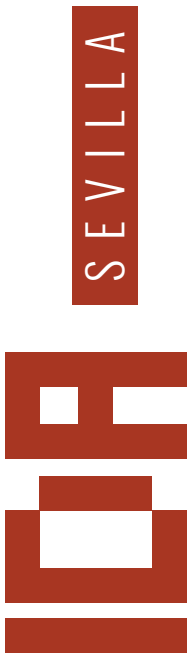
SEVILLA

IDA: ADVANCED DOCTORAL RESEARCH IN ARCHITECTURE



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FOREWORD

The Instituto Universitario de Arquitectura y Ciencias de la Construcción (IUACC), in collaboration with the Escuela Técnica Superior de Arquitectura (ETSAS) and the Escuela Internacional de Doctorado (EIDUS) of the University of Seville are pleased to welcome the heads of research from both Spanish and overseas universities, consolidated researchers and young doctoral researchers to the First International Congress of Doctorates in Architecture IDA Sevilla, from 27th to 28th November 2017.

The **IDA_Sevilla 2017** Congress offers a general perspective of doctoral studies in the field of Architecture and its related disciplines: urban planning, heritage, landscape, construction technologies and sustainability. In the new context generated after the elimination of the doctoral programs prior to RD 99/2011, it is necessary to carry out an analysis of the complex panorama that the former programs and the new doctoral programs have drawn up, in order to know in detail both what has been achieved so far, as well as the challenges of the future of advanced doctoral research in Spain, in the European and international context.

The startling changes that are taking place in our society call for a vision of research that is not compartmentalised into traditional disciplines or areas of knowledge. Doctoral research in Architecture must adapt to changes in society and to the sustainable productive needs of territory.

The congress will take place at the Escuela Técnica Superior de Arquitectura de Sevilla, organised in four simultaneous thematic tables, a workshop on the administration of doctoral programs and two plenary sessions.

The **thematic tables** are aimed at young doctors and doctoral students of the different participating universities who will present their experiences and methods of their research - in development or recently concluded. The participation in the thematic tables is carried out through the selection procedure with blind peer review established in the call for papers and through express invitations to the debate. The almost 70 communications have been structured in four thematic areas representative of the PhD programs in Architecture.

The **open workshop** will be held in two sessions with the participation of the coordinators of each of the collaborating programs of the Congress, and professors with extensive doctoral experience. Its objectives are multiple: to discuss the experiences undertaken in the different universities, exchange ideas about the approaches and models applied, address the challenges of internationalization and management, launch the new Industrial Doctorate with companies and public agencies, and so on.

There are two **plenary sessions**: one, a plenary session of introduction to the congress, with the participation of coordinators of national and foreign doctoral programs; and a closing plenary session, with an open debate for the going-over of the conclusions drawn from the thematic tables and the workshop, and the presentation of final conclusions.

We thank the Escuela Internacional de Doctorado of the University of Seville, and the Escuela Técnica Superior de Arquitectura de Sevilla for the support they have provided for the holding of this meeting, which contributes so much to the clarification of the future of doctoral studies in Spanish universities in the face of the great challenge of internationalization and the continuous improvement of the quality of research in Architecture. We also thank those responsible for the participating Doctoral Programs, the Architecture library of the US and all the participants and attendees.

Antonio Tejedor Cabrera
Marta Molina Huelva

Conference Chairpersons IDA_Sevilla 2017
Instituto Universitario de Arquitectura y Ciencias de la Construcción IUACC

PRÓLOGO

El Instituto Universitario de Arquitectura y Ciencias de la Construcción (IUACC), con la colaboración de la Escuela Técnica Superior de Arquitectura (ETSAS) y la Escuela Internacional de Doctorado (EIDUS) de la Universidad de Sevilla, se complacen en recibir a los responsables de investigación de universidades españolas y extranjeras, a los investigadores consolidados y a los jóvenes investigadores de doctorado en el I CONGRESO INTERNACIONAL DE DOCTORADOS EN ARQUITECTURA IDA_Sevilla, del 27 al 28 de noviembre de 2017.

El congreso **IDA_Sevilla 2017** ofrece una perspectiva general de los estudios de doctorado en el campo de la Arquitectura y sus disciplinas afines: urbanística, patrimonio, paisaje, tecnologías de la construcción y sostenibilidad. En el nuevo contexto generado tras la extinción de los programas doctorales anteriores al RD 99/2011 es necesario realizar un análisis del complejo panorama que han construido los programas extintos y los nuevos programas de doctorado, con el objeto de conocer con detalle tanto lo conseguido hasta ahora como los retos que depara el futuro de la investigación doctoral avanzada en España, en el contexto europeo e internacional.

Los vertiginosos cambios que se están produciendo en nuestra sociedad reclaman una visión de la investigación no compartimentada en disciplinas o áreas de conocimiento tradicionales. La investigación doctoral en Arquitectura debe adaptarse a los cambios de la sociedad y a las necesidades productivas sostenibles en el territorio.

El congreso se celebra en la Escuela Técnica Superior de Arquitectura de Sevilla organizado en cuatro mesas temáticas simultáneas, un taller sobre la gestión de los programas de doctorado y dos sesiones plenarias.

