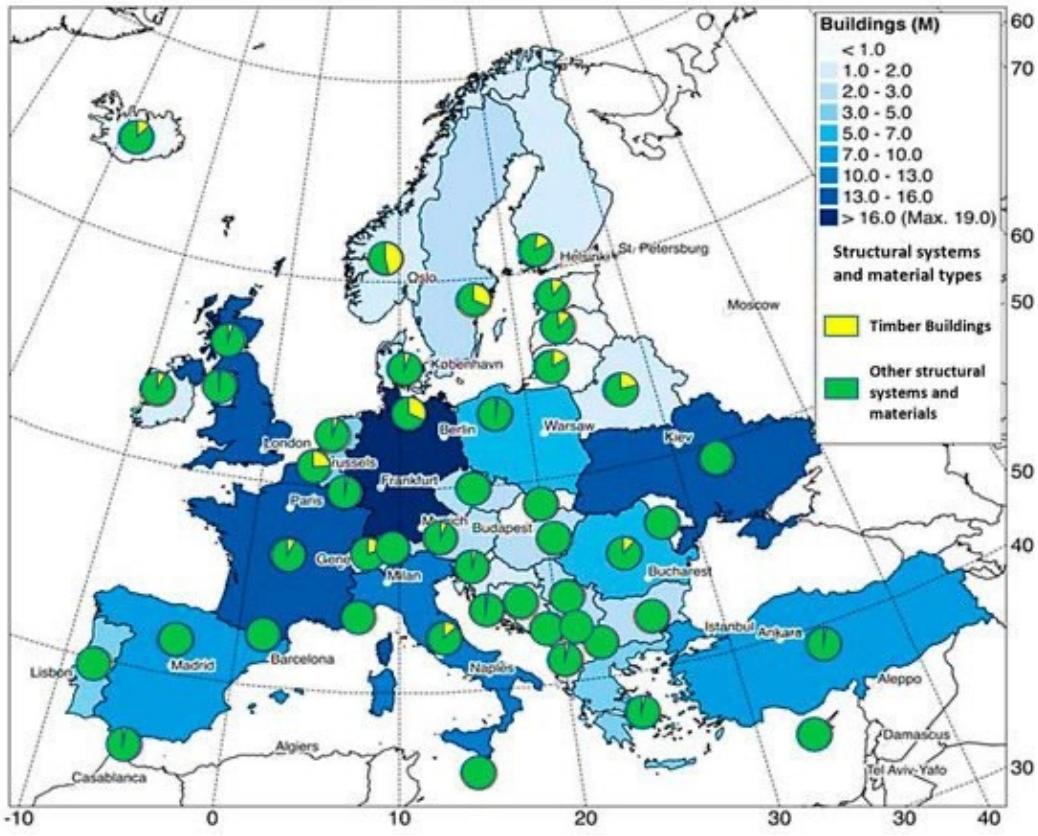


Figure 37: Total number of buildings in the European countries (in millions) and the exposure distribution of timber buildings

FLOMPY: An Open-Source Toolbox for Floodwater Mapping Using Sentinel-1 Intensity Time Series

Karamvasis Kleanthis, Karathanassi Vassilia
Water, (2021), 13(21):2943-2957, MDPI

Keywords: flooding; time series; Sentinel-1; thresholding; open-source software

Abstract

A new automatic, free and open-source python toolbox for the mapping of floodwater is presented. The output of the toolbox is a binary mask of floodwater at a user-specified time point within geographical boundaries. It exploits the high spatial (10m) and temporal (6 days per orbit over Europe) resolution of Sentinel-1 GRD intensity time series and is based on four processing steps. In the first step, a selection of Sentinel-1 images related to pre-flood (baseline) state and flood state is performed. In the second step, the preprocessing of the selected images is performed in order to create a co-registered stack with all the pre-flood and flood images. In the third step, a statistical temporal analysis is performed and a t-score map that represents the changes due to a flood event is calculated. Finally, in the fourth step, a classification procedure based on the t-score map is performed to extract the final flood map. A thorough analysis based on several flood events is presented to demonstrate the main benefits, limitations and the potential of the proposed methodology. The validation was performed using Copernicus Emergency Management Service (EMS) products. In all case studies, overall accuracies were higher than 0.95 with Kappa scores higher than 0.76. We believe that the end-user community can benefit by exploiting the flood maps of the proposed methodological pipeline by using the provided open-source toolbox.

To download the full issue or read more, visit the following link: https://doi.org/10.3390/w13212943

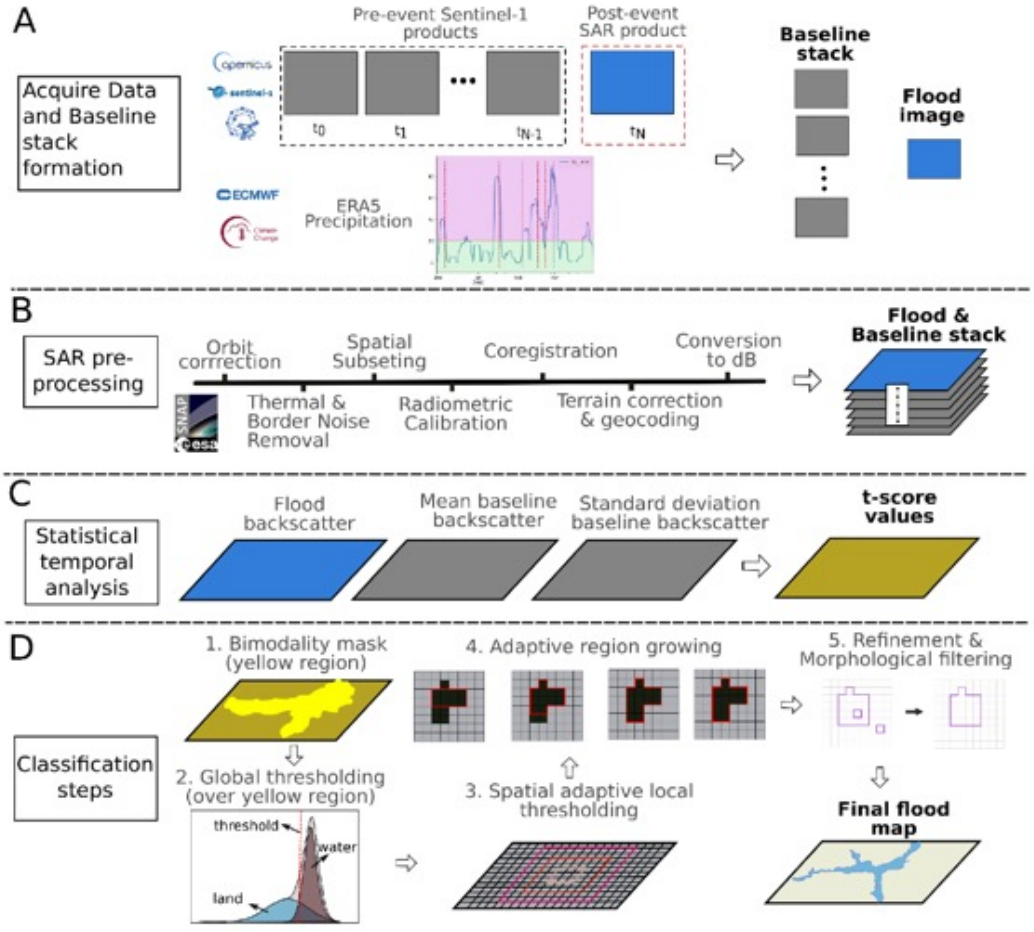


Figure 38: Flowchart of the four-step proposed methodological pipeline (FLOMPY).

Seismic response distribution expressions for on-ground rigid rocking blocks under ordinary ground motions

Athanasia K. Kazantzi, Christos G. Lachanas, Dimitrios Vamvatsikos
Earthquake Engineering and Structural Dynamics, (2021), 50(12):3311-3331, Wiley

Keywords: earthquake, engineering, overturning, rocking response, seismic response

Abstract

Predictive relationships are offered for the response of on-ground 2D rigid blocks undergoing rocking. Among others, this is pertinent to (1) modern or classical antiquity structures that utilize rocking as a seismic protection mechanism and (2) freestanding contents (e.g., cabinets, bookcases, and museum artifacts) located on the ground or lower floors of stiff buildings. Blocks of varying dimensions were subjected to a full range assessment of seismic response under increasing intensity levels of ordinary (no-pulse and no-long-duration) ground motions, parameterized by peak ground acceleration or velocity. Both response and intensity were normalized, allowing the fitting of general-purpose parametric expressions to determine the mean and dispersion of response for an arbitrary block of interest. These can be utilized in the same way as conventional strength-ratio/ductility/period relationships of yielding oscillators, to enable the rapid assessment or design of simple rocking systems.

