

University of Cantabria / University of Granada

Organizers:



# REHABEND 2022

## Euro-American Congress

CONSTRUCTION  
PATHOLOGY,  
REHABILITATION  
TECHNOLOGY AND  
HERITAGE MANAGEMENT

Granada (Spain) - September 13<sup>th</sup>-16<sup>th</sup>, 2022

Sponsor entities:



# ***REHABEND 2022***

***CONSTRUCTION PATHOLOGY, REHABILITATION TECHNOLOGY AND  
HERITAGE MANAGEMENT***

*(9<sup>th</sup> REHABEND Congress)*

**Granada (Spain), September 13<sup>th</sup>-16<sup>th</sup>, 2022**

PERMANENT SECRETARIAT:

**UNIVERSITY OF CANTABRIA**

Civil Engineering School

Department of Structural Engineering and Mechanics

Building Technology R&D Group (GTED-UC)

Avenue Los Castros 34, 39005 SANTANDER (SPAIN)

Tel: +34 942 201 761 (43)

Fax: +34 942 201 747

E-mail: [rehabend@unican.es](mailto:rehabend@unican.es)

[www.rehabend.unican.es](http://www.rehabend.unican.es)

## REHABEND 2022

ORGANIZED BY:



UNIVERSITY OF CANTABRIA (SPAIN)  
[www.unican.es](http://www.unican.es) // [www.gted.unican.es](http://www.gted.unican.es)



UNIVERSIDAD  
DE GRANADA

UNIVERSITY OF GRANADA (SPAIN)  
[www.ugr.es](http://www.ugr.es)

CO-ORGANIZERS ENTITIES:



CHILE-UNIVERSIDAD AUSTRAL DE  
CHILE



ITALY-POLITECNICO DI BARI



MEXICO-UNIV. MICHOACANA DE  
SAN NICOLÁS DE HIDALGO



PERU-UNIVERSIDAD NACIONAL  
PEDRO RUIZ GALLO



PORTUGAL-UNIVERSIDADE  
DE AVEIRO



PORTUGAL-INSTITUTO SUPERIOR  
TÉCNICO | UNIV. DE LISBOA



SPAIN-TECNALIA RESEARCH &  
INNOVATION



SPAIN-UNIVERSIDAD DEL  
PAÍS VASCO



SPAIN-UNIVERSIDAD POLITÉCNICA  
DE CATALUÑA



SPAIN-UNIVERSIDAD DE BURGOS



SPAIN-UNIVERSIDAD POLITÉCNICA  
DE MADRID



SPAIN-UNIVERSIDAD DE SEVILLA



SPAIN-UNIVERSIDAD EUROPEA  
MIGUEL DE CERVANTES



UNITED STATES OF AMERICA-  
UNIVERSITY OF MIAMI



URUGUAY-UNIVERSIDAD  
DE LA REPÚBLICA

CONGRESS CHAIRMEN:

IGNACIO LOMBILLO  
MARIA PAZ SÁEZ

CONGRESS COORDINATORS:

HAYDEE BLANCO  
YOSBEL BOFFILL

EDITORS:

HAYDEE BLANCO  
YOSBEL BOFFILL  
IGNACIO LOMBILLO

GUEST EDITOR:

MARIA PAZ SÁEZ

INTERNATIONAL SCIENTIFIC ADVISORY COMMITTEE:

HUMBERTO VARUM – UNIVERSITY OF PORTO (PORTUGAL)  
PERE ROCA – TECHNICAL UNIVERSITY OF CATALONIA (SPAIN)  
ANTONIO NANNI – UNIVERSITY OF MIAMI (USA)

The editors does not assume any responsibility for the accuracy, completeness or quality of the information provided by any article published. The information and opinion contained in the publications are solely those of the individual authors and do not necessarily reflect those of the editors. Therefore, we exclude any claims against the author for the damage caused by use of any kind of the information provided herein, whether incorrect or incomplete.

The appearance of advertisements in these Scientific Publications (Printed Book of Abstracts & Digital Book of Articles - REHABEND 2022) is not a warranty, endorsement or approval of any products or services advertised or of their safety. The Editors does not claim any responsibility for any type of injury to persons or property resulting from any ideas or products referred to in the articles or advertisements.