Las **mesas temáticas** están dirigidas a los jóvenes doctores y a estudiantes de doctorado de las diferentes universidades participantes que exponen sus experiencias y métodos sobre las investigaciones en desarrollo o recientemente concluidas. La participación en las mesas temáticas se realiza por el procedimiento de selección con revisión por pares ciegos establecido en la *call for papers* y por medio de invitaciones expresas al debate. Las casi 70 comunicaciones se han estructurado en cuatro áreas temáticas representativas de los programas de doctorado en Arquitectura.

El **taller** de puesta en común se realiza en dos sesiones con la participación de los coordinadores de cada uno de los programas colaboradores del Congreso y de profesores con amplia experiencia doctoral. Sus objetivos son múltiples: debatir sobre las experiencias desarrolladas en las distintas universidades, intercambiar ideas sobre los enfoques y los modelos aplicados, abordar los retos de internacionalización y de gestión, poner en marcha el nuevo Doctorado Industrial con empresas y agencias públicas, etc.

Las **sesiones plenarias** son dos: una sesión plenaria de introducción al congreso, con la intervención de coordinadores de programas de doctorado nacionales y extranjeros; y una sesión plenaria de clausura, con un debate abierto para la reelaboración de las conclusiones extraídas de las mesas temáticas y del workshop y la presentación de las conclusiones finales.

Agradecemos a la Escuela Internacional de Doctorado de la Universidad de Sevilla y a la Escuela Técnica Superior de Arquitectura de Sevilla el apoyo que han proporcionado para la realización de este encuentro que tanto contribuye a clarificar el futuro de los estudios doctorales en las universidades españolas ante el gran reto de la internacionalización y la continua mejora de la calidad de la investigación en Arquitectura. Damos los gracias también a los responsables de los Programas de Doctorado participantes, a la Biblioteca de Arquitectura de la US y a todos los participantes y asistentes.

Antonio Tejedor Cabrera
Marta Molina Huelva

Directores Congreso IDA_Sevilla 2017
Instituto Universitario de Arquitectura y Ciencias de la Construcción IUACC

OBJECTIVES

1. Analyze the research lines of the various programs and build a map of doctoral research in Spain with the support of coordinators, tutors / thesis supervisors, doctoral students and young doctors in the disciplines related to Architecture and their related areas.

2. To know the status of doctoral theses in progress or defended in the last three years, selected by means of a call with blind peer evaluation of the doctoral programs participating in the congress.

3. Discuss the structure and university management of doctoral programs in relation to employment challenges, collaboration with the productive sector and national research programs.

4. Exchange experiences with other international doctoral research programs on international mobility management, theses with international mention, co-supervised theses, theses with industrial mentions, etc.

5. No less important, consolidate a national and international network of Doctoral Programs related to Architecture, Urban Planning, Heritage, Landscape, Technologies and related disciplines.

IDA ADVANCED DOCTORAL RESEARCH SEVILLA 2020

LT 1 ARCHITECTURE TECHNOLOGIES

LT 2 HOUSING, CITY AND TERRITORY

LT 3 HERITAGE AND REHABILITATION

LT 4 ANALYSIS AND ADVANCED PROJECTS

FORMAT

Thematic tables
The thematic tables are places to present the methodologies and experiences of young doctors and doctoral students from different universities. They are managed by the doctorate students themselves, who generate conclusions to be debated and reworked in the final plenary session. The sessions are developed simultaneously with the presentation of the papers selected in the call, organized in four areas or thematic lines:

1. Architectural technologies
2. Housing, city and territory
3. Heritage and Rehabilitation
4. Analysis and advanced projects

Workshop
The workshop of the Congress is oriented towards the analysis of the problems and management needs of the Doctorate Programs, with the objective of arriving at conclusions that may be useful to the Universities involved. The coordinators of the Doctorate in Architecture programs and the doctoral students' representatives will participate in the workshop. The following are topics for debate: lines of research, methodologies, organizational needs of the doctoral programs, the International Doctorate and the Industrial Doctorate, and the future of doctoral research.

Plenary Sessions
The plenary sessions are held at the beginning and end of the Congress. In the first session of welcome and introduction to the Congress, researchers from the national and international scene and the coordinators of the doctorate programs are invited to participate. In the second plenary session an open debate is proposed for the going over of the proposals drawn from the workshop and the thematic tables. It also serves as a closing ceremony with the presentation of the final conclusions of the 2017 IDA_Sevilla Congress.

OBJETIVOS

1. Analizar las líneas de investigación de los diversos programas y construir el mapa de la investigación doctoral en España con el apoyo de los coordinadores, los tutores/directores de tesis, los doctorandos y los jóvenes doctores en las disciplinas relacionadas con la Arquitectura y sus áreas afines.

2. Conocer el estado de las tesis doctorales en marcha o defendidas en los últimos tres años, seleccionadas por medio de una *call* con evaluadores por pares ciegos de los programas de doctorado participantes en el congreso.

3. Debatir sobre la estructura y la gestión universitaria de los programas de doctorado en relación con los retos de empleo, colaboración con el sector productivo y los programas nacionales de investigación.