To download the full issue or read more, visit the following link: https://doi.org/10.1002/eqe.3511

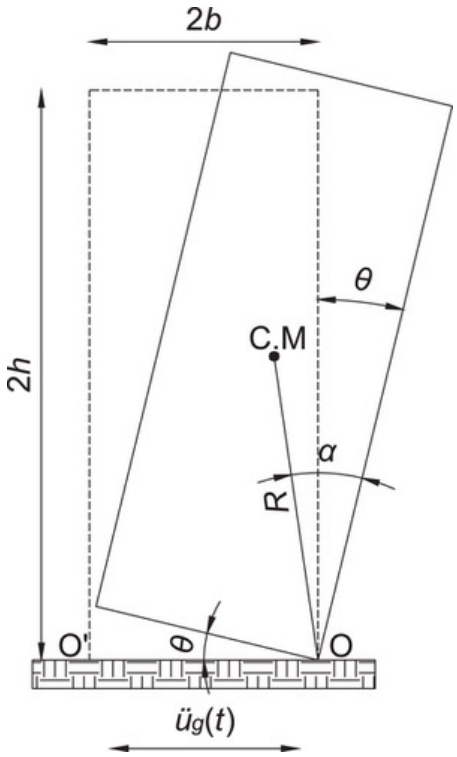


Figure 39: Geometry of the rigid rocking block. The center of mass (CM) coincides with the geometric center

The four publications that were not included in the Annual Magazin II, are the following:

Conditional spectrum record selection faithful to causative earthquake parameter distributions

Andrea Spillatura, Mohsen Kohrangi, Paolo Bazzurro, Dimitrios Vamvatsikos
Earthquake Engineering and Structural Dynamics, (2021), 50(10):2653– 2671, Wiley

Keywords: causative parameters, conditional spectrum, duration, hazard consistency, record selection, spectral shape.

Abstract

In performance-based earthquake engineering, record selection comes into play at the interface of seismic hazard and structural analysis aiming to repair any loss of essential seismological dependencies caused by the choice of an insufficient intensity measure to be used for structural response prediction. Site-specific selection is best exemplified by the prominent conditional spectrum (CS) approach that attempts to ensure a hazard-consistent response prediction by involving site hazard disaggregation. Specifically, CS utilizes a target spectrum (with mean and dispersion) that, in its latest formulation, accounts for all the scenarios (in terms of magnitude, M, and closest to rupture distance, R) contributing to the hazard of the site at a given intensity level. The ground motion records, however, are selected to match this target spectrum–based solely on their spectral shape but with no explicit consideration to their underlying M-R characteristics. The main focus of this study is to explore whether the reintroduction of M-R criteria in the selection process preserves hidden dependencies that may otherwise be lost through a spectral-shape-only proxy. The proposed record selection method, termed CS-MR, offers a simple approach to maintain a higher order of hazard consistency able to indirectly account for metrics that depend on M-R (e.g., duration, Arias intensity) but are not captured in the response spectra. Herein the CS-MR response prediction is favorably compared to CS and to the generalized conditional intensity measure methods that select records according to, respectively, spectral shape only and, for the case at hand, to spectral shape plus duration.

To download the full issue or read more, visit the following link: https://doi.org/10.1002/eqe.3465

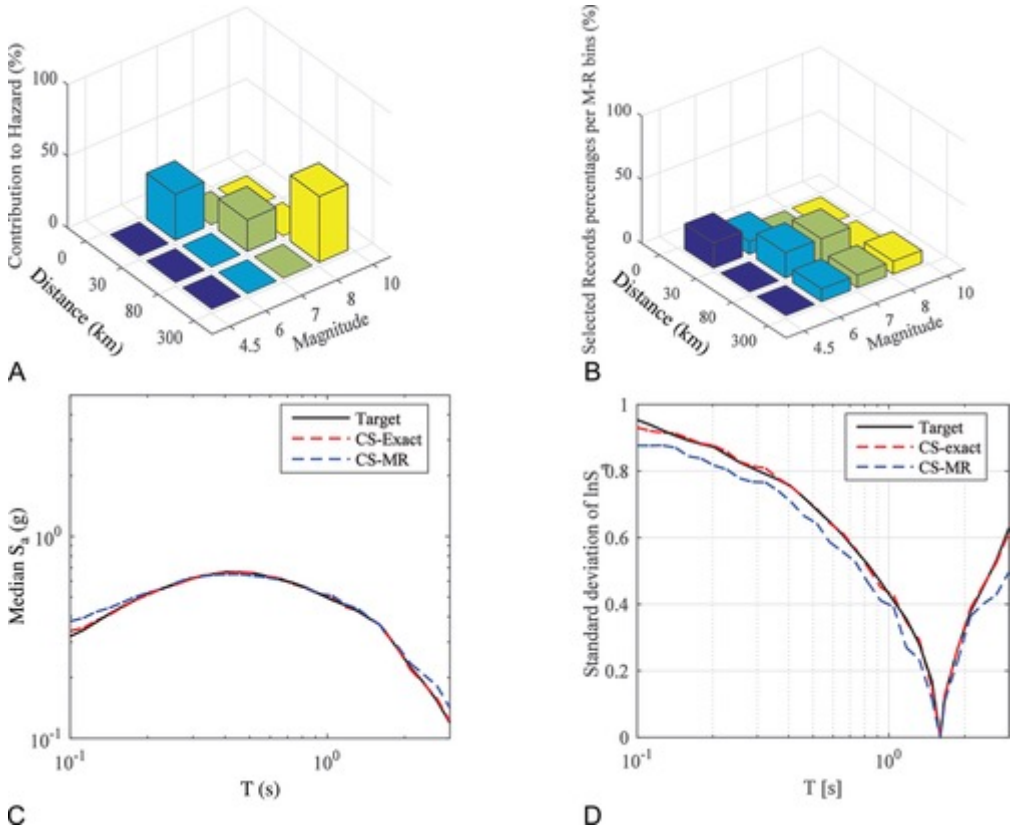


Figure 40: Comparison of record selection based on CS-exact and CS-MR methods for a site in Seattle corresponding to a conditioning period of T = 1.6 s for the 5% in 50 years value of Sa(1.6 s) = 0.37 g. (A) M and R disaggregation, perfectly matched by CS

Seismic risk and loss estimation for the building stock in Isfahan. Part I: Exposure and vulnerability

Mohsen Kohrangi, Paolo Bazzurro and Dimitrios Vamvatsikos
Bulletin of Earthquake Engineering, (2021), 19:1709–1737, Springer

Keywords: Urban risk assessment, Earthquake, Isfahan, Iran

Abstract

This paper focuses on the exposure and fragility/vulnerability of the residential, mixed residential/commercial, and public building stock of the city of Isfahan, in Central Iran, and constitutes the first part of a seismic risk assessment study for that city. To determine the assets at risk, we first summarize the details of the building stock and population from the available georeferenced 2011 Census data. From this dataset and from a local survey of the city, we categorize the building taxonomy in 27 construction classes characterized by age, height, and material/lateral-load-resisting system. A building exposure model is then assembled by first dividing Isfahan in city blocks and then by assigning the appropriate statistical properties to the buildings, such as construction class, built area, and replacement cost. The population of each city block is also estimated and accounted for. To assess the fragility and vulnerability to earthquake ground motion, for each building class we performed nonlinear dynamic analysis of multiple equivalent single-degree-of-freedom systems. This process generated a set of class- and region-specific fragility and vulnerability functions that considered both record-to-record and building-to-building response variability. In the companion paper we used the exposure model and the fragility and vulnerability curves generated for all these asset classes to probabilistically assess the seismic risk of Isfahan.

To download the full issue or read more, visit the following link: https://doi.org/10.1007/s10518-020-01036-2

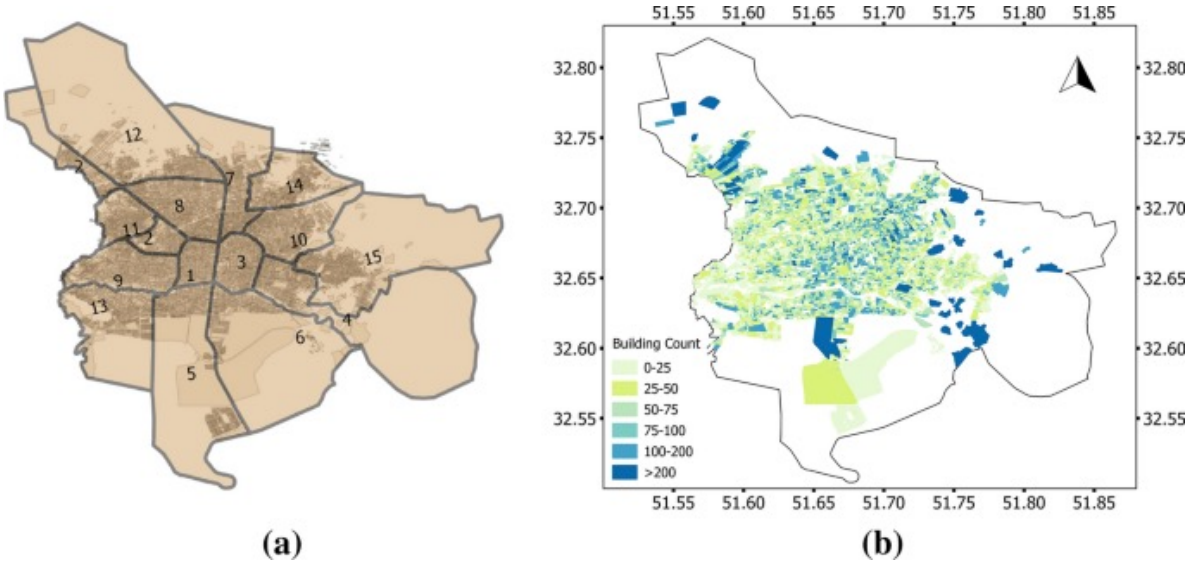


Figure 41: Map of Isfahan illustrating: (a) the spatial location of the 15 districts; and, (b) building count per block

Seismic risk and loss estimation for the building stock in Isfahan. Part II: Hazard analysis and risk assessment

Mohsen Kohrangi, Paolo Bazzurro & Dimitrios Vamvatsikos
Bulletin of Earthquake Engineering, (2021), 19: 1739–1763, Springer

Keywords: Urban risk assessment, Earthquake, Isfahan, Iran

Abstract

The second part of a seismic risk assessment study for the Iranian city of Isfahan is presented, focusing on the description of the hazard, the risk analysis, and the discussion of the results. This study utilizes the building exposure model, the fragility and the vulnerability curves illustrated in the companion paper. The earthquake occurrence source model adopted is based on the EMME14 hazard study. The site effects accounting for the soil nonlinear behavior are modeled by means of a Vs30 map derived from the topographical slope. The validity of this map is tested based on the local surface geology and geotechnical reports. The probabilistic seismic hazard maps for different return periods that account for site effects are generated and compared with the design spectra mandated by the Iranian national seismic design code. In addition, direct seismic monetary and human losses are estimated for two earthquake scenarios and also for 100- and 475-year return periods. We show loss maps and loss curves, offering insights on the most vulnerable building classes and the spatial distribution of the estimated losses. The results provide a basis for pre- and post-disaster emergency planning, for global and local urban planning, as well as for conceiving adequate risk mitigation strategies including devising fair earthquake insurance policies. This study may also serve as a blueprint for carrying out similar work in other urban areas of the Middle East.