The sole responsibility to obtain the necessary permission to reproduce any copyright material from other sources lies with the authors and REHABEND 2022 Congress can not be held responsible for any copyright violation by the authors in their article. Any material created and published by REHABEND 2022 Congress is protected by copyright held exclusively by the referred Congress. Any reproduction or utilization of such material and texts in other electronic or printed publications is explicitly subjected to prior approval by REHABEND 2022 Congress.

ISSN: 2386-8198 (printed)

ISBN: 978-84-09-42252-4 (Printed Book of Abstracts)

ISBN: 978-84-09-42253-1 (Digital Book of Articles)

Legal deposit: SA - 132 - 2014

Printed in Spain by Círculo Rojo



**KEYNOTE LECTURES**

1 THE USE OF TITANIUM IN CONSERVATION AND SEISMIC REINFORCEMENT OF MASONRY STRUCTURES <i>Corradi, Marco; Adkins, Jill</i>	.....	2
2 STRENGTHENING OF MASONRY STRUCTURES WITH INORGANIC MATRIX COMPOSITES (IMCS) <i>Aiello, Maria Antonietta</i>	.....	16
3 PROGRESSIVE COLLAPSE AND ROBUSTNESS OF BUILDINGS AND BRIDGES <i>Adam, José M; Buitrago, Manuel; Makoond, Nirvan</i>	.....	28
5 ARCHITECTURE OF MANY EPOCHS: THE SACROMONTE ABBEY IN GRANADA <i>Martín Muñoz, Antonio</i>	.....	35
6 CONSERVATION AND MANAGEMENT OF THE BUILT HERITAGE: RECENT WORKS ON MODERN HERITAGE BUILDINGS OF PORTUGUESE ORIGIN <i>Lourenço, Paulo B.; Mendes, Nuno; Ortega, Javier</i>	.....	45