4. Intercambiar experiencias con otros programas de investigación doctoral a escala internacional sobre gestión de la movilidad internacional, tesis con mención internacional, tesis en cotutela, tesis con mención industrial, etc.

5. No menos importante, consolidar una red nacional e internacional de Programas de Doctorado relacionados con la Arquitectura, la Urbanística, el Patrimonio, el Paisaje, las Tecnologías y sus disciplinas afines.

IDA INVESTIGACIÓN DOCTORAL AVANZADA

LT 1 TECNOLOGÍAS DE LA ARQUITECTURA

LT 2 VIVIENDA, CIUDAD Y TERRITORIO

LT 3 PATRIMONIO Y REHABILITACIÓN

LT 4 ANÁLISIS Y PROYECTOS AVANZADOS

FORMATO

Mesas temáticas
Las mesas temáticas son lugares de presentación de las metodologías y las experiencias de jóvenes doctores y de estudiantes de doctorado procedentes de las diferentes universidades. Son gestionadas por los propios estudiantes de doctorado que generan unas conclusiones para ser debatidas y reelaboradas en la sesión plenaria final. Las sesiones se desarrollan de manera simultánea con la presentación de los *papers* seleccionados en la *call*, organizados en cuatro áreas o líneas temáticas:

1. Tecnologías de la Arquitectura
2. Vivienda, Ciudad y Territorio
3. Patrimonio y Rehabilitación
4. Análisis y Proyectos Avanzados

Taller
El workshop del Congreso se orienta hacia el análisis de los problemas y las necesidades de gestión de los Programas de Doctorado con el fin de extraer conclusiones que pueden ser útiles a las Universidades implicadas. En el workshop participan los coordinadores de los programas de Doctorado en Arquitectura y los representantes de los doctorandos. Son temas de debate: las líneas de investigación, las metodologías, las necesidades organizativas de los programas de doctorado, el Doctorado Internacional y el Doctorado Industrial, y el futuro de la investigación doctoral.

Sesiones Plenarias
Las sesiones plenarias se realizan al inicio y al final del Congreso. En la primera sesión de bienvenida e introducción al Congreso se invita a participar a expertos investigadores del panorama nacional e internacional y a los coordinadores de los programas de doctorado. En la segunda sesión plenaria se propone un debate abierto para la reelaboración de las propuestas extraídas del taller y de las mesas temáticas. Sirve también de clausura con la presentación de las conclusiones finales del Congreso IDA_Sevilla 2017.


IDA
SEVILLA

LT 1

TECNOLOGÍAS DE LA ARQUITECTURA

ARCHITECTURE TECHNOLOGIES / TECNOLOGÍAS DE LA ARQUITECTURA

STUDY AND ASSESSMENT OF THE SEISMIC VULNERABILITY OF PRIMARY SCHOOL BUILDINGS LOCATED AT THE ALGARVE AND HUELVA: STATE OF THE ART

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Abstract: the main objective of this research is the study and assessment of the seismic vulnerability of primary schools in the territory of the Algarve (Portugal) and Huelva (Spain). This research will be performed cooperatively, in accordance with the objectives established by the National Platforms for the Reduction of Risk Disasters (PNRRC) of the National Civil Protection Commissions of Portugal and Spain. The Eurasian and African tectonic plates converge close to this geographical area, constituting one of the zones with the highest seismic hazard of the Iberian Peninsula. Primary schools are one of the most vulnerable buildings. Therefore, it is essential to verify and guarantee their structural stability in case of an earthquake.
This article presents a review of the seismic hazard in the area and the main initiatives related to the study of the seismic risk for these buildings. This analysis will be focused on the educational typology and the regulations of both countries will be considered. In addition, the methodology that will be developed is presented. This is centered on the development of diagnostic and evaluation tools for the typologies to obtain a classification of their earthquake vulnerability. According to this classification, measures will be proposed for the treatment and rehabilitation of these buildings. Moreover, it will be applied to the cases with more unfavorable behavior to optimize the designed solutions.

Keywords: Seismic vulnerability, School-score, Resilience, Cooperation.

1. Introduction

The Iberian Peninsula (IP) is characterized by its moderate seismicity. The south is the area with the highest seismic activity (Carre and Zornoza 2011). Recently, a large number of studies have been carried out to obtain the seismic hazard of this zone. These have been motivated by the earthquakes felt in the last decades in the area, whose magnitudes have surpassed the average values, causing considerable effects.
Earthquakes are one of the natural disasters that cause more victims and economic losses (Perepérez 2014). In this context, several authors have established the importance of the study of buildings seismic risk. It allows estimating and assessing the possible damages that seismic actions can cause, in order to minimize human, material and economic losses.
The study of buildings seismic risk depends on two fundamental factors. First, the seismic hazard which is established according to the seismicity of the area where the studied building is located. Second, the vulnerability which depends on the constructive and structural characteristics of the building (Arroyo and Berenguer 1999).