To download the full issue or read more, visit the following link: https://doi.org/10.1007/s10518-020-01037-1

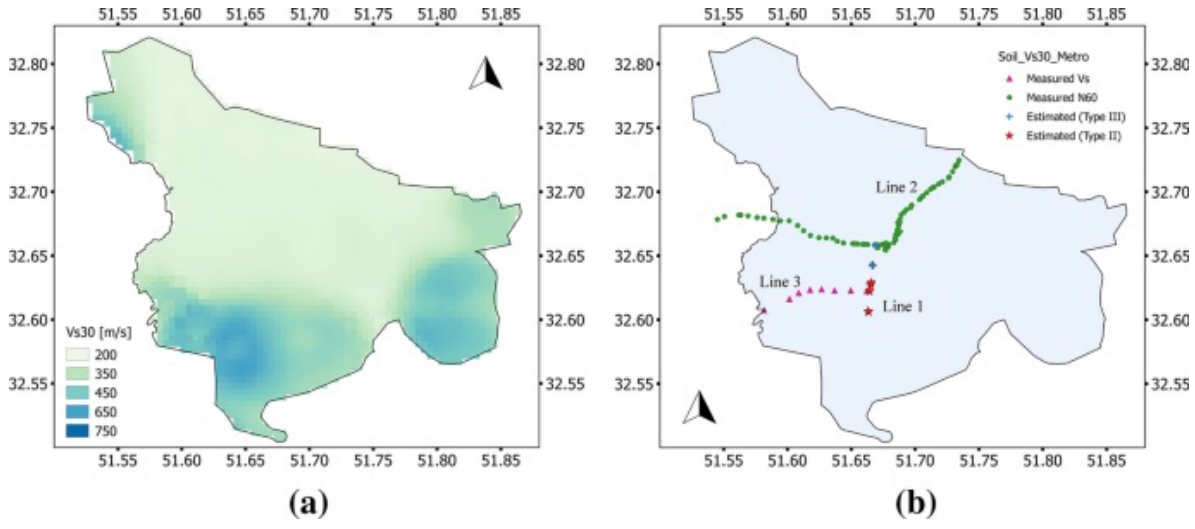


Figure 42: (a) Spatial Vs30 distribution map for Isfahan developed based on the topographical slope (Wald and Allen 2007); (b) location of the subway project boreholes where geotechnical data are available

Practical performance-based design of friction pendulum bearings for a seismically isolated steel top story spanning two RC towers

A. K. Kazantzi and D. Vamvatsikos

Bulletin of Earthquake Engineering, (2021), 19:1231–1248, Springer

Keywords: Friction pendulum bearings, Performance-based seismic design, Base isolation, Nonlinear analysis

Abstract

A case study of performance-based design is presented for a seismically isolated steel structure that rests on top of two adjacent high-rise reinforced concrete towers, the latter separated by means of an expansion joint. The isolation system comprises Friction Pendulum Bearings (FPBs) that are designed to accommodate two salient characteristics of the system. First, the isolated top floor is subjected to narrow-band floor acceleration histories as the ground motion excitation is filtered by the dynamic response of the supporting towers. Second, the displacement demands imposed to the FPBs are affected by the in-phase or out-of-phase movement of the supporting structures, with the latter case potentially giving rise to higher displacement capacity requirements for the bearings. In a search for a solution beyond conventional design norms, the probability of bearing failure associated with a wide range of FPB displacement capacities was determined via an explicitly risk-consistent performance-based seismic design. Overall, the case-specific design approach is shown to be able to meet any desired performance objective, consistently determining the final compromise between safety, cost-efficiency and practicability.

To download the full issue or read more, visit the following link: https://doi.org/10.1007/s10518-020-01011-x

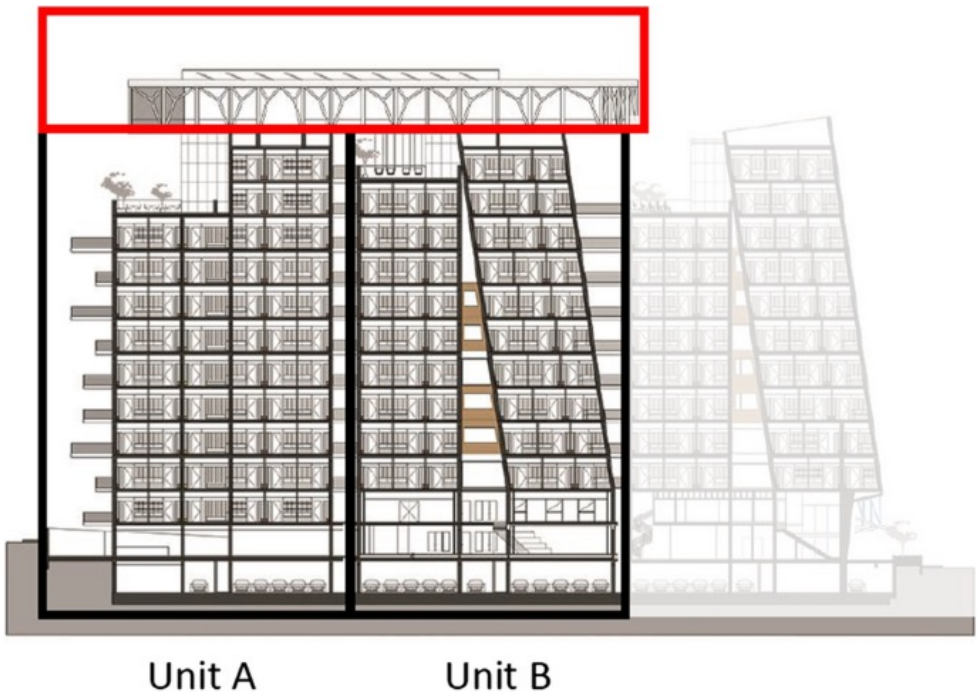


Figure 43: Side view of the six towers building complex showing the three independent units and the location of the expansion/seismic joints

2. HYPERION's Pilot Sites

Figure 44: El Real Monasterio de San Jerónimo, Granada, Spain

Figure 45: Clock Tower, Venice, Italy

Figure 46: Brick Tower, Tonsberg, Norway

Figure 47: Saint Nickolas Fortress, Rhodes, Greece

3. HYPERION's Communication Progress

3.1 Multiplier Events

EU Taskforce for Climate Neutral and Resilient Historic Urban Districts Meetings

The EU Task Force for Climate Neutral and Resilient Historic Urban Districts has been established by the Horizon 2020 projects: HYPERION, ARCH, SHELTER, in response to and support of the Horizon 2020 "Heritage Alive" orientation to increase resilience and sustainable reconstruction of historic areas to cope with climate change and hazard events. The Task Force kicked-off on June 2021 and organized three meetings, on June 2021, on the 14th & 15th of December 2021 and on 3rd of June 2022.

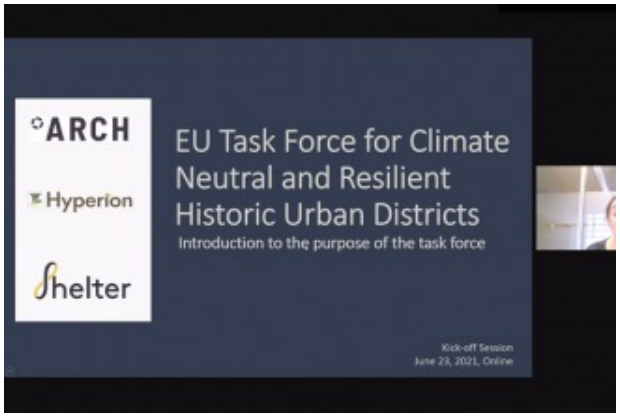


Figure 48: Aitzber Egusquiza Ortega introducing the purpose of the task force

Figure 49: Poster of the 2nd EU Task Force meeting

2nd EU Task Force Meeting for Climate Neutral and Resilient Urban Districts

The 2nd Meeting of the EU Task Force for Climate Neutral and Resilient Historic Urban Districts was conducted virtually on the 14th & 15th of December 2021. The event, included open discussions in three thematic areas:
1. The resilience of historic urban districts;
2. The assessment, monitoring, and evaluation of risks and resilience;
3. The development of equitable solutions for and with the communities;

The purpose of the meeting was to bring together actors from the cultural sector, the research community, and policy-makers to discuss and identify the obstacles, opportunities, best practices, and tools to render the historic urban districts, climate neutral.
By doing so, the task force aims to provide support to the European authorities and decision-makers to develop common evidence-based policies, strategies, and procedures to support the adaptation of historic districts to climate change.
During the second workshop cross-thematic problems, opportunities, and best practices from daily experience, as well as methods and tools to address problems and support opportunities were examined.