**1.- PREVIOUS STUDIES**

**1.1.- Multidisciplinary studies (historical, archaeological, etc.).**

3	CHROMATIC ANALYSIS OF THE FINISH OF THE 17TH CENTURY WALL OF THE SANTO DOMINGO FORTRESS IN DOMINICAN REPUBLIC <i>Flores-Sasso, Virginia; Pérez, Gloria; Ruiz-Valero, Letzai; Martínez-Ramírez, Sagrario; Prieto-Vicioso, Esteban</i>	54
16	DEVELOPMENT OF THE CONSTRUCTION SYSTEM OF THE SOUTHERN GOTHIC CATHEDRAL PROFILE <i>Lluís-Teruel, Cinta; Lluís i Ginovart, Josep</i>	63
20	THE HOROLOGION OF ANDRONIKOS OF KYRROS IN ATHENS, GREECE: CULTURAL HERITAGE ISSUES AND HISTORICAL EVIDENCE <i>Panou, Evangelia; Alexopoulou, Athina Georgia</i>	72
33	RESTORATION AND ACCESS TO THE INCA CEREMONIAL SANCTUARY OF MAUCALLACTA AND ITS INSERTION IN THE TOURIST CIRCUIT OF SOUTHERN PERU <i>Cusihamán Sisa, Gregorio Nicolás; Alarcón Condori, Javier Guido</i>	83
34	THE CITY OF SUCEAVA - ASPECTS OF URBAN DEVELOPMENT <i>Cioban, Andreea G.; Agachi, Mihaela I. M.</i>	92
65	THE HISTORIC ARCHITECTURAL COMPLEX OF MANGUINHOS, RIO DE JANEIRO, RJ, BRAZIL <i>Oliveira, Benedito Tadeu de</i>	100
95	HISTORICAL ARCHIVE OF THE CITY OF LOJA, ECUADOR <i>Delgado Cruz, María José; Sanz González, Sofía</i>	109
148	MEXICAN TEMPLES OF MENDICANT CONVENTS: STRUCTURAL CONFIGURATION AND DAMAGES DUE TO EARTHQUAKES <i>García Gómez, Natalia; Peña Mondragón, Fernando; Chávez Cano, Marcos M.</i>	118
150	BLURRED FAÇADE AS THRESHOLD ARCHITECTURE <i>Yapicioglu, Balkiz; Cazacova, Liudmila</i>	126
194	OPTICAL AND COLOR ANALYSIS OF ROMAN WALL PAINTINGS FROM THE FORUM DISTRICT OF CARTHAGO NOVA <i>Martínez-Arredondo, Ana; Navarro-Moreno, David; Mestre-Martí, María; Lanzón, Marcos</i>	135
283	DOCUMENTARY RESEARCH AND CONSTRUCTIVE UNDESTANDING OF THE PICASSO AND NESJAR MURALS IN THE BUILDING OF THE ARCHITECTS' ASSOCIATION OF CATALONIA IN BARCELONA, SPAIN <i>Bosch González, Montserrat; González-Sánchez, Belén; Rosell Amigó, Joan Ramon</i>	143
290	THE FIRST APPROACH TO TRENCADIS OF GAUDI: METHODS OF GEOMETRIC ANALYSIS <i>Asadova, Zahra; Navarro, Isidro; Santana, Galdric</i>	150
294	SANTA COLOMA D'ANDORRA - THE CONCEPTION OF A CHURCH BEFORE THE 11TH CENTURY. <i>Pedragosa Batllori, Gemma</i>	160
297	ANALYSIS AND PROPOSAL FOR RECOVERY OF ARCHITECTURAL HERITAGE. THE CASE OF THE TEMPLAR COMMANDRY OF ABERIN IN NAVARRE <i>Roces Gonzalo, Clara; Torres Ramo, Joaquín</i>	170
318	ARCHAEOLOGY OF ARCHITECTURE APPLIED TO CONSERVATIVE ARCHITECTURAL RESTORATION: CASE STUDY OF STRATIGRAPHIC ANALYSIS OF VOLUMES AND COATINGS <i>Cascone, Santi Maria; Longhitano, Lucrezia; Longhitano, Giuseppe Antonio</i>	179
330	USE VALUE VS TECHNICAL REQUIREMENTS. METHODOLOGY FOR ASSESSING POTENTIAL USES IN HERITAGE BUILDINGS. THE CASE OF LUCENA (CORDOBA) <i>Mosquera-Pérez, Clara; Navarro-de-Pablos, Javier; Rodríguez-Lora, Juan-Andrés; Navas-Carrillo, Daniel</i>	188
348	ON ARCHITECTURE FROM THE SECOND HALF OF THE XX CENTURY IN POLAND <i>Zychowska, Maria J.; Bialkiewicz, Andrzej</i>	197
366	DETERIORATIONS AND RECOVERY PROJECTS IN THE FORTIFICATIONS OF THE CARIBBEAN COAST OF PANAMA, PORTOBELLO AND SAN LORENZO. <i>Durán, Félix; García, Elizabeth</i>	206
368	VERNACULAR ARCHITECTURE OF QUINGEO PARISH (AZUAY, ECUADOR). DEFINITION OF THE HISTORICAL-CONSTRUCTIVE CONTEXT FROM THE MURAL STRATIGRAPHIC ANALYSIS <i>López Suscal, Michelle; Aguirre Ullauri, María del Cisne</i>	215
372	CONSERVATION AS A DESIGN OPPORTUNITY. PROTECTION SYSTEMS IN THE ARCHAEOLOGICAL FIELD <i>Cadoni, Stefano</i>	226

391	SANTA MARÍA DEL CAMPO AND SANTA MARÍA DE RIOSECO: EVOLUTIVE CONCORDANCES OF TWO OUTSTANDING CASTILLIAN BELL-TOWERS <i>Sánchez Rivera, José Ignacio; Sáiz Virumbrales, Juan Luis</i>	238
-----	--	-----