1.1. *Seismicity in the south of the Iberian Peninsula*

The south of the IP is the zone of highest level of seismic activity. It is associated with the convergence between the African and Eurasian plates. This configures a large area of important earthquakes with long return periods (Martínez-Álvarez et al. 2013).
The Algarve-Huelva area is affected by a series of major faults as result of these plates convergence. Recent studies have identified these faults in the southwest of the Algarve. These are the “Herradura” fault, the “Marquis of Pombal”, or the fault of “San Vicente” (Figure 1) (Gràcia et al. 2010). This area is

characterized by the occurrence of large earthquakes with long return periods. Among them, the 1969 earthquake of San Vicente Cape and the well-known earthquake and subsequent tsunami of Lisbon 1755 -whose magnitudes were very large, Mw>7.0- are remarkable. The last one caused the destruction of a great part of the territory of the Algarve and Andalusia (Instituto Español para la Reducción de los Desastres 2016).

Fig. 1 Map of active quaternary faults of the IP (Instituto Geográfico Nacional 2017).

The following earthquakes felt in the IP have been selected due to their large magnitude and serious effects caused:

Table 1. Historical earthquakes felt in the IP (Silva, P.G. and Rodriguez Pascua 2014).

YEAR	LOCATION	MAGNITUDE	CONSEQUENCES
1522	Alboran Sea	6.5	Total destruction of the city of Almería and towns in Granada.
1531	Lisbon	7.0	Around 30,000 deaths in the city of Lisbon.
1680	Alahaurín el Grande (Málaga)	6.8	Several towns were affected and it produced minor damages.
1755	SW of San Vicente Cape	8.5	Destruction of most of the city of Lisbon and it produced a tsunami of almost 15m high. There were between 10,000 and 90,000 deaths due to both phenomena.
1804	Alboran Sea	6.7	Serious damages suffered in Motril (Spain).
1829	Torrevieja (Alicante)	6.6	Destruction of more than 2,000 homes from several towns in the region. About 400 deaths.
1884	Arenas del Rey, Granade	6.7	Nearly a thousand deaths.
1969	San Vicente Cape	8.0	Several deaths and minor damages.

According to Table 1, the earthquakes of larger magnitude, which also had the most devastating effects, were those caused by the faults located in the area of San Vicente Cape, such as the earthquakes of 1531, Lisbon 1755 and 1969. It is concluded that the event of Lisbon caused the worst effects.

During the last decades, several earthquakes of moderate magnitude have occurred (Table 2). This demonstrates the important seismic activity that currently exists in the studied area:

Table 2. Earthquakes felt in the Peninsula in the last decades.

YEAR	LOCATION	MAGNITUDE	CONSEQUENCES
2007	SW of San Vicente Cape	6,1	Minor damage.
2009	Isla Cristina (Huelva)	6,3	Minor damage. Cracks in buildings and old walls collapsed.
2011	Lorca (Murcia)	5,1	Considerable damage and victims. Buildings collapses of great importance
2016	Alboran Sea	6,3	Facades detachments, cracks and minor injuries. Slight tsunami felt in the Balearic Islands (Spain)

Of this list, the earthquake of San Vicente Cape 2007 and the earthquake felt in Lorca (Murcia) are the most important. The last one had devastating consequences: more than 300 people were injured and about 10,000 people were displaced from their homes (Salgado-Gálvez et al. 2016).
According to the updated seismic hazard map (Martínez Solares 2013) (Figure 2), the region of highest seismic hazard is the southeast of Spain. This area has suffered a great number of earthquakes. Therefore, the majority of the studies about the seismic risk and hazard are concentrated in this area. The southwest of Spain, is considered an area of moderate hazard and there are not many studies focused on this zone. However, when analyzing the earthquakes felt in the IP records, it is observed that the three largest and most destructive earthquakes have been produced by faults that affect this area. Therefore, if a seism occurs due to these faults, it is the geographic area that would suffer the worst consequences, affecting both countries equally.

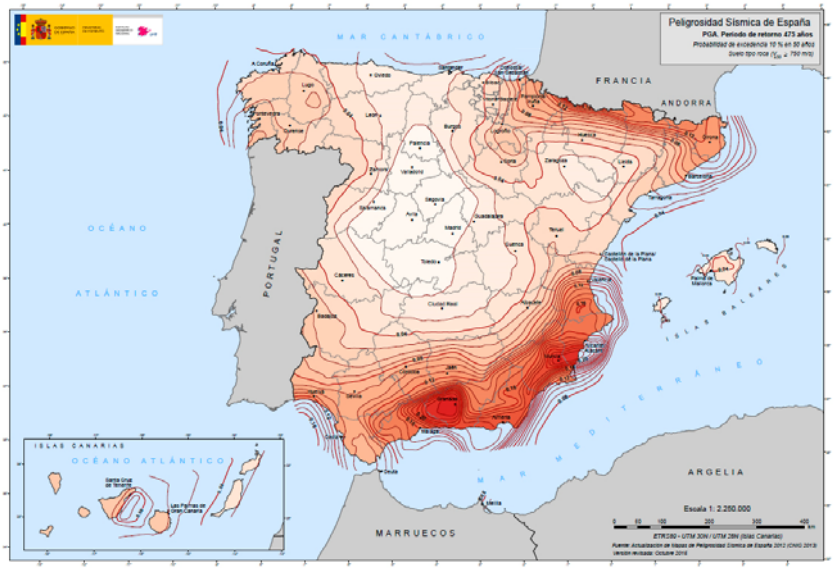

Fig. 2 Updated seismic hazard map of Spain, in acceleration values for a return period of 475 years (Instituto Geográfico Nacional 2015)