3rd EU Task Force Meeting For Climate Neutral and Resilient Historic Urban Districts |3 June |Thessaloniki, Greece & Online

The 3rd EU Task Force Meeting was organised in the 3rd of June 2022. The meeting, took place in Thessaloniki (Greece), under the scope of ARCH Stakeholder Dialogue and was also held as a hybrid event. The meeting's goal was to discuss the up-to-date iteration of a policy recommendation paper that the three projects were preparing, which focused on the challenges, opportunities, and recommendations for resilient historic districts.
The third meeting refined the identified challenges and formulated initial recommendations to address these challenges and was the final step for the creation of white paper for the EU.

Figure 50: Poster of the 3rd EU Task Force meeting

Presentation of the EU Task Force Results at the European Week of Regions and Cities 2022

The European Week of Regions and Cities 2022 was the biggest annual Brussels-based event dedicated to cohesion policy bringing together regions and cities from all over Europe, including politicians, administrators, experts and academics. In the event's context, the EU Task Force organized an online workshop entitled "Climate-neutral and resilient historic districts: Findings from the EU R&I Task Force" on the 12th of October 2022. During the event, HYPERION, ARCH and SHELTER presented their results and how their tools and concepts can support Cultural Heritage resilience.

In this session, Task Force partners and actors at the cross-section of climate change adaptation, mitigation, and disaster risk management for historic districts presented and discussed the main findings of the Task Force, including:

- Resilience Framework developed into a CEN Workshop Agreement;
- Methods and tools for assessing the resilience of historic districts;
- Research and policy recommendations to address resilience challenges facing historic districts;

In an interactive discussion, panellists highlighted how these solutions have been applied in a number of European cities and discussed with participants how these solutions can be applied in other cities and what challenges still remain to making historic districts more resilient.

The recording of the workshop is available here.

Figure 51: Workshop's Poster

Figure 52: Antonis Kalis, HYPERION PM presenting HYPERION project

Cross-project Peer learning Workshop with the sister projects ARCH & SHELTER

On the 6th of April 2022, HYPERION, ARCH and SHELTER organised an online cross-project peer learning workshop. The objective of the event was to discuss and share experiences and practices on planning and implementing measures to build resilience. A very fruitful space to think together new ways to make cultural heritage more resilient to Climate Change and other hazards.
Antonis Kalis, HYPERION's project manager, opened the session, while Claudio Mazzoli, Mahdi Kioumarsi and Amirhosein Sabani presented the pilot cases of Venice and Tønsberg, respectively. The main results of the workshop are accessible here.

Figure 53: Screenshot from the Peer Learning Workshop

HYPERION at the European Researchers' Night in Cyprus

On the 30th of September 2022, HYPERION project was presented at the European Researchers 'Night in Cyprus where CYRIC showcased HYPERION's technologies and discussed with the attendees about the project's goals and recent developments.
The event was organised by the Research and Innovation Foundation in Cyprus in collaboration with the main actors of the local research and innovation ecosystem (Public and Private Universities, Research Centres, Non-Governmental Organisations, Businesses, etc.).
The event aimed to nurture a research and innovation culture and to raise awareness with regards to the research activity implemented in the country. During the event, visitors of all ages had the opportunity to get in touch with research teams, participate in experiments and interactive games, live discussions, awards and much more.

Figure 54: Photo from the event in Cyprus

New European Bauhaus Festival

HYPERION had the great honour to be among the 100 selected projects to participate at the New European Bauhaus portable exhibition/ fair which took place from the 9th to the 12th of June 2022 in Brussels. The event among a variety of activities, hosted local citizen labs, pioneering research, innovative prototypes, and proposals in a mobile exhibition that travelled the participants through the centre of Brussels on e-bikes and electric tuk-tuks to the sound of a live DJ set. The festival aimed to link science and technology with art and culture to approach the significant challenges of the 21st century in an inclusive, sustainable way.
The ISENSE Group of ICCS participated in the event showcasing two of its innovative tools, an environmental sensor, known as SmartTag, which allows the monitoring of environmental conditions and changes and the Community Engagement Tool, which aims to engage the communities of historical areas and establish their collaboration in the preservation of tangible Cultural Heritage.

Horizon Results Booster (HRB)

HYPERION participated a Horizon Results Booster along with the sister projects SHELTER and ARCH and successfully completed the educational part; During the programme the three projects have organized a peer learning workshop; a creative infographic with the results and a variety of communication materials (logo, video, leaflet, poster).

Figure 55: The common logo that was produced during the HRB programme

Deployment of the cubes

An innovative experimental method for a long-term monitoring of outdoor microclimate and material decay at cultural heritage sites was developed to aid the formulation of new damage functions and models for climate-change risk assessments. Three experimental apparatuses have been created, each consisting in a cubic stainless still framework and three squared polypropylene H (PP-H) stands, one of which is horizontal, while the others are vertical, with two opposite orientations facing north and south, respectively. Stone tiles and wood samples have been secured to the different stands and their surface temperature and moisture monitored by dedicated sensors. Data is remotely collected.

One of the cubes has been deployed in Padova, on the roof of the Department of Geosciences (UPD); the control unit is wire-connected to the local intranet.

At the same time, a team formed by partners from Padova and Tønsberg installed a second cube on top of the Vestfold Og Telemark Fylkeskommune in Tønsberg. The cube is wire-connected to the local intranet and the colleagues configured a NAT gateway to assign a public IP address, thus allowing remote access.

A third cube have been installed on the highest terrace of the Clock Tower in Venice. Data is remotely collected via GPRS. The three sites have been also equipped with a climate station to measure standard climate parameters, such as air temperature, relative humidity, rain, wind direction and speed, and solar irradiation.

Deployment of the smart tags at the Clock tower in Venice

On December, 2021 a team from City of Venice and UNIPD (Alessia Porcu, Ruggero Munarin, Luigi Germinario, and Claudio Mazzoli) installed seven smart tags (Ven-01 to Ven-07) and five dataloggers (VCE-01 to VCE-05) at the Clock Tower in Venice. The smart tags, all located on the external walls of the tower (Figure 1), have been designed and developed by ICCS to upload temperature and humidity measurements periodically. Dataloggers have been installed at different elevations inside the building (Figure 1), in the same position where outside a smart tag was already placed. They require periodic inspection to download recorder temperature and humidity data. The data obtained from the smart tags are essential to predict the hydrothermal behaviour of the building according to the model developed by colleagues from OSLOMET in order to feed the response of the building to micro-climate conditions into the Holistic Resilience Assessment Platform (HRAP) platform.

Figure 56: Location of the smart tags (red circles) on the external walls of the Clock Tower, and of the dataloggers (blue circles) inside the building.

HYPERION at the ERASMUS+ ICM Meeting

On the 6th of December 2022, the University of West Attica organized the ERASMUS+ International week at its premises in Athens, Greece. Dr. Antonis Kalis, HYPERION PM had the opportunity to disseminate the program results to delegations from Albania, Azerbaijan, Benin, Cameroon, Egypt, Jordan Lebanon and Moldova. During his presentation, Dr. Kalis explained to the audience the stages of the development of the platform which will facilitate the authorities in preserving the Cultural Heritage Monuments from the climate change.

Figure 57: Dr. Antonis Kalis presenting the HYPERION solutions to the delegations from various non-EU countries

Installation of the measuring Sensors on the Clock Tower in Piazza San Marco in Venice

On March 10th, 2022 Claudio Mazzoli's team (University of Padova - UNIPD) uploaded on YouTube a Video they shoot during the deployment of the experimental apparatus on the top terrace of the Clock Tower in Saint Mark square in Venice (Figures 3 and 4). Venice is one of the four cities, together with Rhodes (Greece), Granada (Spain) and Tønsberg (Norway), which are experimenting with technologies and tools developed by the HYPERION project to assess the impact of microclimate conditions and atmospheric events on their monuments in the historic centres. The objective of the HYPERION, in which the Department of Geosciences (UNIPD) participates, is to assist

Figure 58: Claudio Mazzoli explaining the different types of rocks and the experimental apparatus

Figure 59. Claudio Mazzoli setting up the environmental sensors

historical areas to deal with global climate change and multiple risk factors based on an integrated platform of resilience assessment. Claudio Mazzoli, UNIPD Partner leader, explained the experimental apparatus which will be used to evaluate the effect of microclimatic conditions on the different rock types, present in the monuments of the four cities.

Watch the full video at https://www.youtube.com/watch?v=SvX5olva5UI&t=199s

HYPERION's Training & Demostration Event in Granada

On November 8th 2022, HYPERION consortium had the pleasure to organize a Training and Demonstration Event at the University of Granada in Spain. The event was co-organised by the Universidad de Granada and the I-SENSE Group. The event's goal was to present HYPERION's developed tools to stakeholders from different fields and facilitate the adoption & exploitation of HYPERION's results in the near future.