### 1.2.- Heritage and territory.

25	TWO ICONS OF BILBAO'S INDUSTRIAL HERITAGE: ETXEBARRIA'S CHIMNEY AND ZORROZA'S CRANE <i>Díez Hernández, Jesús; Piñero, Ignacio; Ezquerro Andreu, Mikel; Briz, Estíbaliz</i>	246
74	METHODOLOGICAL PROPOSAL FOR THE ANALYSIS OF THE HERITAGE VULNERABILITY OF PRODUCTIVE RURAL GROUPS. THE CASE OF THE SAN PEDRO RIVER BASIN, LOS RÍOS REGION, CHILE <i>Vásquez Fierro, Virginia; Horn Morgenstern, Andrés</i>	257
103	JESUIT RANCHES HERITAGE OF NUEVA ANDALUCÍA AND TERRITORY ARTICULATION. A CASE FOR MANAGEMENT, PRESERVATION AND REACTIVATION <i>Saborido Forster, Gustavo Adolfo; Mosquera Adell, Eduardo; Ponce Ortiz de Insagurbe, María Mercedes</i>	267
111	THE SAN TELMO BRIDGE IN SEVILLE. A PIONEERING WORK IN REINFORCED CONCRETE AT THE BEGINNING OF THE 20TH CENTURY <i>González García de Velasco, Concepción; Agudo Martínez, Andrés; González Vilchez, Miguel</i>	277
121	FROM THE CATALAN MASIA TO THE MASSERIA OF SOUTHERN ITALY: PATHS FOR THE RECOVERY AND REUSE OF RURAL ASSETS IN BASILICATA <i>Guida, Antonella; Porcari, Vito Domenico; Andrulli, Giovanna</i>	285
126	CHARACTERIZATION OF NATIVE SHUAR ARCHITECTURE: ARCHITECTURAL TYPES, REPRESENTATIVE ELEMENTS AND CONSTRUCTION SYSTEMS <i>Soto Toledo, Katherine Haydee; Rodríguez Torres, María José</i>	294
127	19TH CENTURY MERSIN COMMERCIAL BUILDINGS, PRESENT CONDITIONS, AND PROBLEMS OF CONSERVATION <i>Darendeli, Tuğçe; Umar, Nur</i>	303
135	DEVELOPMENT LINE OF THE RESIDENTIAL ARCHITECTURE OF THE ISLAND OF SAN CRISTÓBAL-GALÁPAGOS: THE CHALLENGE OF OFFERING VERNACULAR ECOLOGICAL SOLUTIONS <i>Matapuncho-Davila, Elvira; Granda-Viñan, Paola; Aguirre-Maldonado, Eduardo</i>	311
144	CANTONA: THE URBAN ARCHEOLOGICAL HERITAGE, AS AN ANALYTICAL PATH TO RECONCEPTUALIZE THE SOCIAL PRODUCTION OF THE HABITAT <i>Álvarez, María del Pilar; Nava, José María Wildford</i>	319
217	EVALUATION OF PROPOSAL FOR THE CONNECTION OF ARCHITECTURAL HERITAGE AREAS. CASE STUDY: MANIZALES, COLOMBIA <i>Escobar, Diego A.; Giraldo, Sofía; Moncada, Carlos A.</i>	329
275	FENCE WALLS IN THE BAIXO TÂMEGA VALLEY <i>Pinto, Jorge; Reis, Cristina; Bento, Ricardo; Bentes, Isabel; Pereira, Sandra</i>	339
284	EUROPEAN SMART VILLAGES: STATE OF THE ART AND POSSIBLE DEVELOPMENT SCENARIOS <i>D'Andria, Emanuela; Fiore, Pierfrancesco; Falce, Carmelo</i>	348
292	TRANSFERENCE FROM INDUSTRIAL ARCHITECTURE TO RESIDENTIAL BUILDINGS: REYES CATÓLICOS STREET DURING THE EXPANSION OF THE SUGAR INDUSTRY IN GRANADA AS A CASE STUDY. <i>Martínez-Ramos e Iruela, Roser; Cervera Fuentes, María Teresa; Adelaida Martín Martín; García Nofuentes, Juan Francisco</i>	357
316	EARLY REPUBLIC PERIOD MALATYA STATION BUILDINGS <i>Sarı, Fatma Zehra; Umar, Nur</i>	367
394	THE RECONSTRUCTION OF ZIKUÑAGA CHAPEL OF HERNANI: BUILT HERITAGE LOST AND FOUND <i>Uranga, Eneko J.; Arraztio, Xabier; Uranga, Juan José</i>	376