1.2. *The tectonics of the Algarve-Huelva area*

The territory of the Algarve and Huelva is characterized by a similar geological profile with certain nuances. In the case of Huelva, it is located in Tertiary and Quaternary materials of the Guadalquivir valley, with clear marine influences and extensive marsh areas (Meijninger 2006). The main geological materials from lower to greater depth are: fluvial deposits, river terraces, basal sands and sandy marlstone. The Bay of the Algarve is essentially characterized by Tertiary materials, especially calcareous materials, clays and sands with some magmatic inclusions (Terrinha et al. 2013).
According to the Spanish seismic regulations, the seismic acceleration depends, among other values, on the amplification coefficient of the soil. This value varies according to the type of soil where the building is located. For areas of soft consistency, the value is higher than for rocky soils. When an earthquake occurs in a soft terrain, the area of amplification is greater since the soil is physically capable of propagating the effect. Meanwhile rocks have inertia and therefore rocky soils are able to absorb part of the energy released by the earthquake (Udías and Mézcua 1986).
Although there are other areas of important seismic activity, such as southeast of Andalusia, whose geological profile is characterized by rocky soils, the seismic action of the Algarve-Huelva area is greater due to its soft soil composition.

1.3. *Evolution of the study of the seismic risk*

The study of the seismic risk has evolved over the years. Its assessment is an important factor for the design of seismic resistant buildings and the improvement of their vulnerability. From the Spanish and Portuguese administrations and international organizations, agreements and regulations have been established to regulate buildings design and to establish action plans in case of emergency.

Regulations regarding the seismic risk in Spain and Portugal

The legal framework on which the seismic design of buildings in Spain is based, as well as the management of emergencies and prevention of disasters, is structured by the following decrees and laws:

- Technical Building Code (CTE) (Ministerio de Fomento de España n.d.).
- Royal Decree 997/2002, of September 27th, approving the new Seismic Resistant Construction Standard (Norma de Construcción Sismorresistente (NCSE-02) 2002).
- Law 17/2015, of July 9th, of the National System of Civil Protection (Ley 17/2015, de 9 de julio, del Sistema Nacional de Protección Civil 2015) and Law 2/1985, of January 21th, on Civil Protection (Ley 2/1985 sobre Protección Civil 1985).
- Royal Decree 407/1992, of April 24th, approving the Basic Regulation of Civil Protection (Norma Básica de Protección Civil Real decreto 407/1992, de 24 de Abril 1992).
- Basic Guideline for Civil Protection Planning for Seismic Hazards (Resolución de 5 de mayo de 1995, por la que se aprueba la Directriz Básica de Planificación de Protección Civil ante el Riesgo Sísmico 1995).
- Modification of the Basic Directive of Civil Protection Planning for Seismic Hazards (Resolución del 17 de Septiembre de 2004 de la Secretaría, por la que se modifica la Directriz básica de planificación de protección civil ante el riesgo sísmo 2004)
- Royal Decree 1053/2015, of 20th November, approving the Basic Directive for civil planning protection against the risk of tsunamis (Real Decreto 1053/2015 por el que se aprueba la directriz básica de planificación de protección civil ante el riesgo de maremotos 2015)

In the case of Portugal, it is applicable:

- UNE-EN 1998-1. Eurocode 8: Projects of seismic structures (Eurocode 8: Design of structures for earthquake resistance. Part 1: General rules, seismic actions and rules for buildings 2006).

Research on seismic risk nowadays: studies in the Iberian Peninsula

The estimation of earthquakes and the evaluation of the seismic risk of buildings are more reliable as research is intensified. Despite the complexity of the phenomenon, many authors have established new methodologies for the evaluation and assessment of the seismic risk and vulnerability of buildings.

In general, the methodologies for the analysis of the seismic action are based on estimates from past events. The geographic areas where a greater number of studies of this nature have been carried out are characterized by an extreme seismic hazard. Examples of these works in these areas are those that use open-source programs such as the OpenQuake-engine to evaluate structural damage in South America (Villar-Vega and Silva, V. 2017), those that analyze past earthquakes to discover precursor patterns of important earthquakes in Chile through new methods (Florido et al. 2015) or those that work on the prediction of moderate magnitude earthquakes through artificial neural networks in Tokyo (Asencio-Cortés et al. 2015).

At European level, there are numerous research projects, such as the European project "Risk-EU" (2003). It includes a general and modular methodology for the creation of scenarios of seismic risk for different European cities. The vulnerability index of the city of Barcelona, Spain (Roca et al. 2006) was obtained and it was concluded that a great part of the buildings of the city are not prepared to the action of an earthquake of considerable magnitude.

About databases, the AHEAD portal highlights at European level, which includes the seismic history of Europe (Locati et al. 2014). Also, the publications and catalogs prepared by the National Geographic Institute of Spain (NGIS) and the Geo-Mining Institute of Spain are important in this field of research.