Prof. Enrique Montes was the moderator of the interesting presentations which took place from: Dr. Antonis Kalis, Project Manager of HYPERION from ISenseGroup of ICCS, Prof. Dimitrios Vamvatsikos, HYPERION Technical Manager from the Lamda Lab of the National Technical University of Athens, Prof. Emilio Molero & Prof. Luisa-Maria Gil from the University of Granada, Dr. Dimitris Tsarpalis from Resilience Guard and Stephanos Camarinopoulos from RISA.
During the event, participants had also the opportunity to visit Granada's pilot site (the Monastery of San Jeronimo) where they learned about the monastery and how HYPERION is assisting in its timely conservation. The event was concluded with an on-site hands-on demonstration of the HYPERION Community engagement tool by Dr. Antonis Kalis, Irini Krimpa and Nikos Mitro from the ISenseGroup of ICCS.

Figure 60: HYPERION's Training & Demonstration Event in Granada

Figure 61: HYPERION's Training & Demonstration Event at the Pilot Site

HYPERION Final Training & Demonstration Event

On the 20th of April 2023, HYPERION's consortium organized the Final – Training & Demo Event of the project at the Palazzo Cavalli Franchetti | Instituto Veneto di Scienze Lettere ed Arti in Venice. Mr. Georgios Charalampous, Research Programme Manager in REA and Mrs. Marie Yeroyianni Senior Expert at European Commission – Innovating Cities inaugurated the event with substantial remarks. Venice's vice mayor, Mr. Andrea Tomaello kicked off the 2nd half of the event, pointing out the importance of HYPERION's results on the survival of Venice's cultural heritage monuments and the city's sustainability.
During the event, a series of interactive presentations and demonstrations took place showcasing HYPERION results and presenting for the Ist time the integrated resilience assessment platform, developed during the project's course. The platform will help local authorities representatives and cultural heritage managers to gain a better understanding of the threats and dangers of tangible Cultural Heritage sites and make decisions for a swifter and more effective response, contributing to the sustainable reorganization of the historical regions under threat.

Figure 62: HYPERION's Final Event Banner

Figure 63: HYPERION Final Event

Figure 64: HYPERION's Consortium at the Final Event

HYPERION's Award from the Russian Academy of Natural Sciences

On November 30th, 2021, HYPERION was awarded with Laureate 1st at the International Environmental Competition EcoWorld-2021, organised by the Russian Academy of Natural Sciences (RAEN). HYPERION project was a candidate among other 103 proposals and received the award for its significant research contribution on the international ecological and architectural impact. The received distinction is a public award for outstanding achievements in environmental protection and environmental safety, as well as in other environmental activities aimed at sustainable development in the 21st century.
The event was held online due to the COVID-19 restrictions, and two members attended the online ceremony being curious about the result as the 1st Laureate was presented last!
On January 26th, 2022 the Diploma was presented to the Project Coordinator by Prof. Ildar Utyamyshev. RAEN was founded in 1990, officially recognized by the UN in 1995 and accredited as a non-government organisation by the UN in 2002. RAEN's members include 18 Nobel prize laureates, over 270 members of the Russian Academy of Sciences, over 30 members of the Russian Academy of Medical Sciences, and more than 20 fellows of other Academies of Sciences. RAEN's international members come from 48 countries around the world.

Figure 65: HYPERION's Award

3.2 Project Meetings

HYPERION's Plenary meeting | Oslo, Norway | 14-16 June 2022

This meeting was the first face-to-face meeting after the COVID-19 pandemic, and the second that was held face-to-face, after the kick off meeting in Athens in 2019.
During the first day, all the Work Package leaders presented HYPERION's progress towards its research objectives. On the second day, all the participants visited Tønsberg and had the opportunity to discuss with the authorities the status of all cultural heritage monuments that are included in HYPERION project. A great opportunity for all participants to row the replica of "Saga Oseberg" a full-scale replica of the Oseberg ship, a Viking ship from the year 820 that was excavated off Tønsberg in Vestfold in 1903. During the third day round tables were organised, for the identification of future steps as well as a fruitful discussion on the most important issues of each work package.

Figure 66: HYPERION'S Consortium at the Plenary Meeting in Oslo

Figure 67: HYPERION Consortium at the Pilot Site of Tonsberg

HYPERION's Plenary Meeting | Granada, Spain | 9-10 November 2022

On the 9th and 10th of November 2022, HYPERION Consortium had the pleasure to organize its plenary meeting along with the Training and Demonstration Event at the University of Granada in Spain. All WP leaders presented the recent research developments and challenges faced while discussing the future steps regarding the upcoming deliverables.

Figure 68: HYPERION Consortium in Alhambra, Granada

HYPERION Plenary Meeting | Venice, Italy | 19 April 2023

The HYPERION Consortium had the pleasure to organize between the 18th and 20th of April 2023, the project's Final Event at Palazzo Cavalli- Franchetti of the "Instituto Veneto di Scienze Lettere ed Arti" in Venice, Italy. The event was co-organised by the Comune di Venezia, the Università Iuav di Venezia, the University of Padova and the project's coordinator, ISenseGroup of ICCS.
The event was inaugurated by Mr. Georgios Charalampous, Research Programme Manager in REA, and Mrs. Marie Yeroyianni Senior Expert at European Commission - Innovating Cities while Venice's vice mayor, Mr. Andrea Tomaello kicked off the 2nd half of the event.
The 4th HYPERION Consortium Meeting was concluded with an interesting visit to the Clock Tower of Venice, where Mrs Daniela Zamperetti explained to the participants all the construction stages of the Tower Clock during the last 500 years.

Figure 69: Mr. Andrea Tomaello addressing to the audience

Figure 69a: HYPERION's Plenary Meeting in Venice

Figure 70: HYPERION's Consortium in the Pilot Site of Venice

3.3 Seminars

Seminar at Santa Maria dei Servi Church, Venice

Chiara Coletti from UNIPD participated in the seminar that took place at Santa Maria dei Servi Church (Tier 2 building) and presented her work on the characterization of historic bricks under the title "Minero-petrographic characterisation of historic bricks in the main façade of Santa Maria dei Servi Church, Venice". She also had the opportunity to disseminate HYPERION project to the audience.

Figure 71: Seminar's leaflet

Seminar "Catastrophe risk modelling in real life: Pacific Islands and the Caribbean"

With the title "Catastrophe risk modelling in real life: Pacific Islands and the Caribbean" Ettore Fagà, COO - Earthquake Risk Senior Manager, and Andrea Amati, Structural Engineer - Catastrophe Risk Modelling, both at RED S.r.l. gave a seminar to the students, on October 27th, 2021 at the Auditorium of the Institute of Steel structures, National Technical University of Athens, Greece. The seminar is also available online, via YouTube: https://www.youtube.com/watch?v=zTX_kxuMZtw

Seminar "The conservation of cultural heritage between climate change and atmospheric pollution"

In November 8th, 2021 under the title "LA CONSERVAZIONE DEI BENI CULTURALI TRA CAMBIAMENTI CLIMATICI E INQUINAMENTO ATMOSFERICO", Rebecca Piovesan, Elena Tesser, and Fabrizio Antonelli from the Laboratory of Analysis of Ancient Materials, IUAV, University of Venice, presented in Venice, Italy, their work: "HYPERION (EU H-2020). Cambiamenti climatici, eventi estremi e resilienza di aree storico monumentali: il caso studio della Torre dell' Orologio di Venezia". The University IUAV of Venice is the "Path for the development of City of Venice" as it was also stated in the presentation, and the seminar leaflet.

3.4 HYPERION in the Media

HYPERION at the Newspaper Dimokratiki

Under the title "Innovative technologies to protect the world's cultural heritage: the award-winning Hyperion project in the medieval city of Rhodes" the local newspaper "Dimokratiki" (Rhodes) presented the HYPERION project goals on the 30th of May 2022.


δημοκρατική

1982

Καινοτόμες τεχνολογίες για την προστασία της παγκόσμιας πολιτιστικής κληρονομιάς: το βραβευμένο έργο Hyperion στη μεσαιωνική πόλη της Ρόδου

19°

ROCON

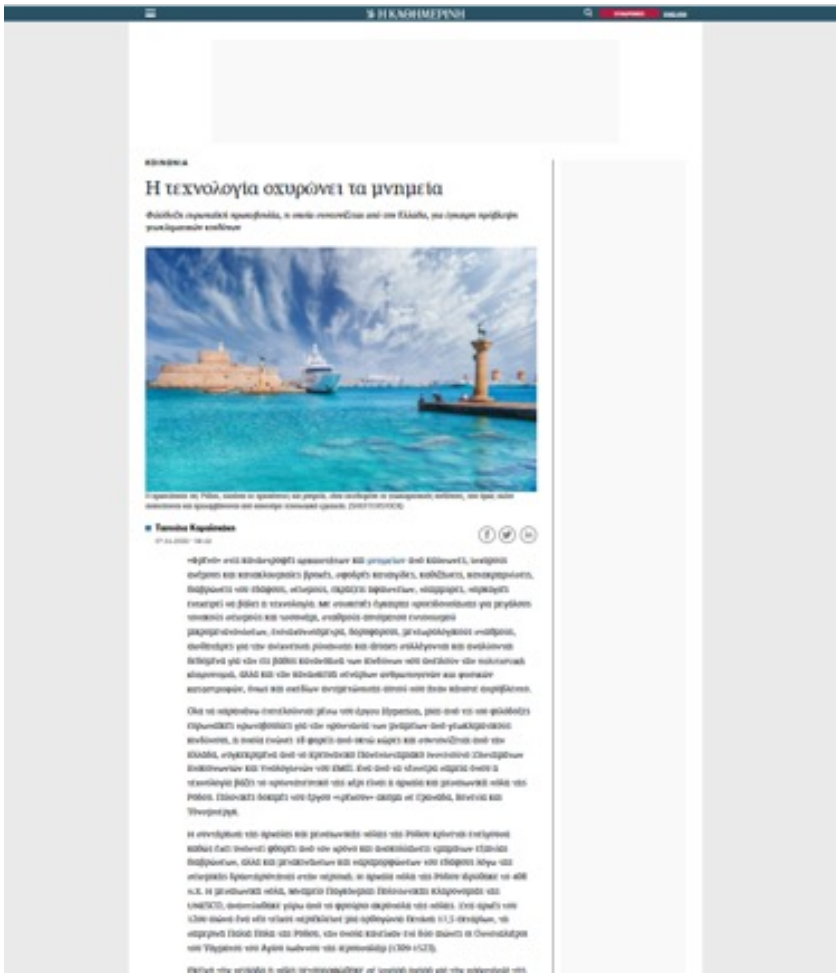
RHODES - FETHIYE

ΦΑΡΜΑΚΕΙΑ

Figure 72: Article about HYPERION at Dimokratiki

HYPERION at the Newspaper Kathimerini (circulating throughout Greece)

Kathimerini, on April 7th, 2022, in both printed and online editions presented HYPERION project under the title "Technology fortifies the monuments", pointing out the ambitious European initiative, coordinated by Greece, for early warning of geoclimatic risks. "Kathimerini" is a political and economic newspaper published in Piraeus and circulated throughout Greece and abroad (in Greek and English). You can read the full article here: https://www.kathimerini.gr/society/561795622/i-technologia-ochyronei-ta-mnimeia%20/



Η τεχνολογία οχυρώνει τα μνημεία

Figure 73: Article about HYPERION at Kathimerini

HYPERION at the Newspaper Eleftheros Typos

On May 15th, 2022, the newspaper "Eleftheros Typos" under the title: "Shield in the Medieval city of Rhodes" presented the HYPERION project stating that "The innovative technology forecasts the condition of the monuments in the coming decades and calculates the cost of restoration, fortifying the cultural heritage of the island of Rhodes". (Reporter: Elpida Oikonomidi).

«ΑΣΠΙΔΑ»
στη μεσαιωνική
πόλη της Ρόδου

Η πρωτοποριακή τεχνολογία κάνει «πρόγνωση» της κατάστασης των μνημείων τις επόμενες δεκαετίες και υπολογίζει το κόστος αποκατάστασης

Το ευρωπαϊκό έργο HYPERION οχυρώνει την πολιτιστική κληρονομιά του νησιού

ΕΛΠΙΔΑ ΟΙΚΟΝΟΜΙΔΗ

ΟΙ ΑΛΛΕΣ ΤΡΕΙΣ ΠΕΡΙΟΧΕΣ

Figure 74: Article about HYPERION at "Eleftheros Typos"

HYPERION at Epixeiro

HYPERION project and the research work implemented in the medieval city of Rhodes was presented in the online edition of the newspaper "Epixeiro", a weekly economic newspaper. (In Greek) (date of publication 04/04/2022)
To read the article, visit: https://www.epixeiro.gr/article/339468


Ειδήσεις | Επιχειρηματικά Νέα

2 λεπ. ανάγνωση

Το βραβευμένο έργο Hyperion στη μεσαιωνική πόλη της Ρόδου

Figure 75: HYPERION at Epixeiro

HYPERION at INEWS.GR

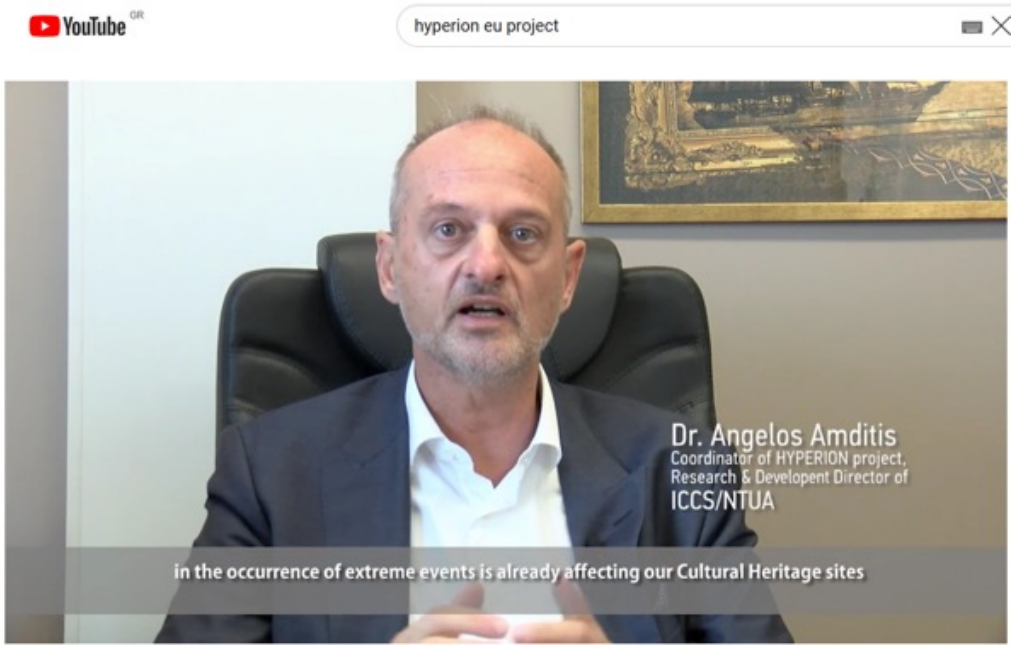
On April 4th, 2022 the online news website "inewsgr.com" presented the HYPERION project (Figure 9).

Figure 76: HYPERION at INEWS.GR

HYPERION Videos in the Social Media

a) HYPERION EU Project - Pilot Sites Video - Short Version

Recent studies highlight the potential impact of climate change and geo-hazards (such as landslides and earthquakes) on historic areas, hosting cultural heritage sites and monuments, which in turn yield significant adverse impacts on economies, politics, and societies. The deterioration of cultural heritage sites is one of the biggest challenges in conservation; Currently, there is no specific process towards understanding and quantifying climate change effects on historic areas; combined with the limited strategies on climate change-related issues, it becomes difficult to assess quantitatively and qualitatively the impact of various climatic and other parameters on the cultural heritage sites. These issues form an integral part of the necessary support that should be provided to governmental bodies and cultural authorities to properly adapt their policies, in the short and long term, towards deploying sustainable mitigation plans and providing efficient reconstruction of the cultural heritage parts that have been damaged. Finally, the absence of social and humanities and communities' participatory aspects to the overall resilience and reconstruction planning of the historic areas is the main challenge to tackle. HYPERION takes into account the local eco-systems in the cultural heritage areas, mapping out their interactions and following a truly integrated/sustainable reconstruction approach (technical, social, institutional, environmental and economic level), by incorporating active communities participation and by supporting new business models based on the concept of a "load-balancing" economy, and offering financial risk-transfer tools that can ensure the immediate funds availability to fuel timely build-back-better efforts. HYPERION aims to use existing tools and innovative technologies and create an integrated resilience assessment platform, in which end users will be able to have a better understanding of the dangers and threats of tangible cultural heritage, make decisions for a swifter and more effective response, and contribute to the sustainable reorganization of the historical regions under threat.



For watch the video use the link: https://www.youtube.com/watch?v=QQ6HZRujYLI

b) Under the title "Hyperion EU project was concluded: an overview on the results" Claudio Mazzoli, Associate professor of the Department of Geosciences and Unipd Partner leader in the HYPERION project, tells more about the remarkable achievements in cultural heritage preservation that were obtained.
After four years full of research and extensive tests in four pilot sites, the experience of HYPERION project, whose goal was to assist historic areas to face global climate change and multi-hazard risks by building upon an integrated resilience assessment platform, was concluded.

Screenshot from Youtube

For further information please use the link: https://www.youtube.com/watch?v=ZJX8Y2PoaW0

HYPERION at NRK TV

On December 2022, NRK TV, the Norwegian Public Broadcaster presented a TV tribute to HYPERION project showcasing the research work implemented in the city of Tonsberg.For watch the tribute, visite the following link: https://tv.nrk.no/serie/distriktsnyheter-fra-vest-fold-og-telemark/202212/DKVT98120222/avspiller (choose feature no. 5 in the menu under the main picture).