Current works are those derived from the earthquake felt in Lorca (Murcia, Spain) in 2011. There are researches that analyze the consequences of an earthquake of the same characteristics in the town (Rivas-Medina et al. 2014) or the assessment of the buildings vulnerability of the historical heritage of the city (García Erviti 2014). After numerous studies on the phenomenon and its consequences (Institut Geològic de Catalunya 2011), it is obtained that the fundamental factors that aggravated its effects were: the poor adequacy of the buildings to the criteria of seismic resistant design (existence of empty ground floors and short columns), lack of maintenance of buildings and lack of preparation of the emergency corps to act after the phenomenon.

In the south of the IPa, there are numerous projects funded through public calls launched by local and national administrations. Their results are included in various publications of interest to this study. Among them, for this study are important: the project "Seismic risk of the Autonomous Community of Murcia (RISMUR, 2006)", which studies the seismic risk in three localities of the region of Murcia (Gaspar-Escribano, J.M., Benito and García-Mayordomo 2008); (Gaspar-Escribano, J.M. et al. 2010),

or the project "Methodology for the Effective Assessment of Urban Seismic Risk (MERISUR)" (Benito et al. 2010).
More focused on the selected studied area, there are studies that analyze the seismic hazard of the zone through new methods such as the “ERSTA” methodology (Study of Seismic Risk and Tsunami in Algarve). This method identifies and characterizes the seismic risk in the territory of the Algarve (Costa, Pires and Vicêncio 2012). The SIRCO method (Simulated Risk Simulator) is important for this research because their results are compared with those obtained by the ERSTA method (Fazendeiro Sá, Morales-Esteban and Durand 2016) and also studies that are focused on computational analysis (Morales-Esteban, Martínez-Álvarez and Reyes 2013).
The researches that obtain the seismic vulnerability of buildings are characterized by a similar work methodology. This is focused on a first analysis of the constructive and structural characteristics through on-site visits to obtain a general analysis of the buildings response to earthquakes. After, in order to optimize their results, a comprehensive analysis of the most unfavorable cases is performed (Valente and Milani 2016) (Barbieri et al. 2013) (Simões et al. 2014) (Candia et al. 2016). Other works are more singular and as result, they obtain the structural capacity and fragility curves to obtain the seismic vulnerability. They finally conclude that most of the buildings of a city are seismically vulnerable (Lamego et al. 2017).

1.4. *Seismic vulnerability. Selection of the typology to be studied.*

In general, earthquakes have damaged the school infrastructure in a systematic way: they have not only affected buildings, due to their poor design and maintenance, but also have a significant impact on children. In this sense, several studies have demonstrated a severe psychological effect on children who have suffered the effects of earthquakes, and the benefits of pre-training (UNICEF 2011). The capacity of seismic resilience of schools is twofold: the buildings structural capacity and the preparation of teachers and non-teaching staff before, during and after the phenomenon. Schools are very vulnerable to earthquakes due to their high concentration of people in a confined space and their relatively small proportion of adults per child.
In this sense, several international researches focus on the study of the seismic risk of this type of buildings by their usage and users in countries such as Istanbul, India or Venezuela. They emphasize the importance of their seismic study and evaluation (Hancilar et al. 2014) (Dhungel et al. 2012) (López et al. 2010). At a national level, studies to estimate an index that allows to know the conditions presented by the structure in the case of an earthquake in the Mérida region (Spain) (Suárez et al. 2009) have also been carried out.
The typologies of primary schools are quite repeated, of small-scale and are an affordable building type. Schools play a vital role in society as they are responsible for the training of young people in a country (of the youngest). Also, they play a key role in promoting social and cultural knowledge (Panahi, Rezaie and Meshkani 2014). In addition, its public character allows easily adapting its typology and can serve as a refuge after the catastrophe.

1.5. *International cooperation for disaster reduction*

In order to promote the cooperation among communities to face disasters, the United Nations adopted the International Strategy for Disaster Reduction (ISDR) in 2000. In this context, Portugal and Spain formed the National Platforms for Disaster Risk Reduction (PNRRC) to comply with the guidelines issued by the ISDR within their respective National Civil Protection Commissions. Finally, they signed the Hyogo 2005-2015 (United Nations 2007) and Sendai 2015-2030 agreements (United Nations 2015) which promote disaster risk reduction cooperatively among countries.
The commitment between Spain and Portugal has as main objective: the cooperation between both countries in the event of a disaster. Working together allows to share information and institutional cooperation for policy actions and decisions, as well as improving research efficiency (Weichselgartner and Pigeon 2015). The importance of this study relies on the seismic hazard in the area: in case of an earthquake of great proportions, both regions will be equally affected.
Therefore, this research proposes the study and assessment of the seismic risk of primary school buildings in the territory of the Algarve-Huelva according to the objectives established by the PNRRC of both countries. This work will be carried out in order to ensure a simultaneous and cooperative response in case of a disaster between Portugal and Spain. To this end, it will be studied the development of tools for diagnosis, evaluation, treatment and rehabilitation of the educational typologies, both before and after the catastrophe. Also, it will promote the awareness of the seismic risk in communities and schools. This work will conclude in the elaboration of a practical guide for the diffusion and awareness of the seismic risk in the teaching population of both regions and the application of the elaborated methodology to rehabilitate this type of buildings.