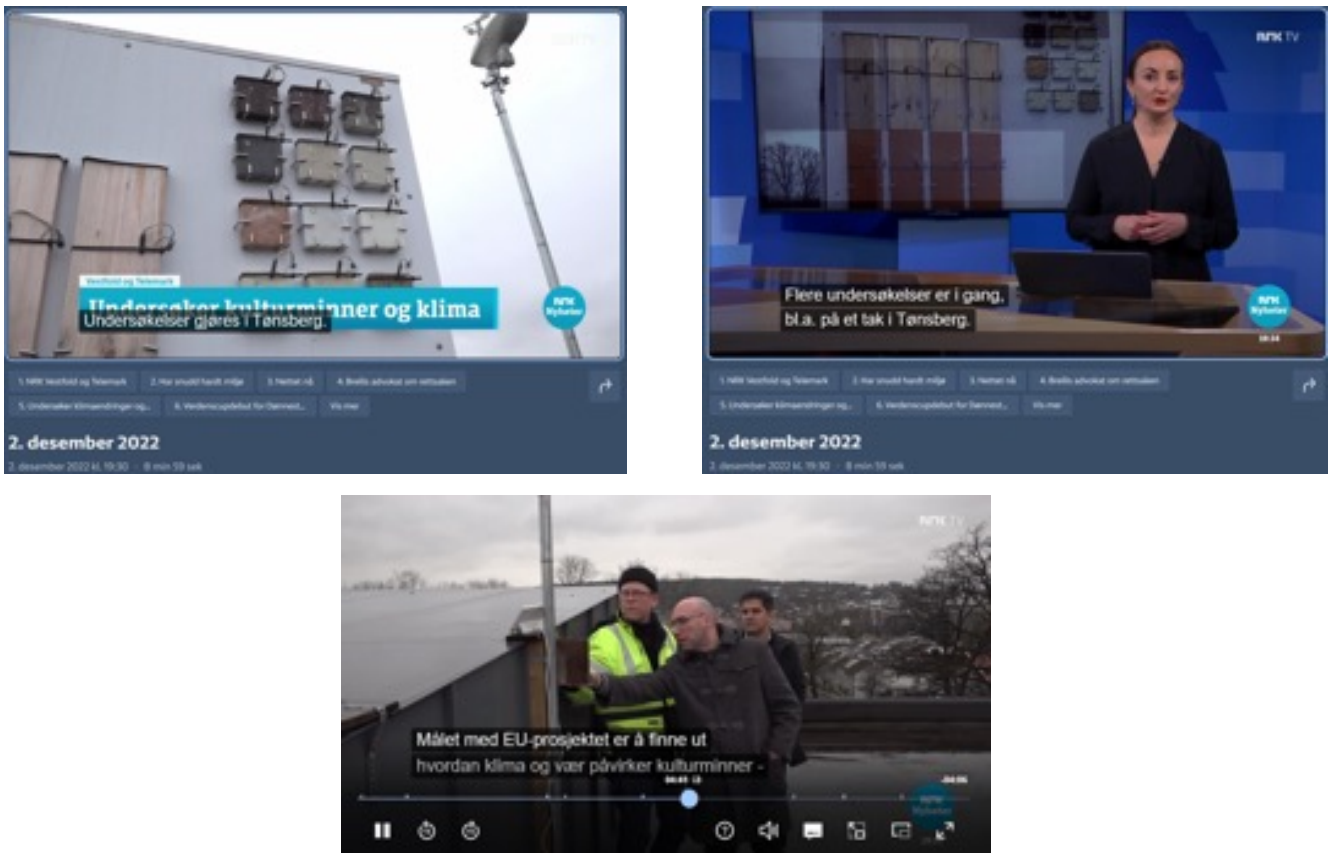


Figure 77: HYPERION at NRK TV

HYPERION at the NRK Radio

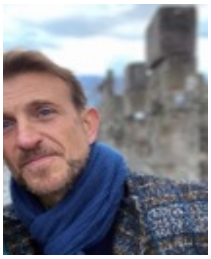
On the 29th of November 2022, HYPERION partners from OLSOMET and the Vestfold and Telemark County Council took part in two radio interviews regarding HYPERION's research activities in Tonsberg.
Listen to the interviews in the following links: https://radio.nrk.no/serie/distriktsprogram-vestfold/sesong/202211/DKVE01023122#t=1h6m0s and https://tv.nrk.no/se?v=NNFA05112922&t=4206s.

Figure 78: Screenshots from the Radio presentation in Norway

HYPERION at SKAI RADIO, April 11, 2023 (Greek)

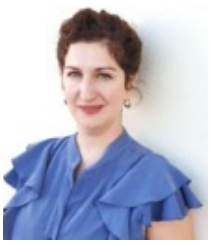
On the 11th of April 2023, HYPERION's results were presented at Skai Radio by Dr. Angelos Amditis, HYPERION's Coordinator from I-SENSE Group of ICCS.
During the interview, Dr. Amditis made an extensive reference to HYPERION's mobile application, developed by the ISENSE Group of ICCS which allows citizens to get actively involved in protecting and preserving Cultural Heritage monuments by posting photos/videos of potential damages, notifying the authorities for potential dangers.
To listen the interview visit https://go.iccs.gr/e6dsuu (00:23:15 – 00:32:31).

THE HYPERION TEAM

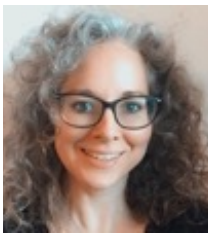
	**Amditis Angelos** is Research and Development Director in the Institute of Communication and Computer Systems (ICCS) of the National Technical University of Athens (NTUA) and member of its Board of Directors. He is the founder and the Director of the I-SENSE Research Group. Since June 2018 he is the ERTICO-ITS Europe Chairman while he has been a member of ERTICO Supervisory Board since 2012. He is the Deputy Chairman of the Athens Urban Transport Organisation (OASA) and member of the Board of Directors of the Athens Water Supply and Sewerage Company (EYDAP S.A.). Dr. Amditis is HYPERION' s Project Coordinator.
	**Kalis Antonis** is working as project manager at ISENSE Group of Institute of Communication & Computer Systems. He has previously been employed as an adjunct professor in Carnegie Mellon University, an Associate Professor in Athens Information Technology, and a visiting scientist in the Centre Tecnològic de Telecomunicacions de Catalunya. He also served as the Head of R&D of Signal GeneriX Ltd, He is HYPERION's Project Manager.
	**Vamvatsikos Dimitrios** is an Associate Professor at the National Technical University of Athens, happily researching earthquakes, winds, weather, probability, and risk, presently confined to Earth but hopefully going to outer space. He is the Technical Manager of HYPERION project.
	**Antonelli Fabrizio,** Full Professor of Georesources and minero-petrographic applications for the environment and cultural heritage at IUAV University of Venice, being since 2014 the Scientific Head of the Laboratory for Analysing Materials of Ancient origin(LAMA) of IUAV. He is an internationally recognized expert in archaeometric studies of ancient marbles and stones. His main research interests also include ceramics, mortars, and glass as well as the scientific issues related to the restoration and conservation of building and ornamental materials of the cultural heritages.
	**Dr. Barmpas Fotios,** holds a Laboratory Research and Teaching Personnel position at the Sustainability Engineering Laboratory, of the Aristotle University of Thessaloniki (AUTh). He holds a B. Eng. (Hons) degree in Aerospace Engineering and an M.Sc. in Applied Mathematics and Fluid Mechanics from the University of Manchester, UK, as well as a Ph.D. from the School of Mechanical Engineering of AUTh).

	**Bazzurro Paolo** full professor of Structural Engineering at IUSS Pavia (Italy) received his MSc and PhD degrees in Civil Engineering at Stanford University, where he has been part-time Consulting Assistant Professor for 4 years. He has more than 20 years of professional experience in Europe and US. His expertise is in the application of probability and statistics to civil engineering problems. Most of his projects dealt with earthquake and wind engineering risk assessments to a variety of structures both on-shore and offshore.
	**Cesaero Ludovica** Pia obtained her Bachelor's degree in Technologies for Conservation and Restoration of Cultural Heritage from Ca' Foscari University of Venice in 2021. Her thesis focused on the mineralogical and textural characterization of the historical bricks used in the main facade of Santa Maria dei Servi Church in Venice. She is currently in the second year of her Master's degree in Conservation Science and Technology for Cultural Heritage at Ca' Foscari University.
	**Chiachío Juan** is an Associate professor and researcher, of the Department of Structural Mechanics and Hydraulic Engineering at the University of Granada (Spain). During his research career, he has worked On prognostic and health management, Bayesian inverse problems, structural reliability and infrastructure asset management.
	**Choidis Petros** is a Civil engineer. He is currently pursuing a Ph.D. at the Department of Civil Engineering and Energy Technology at Oslo Metropolitan University. His research focuses on the impact assessment of climate change on tangible cultural heritage.
	**Coletti Chiara** Dr. graduated in 2010, in Science and Technology for Archaeolo-gical and Artistic Heritage and received her PhD, in 2016, in Earth Science. She is researcher at the University of Padova, Department of Geosciences. Her research interests mainly include the characterization of natural and artificial rocks applied in built heritage, the radon occurrence, and archaeometry.
	**Gansum Terje** is the Head of The Cultural Heritage section at VTFK and holds a PhD in Archeology from The University of Gothenburg. In 2017, he was a visiting professor at The University of Vienna and has been a requested guest lecturer at several Scandinavian Universities.
	**Georgopoulos Andreas,** is Professor of Photogrammetry at NTUA, holding a Diploma of Surveying Engineering (NTUA, 1976), an MSc 1977 and a PhD (1981) in Photogrammetry from University College London. Since 1980, he has been teaching Photogrammetry and Documentation of Monuments in UCL, NTUA and as visiting professor in KULeuven (RLICC - ArchDOC), CUT (Dept. of Civil & Geomatics Eng.) and the University of the Aegean. His research interests focus on 3D modelling of cultural heritage, photogrammetric automation, and digital contemporary techniques.