2. Methodology

To achieve the main objective proposed by the project, the following work plan is established and described:

1. **Analyze the seismic hazard of this geographic area by updating a new model for the estimation of the seismic action that has already been developed by the research group.**

- **Action 1:** analysis of seismic maps and databases of the area to update the model already developed.
- **Action 2:** analysis of regulations related to structural safety in case of an earthquake of educational buildings that are established in Spain and Portugal and at European level.
- **Action 3:** bibliographical review (publications and research projects) of methodologies and results that establish similar research works in order to obtain an overview on how to address this problem.
- **Action 4:** review of the application of seismic risk studies in new emergency or natural disaster mitigation plans.

2. **Analyze the constructive and structural characteristics of the different typologies of primary schools in the study area**.

- **Action 1:** bibliographical review of the constructive and structural characteristics of primary schools in the territory.
- **Action 2:** creation of a georeferenced database where the information on constructive and structural characteristics of the centers of both countries can be included systematically. Online surveys will be sent to the schools in order to obtain an overview of the characteristics. This action allows to obtain quickly and easily information about a large number of buildings in a short period of time.
- **Action 3:** creation and completion of characterization school's sheets with the information collected during school's on-site visits. During these visits, the buildings will be inspected and also their surroundings for a later evaluation and diagnosis. The sheets will include aspects related to the environment and the constructive, structural and pathological characteristics (if any) of the schools. They should include the following sections:

- General information about the building. In this part, the school will be identified, its location and age of construction, levels, services and ratios.
- Urbanistic information. In this section characteristics related to the topography, boundary conditions of the building; surface area of the center, number of isolated buildings (sports pavilions, workshops, etc.), and general conditions of accessibility in case of emergency will be included.
- Technical characterization. This part will refer to the type of structure (vertical and horizontal elements), highlighting if there are elements of special importance in the study of the seismic vulnerability such as short columns, "pilotis" (empty ground floors), short corbels, etc.; the constructive characteristics of facades, roofs and wall finishes; structural regularity (plant type and volumetric); the characterization of isolated buildings in case they exist…
- Pathological characterization. List of injuries if necessary.

3. **Obtain a classification system of the school's vulnerability to earthquakes (Score of each school) by creating a computer application.**

- **Action 1:** creation of algorithms and software routines to determine a final score for each school analyzed. The score will be designated according to its constructive and structural characteristics and the seismic hazard obtained from the estimation model. The proposed model has already been developed by the research group (Fazendeiro Sá, Morales-Esteban and Durand 2016) and it is based on empirical methods developed by Giovinazzi and Lagomarsino (Lagomarsino and Giovinazzi 2006)(Giovinazzi and Lagomarsino 2004)(Bernardini et al. 2007). These methods are based on the concepts of the EU-98 Macro-Seismic Scale (Grünthal 1998).
- **Action 2:** obtain the "School Score" or score of each school which will be an indicator of the level of intervention that will be needed to perform according to the seismic vulnerability of the school. This "School-Score" is translated into a list of necessary constructive and structural actions to correct the deficiencies of the building in order to comply with current regulations. The capacity and use of the spaces will remain. This indicator will also serve to determine the scope of action required, which may be partial, integral or total (reconversion of the school) and the guidelines for the building maintenance.
- **Action 3:** evaluation of possible human losses and material damages that would occur for different seismic scenarios.

4. **Elaborate a methodology of treatment and rehabilitation of the buildings according to the classification of vulnerability to earthquake that will be obtained**.

- **Action 1:** bibliographical review on structural rehabilitation techniques (structure, foundations and constructive solutions) to propose new solutions or to apply the existing ones.
- **Action 2:** development of a catalog of reinforcement solutions for building deficiencies and injuries, as well as the inclusion of recommendations. The methodology will facilitate the work of the designers for the assessment and adequacy of the buildings. It will be available in an online portal that will be developed throughout the project.

5. **Apply the rehabilitation methodology to the case with the most unfavorable behavior in case of an earthquake, in order to optimize the proposed solutions to facilitate their reproduction in both Spain and Portugal**.

- **Action 1:** study and selection of schools with a school-score index that is more unfavorable to earthquakes action in cooperation with the competent Portuguese and Spanish authorities. The seismic analysis will be carried out exhaustibility by using techniques of non-linear analysis that will serve to calibrate the vulnerability index proposed from accurate data. The cases that present structural elements that aggravate the seismic behavior of the buildings will be included in this analysis: the existence of empty ground floors (pilotis) or short columns since they are factors that aggravated the effects of the earthquake of Lorca of 2011 (Lloret and Regalado 2011).
- **Action 2:** application of the reinforcement techniques in order to be checked and optimized and therefore their reproduction will be facilitated. This action aims to encourage the modernization of schools to ensure their proper behavior in case of an earthquake.

6. **Develop educational material to assist in the dissemination and awareness of the seismic risk in the teaching population of both regions. Also a practical guide will be developed for the implementation of the proposed rehabilitation methodology including recommendations for action plans in case of emergency**.

- **Action 1:** communication of the seismic risk through a document that includes the performance of didactic activities for the preparation of students. In addition, educational material will be developed and distributed for the training of the teaching staff. In this material, disaster planning and simulation activities will be included to alert students to correctly behave during emergency situations.
- **Action 2:** preparation of a practical guide for the implementation of the proposed rehabilitation methodology. This guide will gather buildings technical information and facilitate the work of the designer to adapt the buildings.
- **Action 3:** list of recommendations to update action plans in case of emergency of the competent security forces.
- **Action 4:** creation of an online portal to inform that could be freely consulted by citizens and public corps. It will provide the characterization of school records as well as the simulation of the calculation of the seismic risk of each building. This portal will allow checking the information and results obtained from the research from any location and will be updated throughout the project.

3. Expected results

The project is divided into two thematic areas. First, it will pursue the analysis of the structural behavior of buildings in case of an earthquake in the studied area. Secondly, the communication and awareness of the seismic risk through the education of the teaching population. This work will be performed in cooperation between Spain and Portugal on the premise that disaster risk reduction is a profitable investment in the prevention of future losses (UNISDR 2015).

The project will be carried out in all primary schools in the province of the Algarve and Huelva, covering the 16 Portuguese municipalities and 79 Spanish municipalities. The estimated student population is around 20,000 in Portugal and 35,000 in Spain for a population residing in both regions of 1,000,000 people.

After the completion of the project, the following results are expected:

- Comply with the Hyogo and Sendai agreements for disaster risk reduction in both countries according to the PNRRC of Spain and Portugal.
- Obtain a system to classify the vulnerability of schools to earthquake (score of each school) by creating a computer application.

- Develop a methodology for treatment and rehabilitation of buildings based on the classification of the obtained vulnerability. It will be applied to cases with an unfavorable behavior.
- Elaborate educational material to help the dissemination and awareness of the seismic risk in the teaching population of both regions. Also, a practical guide will be developed for the application of the obtained methodology for the rehabilitation and reinforcement of the typologies.

4. Discussion

The present research proposal and its objectives are in line with the growing interest and concern of the European Union in contributing to the reduction of the seismic risk. This interest is directed through the promotion of studies on seismic hazard and physical vulnerability of buildings after the major magnitude earthquakes occurred in recent years in European localities such as Lorca, Murcia (Spain) in 2011, Amatrice (Italy) in 2016 and the most recent in Lesbos (Greece) in June 2017.
According to the analysis of the state of the research nowadays, all authors emphasize the importance of the study and evaluation of the seismic risk of buildings. This work should be performed either through the improvement and precision of the analysis of the seismic hazard with new models of estimation or the study of the improvement of the seismic vulnerability of buildings by proposing new methodologies.
In this sense, many authors insist on the importance of this type of study due to the obsolescence of current legislation. They propose new measures for its updating (Trifunac 2012) and even they stablish the need for more exhaustive analysis of the structure for the correct estimation of the seismic action (Trifunac 2016).
In spite of being an area of apparent seismic danger and unlike other close areas, there is not a great amount of this type of studies in the area of Algarve-Huelva. Therefore, due to this lack, it is concluded the necessary performance of this research in this zone.
As for the selection of the typology to study, historically the consolidation of buildings to resist earthquakes has been performed primarily in schools and hospitals in different cities. They are the most vulnerable typologies and there are some examples such as in the city of California, United States, during the 1970s (Green 1980). At an institutional level, the project is supported by the interest of many countries in reducing the seismic risk of primary and secondary education buildings such as the United States, Iceland, Italy and Portugal (Bernhardsdottir et al. 2016). This interest relies on the funding of research projects and the improvement and updating of policies and action plans. As result of this concern, guidelines for the design and restoration of seismic-resistant buildings have been published in the United States (Federal Emergency Management Agency (FEMA) 2006) (Federal Emergency Management Agency (FEMA) 2002). These are similar to those proposed by this project but they are not scientifically rigorous and are destined to the teaching population and not to professional technicians.

5. Conclusions

After the elaboration of this initial phase of the project, it is concluded that:
- According to the seismic record, in the area of Algarve-Huelva there is an important seismic hazard. This zone is affected by faults that have produced the most important earthquakes suffered by the IP.
- Studies on seismic risk are concentrated in the southeastern of the IP as it is the area of greatest hazard in the Peninsula. However, despite its catastrophic potential, in the Algarve-Huelva area there is not a considerable amount of studies of this type.
- The presence of soft soils in the studied area implies that the amplification coefficient of the soil in the calculation of the seismic action is great and, therefore, the earthquake effects can be more serious and devastating.
- The study of the management performed after the earthquakes suffered in recent years in the Peninsula, especially the Lorca earthquake in 2011, establishes the importance of the action protocols in case of disaster of emergency corps to correctly act and minimize possible losses, as well as the importance of buildings maintenance.
- After this first study, it is also concluded that in parallel with the obvious importance of the structure, the constructive definition is also necessary to be studied. After the case of the Lorca earthquake, it has been proved that most of the accidents were suffered due to problems in the constructive solutions.

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