	**Germinario Luigi** is a Marie Skłodowska-Curie researcher at the University of Padova in Italy. He holds a "European PhD" in Earth Sciences, as well as an MSc/BSc in Conservation of Cultural Heritage. His research interests lie in heritage science, with a focus on stone weathering in monuments, caves, and underwater sites; the interaction between cultural heritage and the environment; and archaeometry of archaeological artifacts and structures.
	**Gil Marin Luisa Maria,** is Professor in the School of Civil Engineering at the University of Granada, Department of Structural Mechanics and Hydraulic Engineering.
	**Grottesi Giulia,** is a Researcher at Oslo Metropolitan University. During her B.Sc. and M.Sc. in Heritage Science, she developed a keen interest in microclimate analysis and climate-induced damage to cultural heritage. Her passion for the topic led her to join the Hyperion project, where she mainly works on the Hygrothermal performance of historical buildings.
	**Hernández-Montes** Enrique is professor at the School of Civil Engineers of the University of Granada. He is working in Structural Engineering, including reinforced concrete, steel structures, earthquake engineering and structural optimization.
	**Jalón María L.** is an assistant professor, of the Department of Structural Mechanics and Hydraulic Engineering at the University of Granada (Spain). During her research career, she has worked on renewable maritime structures, stochastic simulations, optimization of problems, and Bayesian techniques applied to the inference of structural models in historical buildings.
	**Karamvassis Kleanthis** is a member of Laboratory of Remote Sensing of National Technical University of Athens and is involved in teaching and research activities. His main research interest is related to time series analysis of interferometric SAR data for ground deformation, soil moisture and floodwater monitoring.

	**Karathanassi Vassilia** since 2000 is employed as a Professor at the School of Rural and Surveying Engineering (NTUA). Her main scientific interests concentrate in multi-spectral and hyperspectral Remote Sensing, Differential Interferometry and DInSAR Time Series. Her published research work includes more than 50 papers in peer reviewed scientific journals, more than 80 papers in international conference proceedings, 45 research project reports and one book chapter.
	**Kioumarsi Mahdi** is an Associate Professor at Oslo Metropolitan University, Norway with over a decade of experience in structural engineering. He has conducted extensive research, ranging from large-scale structures and infrastructures to small-scale material investigations. His research ap proach combines finite element modelling, soft computing methods, and experimental work to provide comprehensive solutions to complex engineering challenges. He is publishing in several high-impact peer-reviewed journals, being appointed to several editorial positions, highlighting his expertise in the field.
	**Karaferi Evdoxia** Has an Integrated Master Diploma in Civil Engineering from NTUA with major in Structural Engineering. She also has a M.Sc. in Analysis and Design of Earthquake Resistant Structures from NTUA. She is a PhD candidate since 2020 on the assessment of the environmental hazard risk in areas of cultural heritage.
	**Kolokoussis Polychronis** holds a Diploma in Rural & Surveying Engineering and a PhD Degree in Remote Sensing from NTUA. He is research/teaching associate of the Remote Sensing Laboratory, at the School of Rural, Surveying & Geoinformatics Engineering, NTUA.
	**Kraniotis Dimitrios** is an Associate Professor at Oslo Metropolitan University, Norway, and Senior Researcher at the Norwegian University of Wood Technology (NTI). He is the leader of the research group 'B3 – Building Technology, Materials and Physics' and the academic coordinator of the master's program in Civil Engineering at OsloMet. His research interest include: i) building physics and climate adaptation, ii) energy efficiency and indoor environment and iii) sustainability in the built environment.
	**Krimpa Irini,** is as a Project Communication Manager at the ISENSE Research Group of the ICCS. She is a graduate of the faculty of Economics of University of Patras and holds an MSc in Services Management from the Athens University of Economics & Business. She holds a diploma in digital marketing. She has worked more than 13 years is several communication & marketing fields on numerous European & global projects. Recently, she has been highly involved in the tech & culture sectors. She is involved in HYPERION's communication and dissemination strategy.

	**Kristollari Viktoria** received an Integrated Master in Rural, Surveying & Geoinformatics engineering from NTUA, in 2016, where she is currently pursuing the Ph.D. degree in remote sensing. Her research interests focus on deep learning methods for multispectral/hyperspectral earth observation data applications.
	**Lehtonen Ilari** holds a Ph.D. degree in meteorology from the University of Helsinki. He is a Research Scientist in the Department of Meteorology of the Finnish Meteorological Institute. He is the member of many international affiliations. He has authored many research articles/books related to Climate research, Aviation weather service.
	**Maritan Lara** is a geologist specializing in the archaeometric analysis of ancient materials such as ceramics, rocks, mortars, pigments, and bones. Her work focuses on determining their provenance, production technology, and state of conservation, as well as developing new methods and protocols for their study.
	**Solstad Jørgen,** is a Senior Adviser working with public management and consulting tasks related to conservation and restoration of listed and protected CH-sites, buildings and monuments at The Cultural Heritage section at VTFK. He holds an MA in Conservation of Fine Art from University of NorthUmbria, UK.
	**Mazzoli Claudio** is an Associate Professor of Applied Petrography at the Department of Geosciences at the University of Padova. His primary research interests lie in the study of stone deterioration, archaeometry of stone and pottery, the development of new building materials using industrial waste, and assessing the risk of radon exposure from the environment and building materials.
	**Melissianos Vasileios** holds a degree and a PhD in Civil Engineering from the National Technical University of Athens (NTUA). He is a Research Associate at the Institute of Steel Structures NTUA, participating in EU-funded research projects. His research focuses on the risk assessment of structures and infrastructure, utilising advanced modelling techniques and probabilistic methods.

	**Mitro Nikos** is a graduate of NTUA, Department of Electrical and Computer Engineering. His main interests are S/W development, embedded systems, and H/W design. He has a 3 year working experience on multiple projects of the H2020 EU's research programs. His expertise focuses on the design and testing of smart integrated systems and their interaction with other subsystems. His is also interested in the design, development and testing of IoT smart embedded systems for biomedical–physiological monitoring.
	**Moussiopoulos Nicolas** is a Full Professor at the School of Mechanical Engineering of the Aristotle University Thessaloniki (AUTh) since 1989 and currently the Head of this University's Sustainability Engineering Laboratory. He is also Honorary Professor at the School of Mechanical Engineering of the Karlsruhe Institute of Technology. Since 2002, he is a member of the German National Academy of Sciences Leopoldina. .
	**Nava Jacopo** holds a PhD in planetary geology from the University of Padova. His research interests lie in the combination of petrographic and spectroscopic studies of meteorites, as well as terrestrial rocks and building materials. He currently works as a laboratory technician at the FEG-FIB laboratory within the Department of Geosciences at the University of Padova.
	**Patatoukos Sotirios** B.Sc., M.Sc., has been working since 1994 for the 4th Ephorate of Byzantine Antiquities and since 2014 he is the Head of the Department of Conservation of Antiquities and Works of Art for the Ephorate of Antiquities of the Dodecanese. In 2004 he became a member of the Local Council of Monuments of the Dodecanese.
	**Piovesan Rebecca** is a geologist and works as a contract researcher at the LAMA Laboratory of the IUAV University of Venice. Her primary research interest focuses on the application of petrography to the study of cultural heritage materials, in particular she is an expert in mortars and pigments. She has collaborated on various national and international projects and her research activity is documented by several articles in ISI journals on archaeometry and applied petrography.
	**Plevris Vagelis** is an Adjunct Professor at Oslo Metropolitan University. He serves as Chief Editor for "Computational Methods in Structural Engineering", by Frontiers in Switzerland. His research interests include (i) Finite Element Method (FEM); (ii) Static and Dynamic Analysis of Structures with FEM; (iii) Earthquake Engineering; (iv) Optimum Design of Structures; (v) Reliability and Probabilistic Analysis of Structures; and (vi) Neural Networks and their Applications in Engineering.
	**Sassi Raffaele** is an Associate Professor of Petrology and Petrography at the Department of Geosciences at the University of Padova. His primary research interests lie in the study of petrographic and petrophysical properties of rocks, the petrologic implications of chemical-physical changes in sheet silicates, as well as applied petrography and the relationship between natural radioactivity and geology.

	**Schneidhofer Petra** works as a Senior Adviser and Researcher at The Cultural Heritage section at VTFK. She holds a PhD in archaeology from the University of Vienna (A) and a Master of Science in geoarchaeology from Reading University (UK). Petra is responsible for public management and research tasks related to the implementation of non-invasive methods in heritage management.
	**Shabani Amirhosein** is a Ph.D. candidate at Oslo Metropolitan University in structural engineering, with research interests in 3D modelling, numerical analysis, and dynamics of structures. He was the best Ph.D. candidate for 2021-2022 at the Department of Built Environment due to his exceptional publication rate. He has worked on notable projects such as the digital twin development of Slottfjel Tower in Tønsberg, Norway, and Roman Bridge in Rhodes, Greece.
	**Skamantzari Margarita** holds a M. Eng. Diploma in Rural, Surveying and Geomatics Engineering, and a M. Sc. in Protection of Monuments: Conservation and Restoration of Historic Buildings and Sites. She is a research collaborator at the Lab of Photogrammetry of the School of Rural, Surveying and Geomatics Engineering of NTUA while the past five years she has been working as a freelance consultant in the Documentation of Monuments.
	**Solstad Jørgen,** is a Senior Adviser working with public management and consulting tasks related to conservation and restoration of listed and protected CH-sites, buildings and monuments at The Cultural Heritage section at VTFK. He holds an MA in Conservation of Fine Art from University of NorthUmbria, UK.
	**Tsegas George** is a postdoctoral researcher at the Sustainability Engineering Laboratory, Department of Mechanical Engineering of AUTH with a research focus on modelling of atmospheric circulation and air pollution. Over the last 17 years he has participated in international research projects as an expert on mesoscale modelling of atmospheric flows, climate model downscaling and air quality assessment.
	**Yannakopoulos Panayotis** is a Full Professor at the Department of Informatics and Computer Engineering, since 2010, at the University of West Attica. Served at the Hellenic NARIC (2013-16), member of the University Governing Body (2012-2016). Head of the Materials Section. Director of the Cybersecurity M.Sc. program. Member of AMOPA.

HYPERION's Latest Poster prepared by ICCS

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