### 1.3.- Urban regeneration.

11	MORE THAN A GREEN FAÇADE: THE GREEN POTENTIAL FOR HISTORIC CENTRES <i>Vallejo Espinosa, Andrea; Davis, Michael Maks; Ramírez, Francisco</i>	385
45	BUILDING AND URBAN CHARACTERISTICS FOR THE DEVELOPMENT OF INTERVENTION STRATEGIES IN THE PONTE GÊA NEIGHBORHOOD OF BEIRA <i>Santos, Michael M.; Ferreira, Ana Vaz; Lanzinha, João C. G.</i>	395
58	THOUGHTS ON PUBLIC SPACE. PROPOSALS FOR THE NEW SQUARE OF THE CHURCH OF SAINT ANTHONY OF PADUA IN THE VILLAGE OF NOVENTANA, ITALY <i>Pietrogrande, Enrico; Dalla Caneva, Alessandro</i>	405
73	THE CHALLENGE OF DECENTRALISATION AND CONTEXTUAL VALUATION IN THE FRAMEWORK OF THE APPLICATION OF TERRITORIAL PLANNING INSTRUMENTS. THE CASE OF THE URBAN WETLANDS OF VALDIVIA AND TEMUCO, CHILE <i>Horn, Andrés; Vásquez, Virginia</i>	415

77	SOCIO-TERRITORIAL CONTEXTUALIZATION OF HERITAGE ON INTRA-URBAN SCALE. THE CURRENT HORIZON OF THE MOST RELEVANT OFFICIAL SOURCES <i>Usobiaga, Elena; De Cos, Olga</i>	426
106	GLOBAL ARCHITECTURE: REHABILITATION AND REGENERATION <i>Vitrano, Rosa Maria</i>	434
299	MANAGEMENT MODELS FOR ENERGY REGENERATION IN URBAN AND RURAL AREAS OF NAVARRA <i>Izcue, Isabel; García Madruga, Carolina</i>	443
369	THE HOUSING HARDSHIP IN ROME. PUBLIC RESIDENTIAL BUILDING VS SOCIAL HOUSING? <i>Crupi, Francesco</i>	454
370	AUGMENTED ARCHITECTURE AND MULTIFUNCTIONAL BUILDING EXOSKELETONS, A LOOK AT THE FUTURE OF EXISTING BUILDINGS IN URBAN AREAS <i>De Vita, Mariangela; Fabbrocino, Giovanni; Mannella, Antonio; Panunzi, Stefano</i>	466
373	URBAN REGENERATION OF VILLAGES AS AN OPPORTUNITY. TOOLS AND METHODS IN THE CASE STUDY OF MOGORO IN SARDINIA <i>Atzeni, Carlo; Cadoni, Stefano; Marras, Francesco</i>	474

### 1.5.- Social participation processes and socio-cultural aspects in rehabilitation projects.

13	RECOGNITION AND IMPROVEMENT OF LOCAL TECHNIQUES, CONTRIBUTION TO THE RE-ROOTING AND EMPOWERMENT OF COLOMBIAN COMMUNITIES IN POST-CONFLICT <i>Chica Segovia, Angélica; Ramos Zapata, María Camila; Fuya Chontal, Néstor; Mosquera Posso, John Keddy</i>	485
169	THE SOCIAL PARTICIPATION IN THE CASE OF MANGUINHOS HISTORIC ARCHITECTURAL NUCLEUS (NAHM) <i>Almeida, Roberta dos Santos; Pinheiro, Marcos José de Araújo</i>	497
327	CITIZEN PARTICIPATION FOR HERITAGE INTERVENTION. AN EXPERIENCE IN LUCENA (CORDOBA) <i>Navas-Carrillo, Daniel; Mosquera-Adell, Eduardo; Pérez-Cano, Teresa</i>	505

### 1.6.- Construction pathology.

5	COLLAPSES IN GLUED LAMINATED TIMBER STRUCTURES OF COVERED POOLS, DUE TO MISTAKES IN ASSIGNMENT OF USE CLASSES <i>Lozano, Alfonso; Lorenzo, David; Martínez, J. Enrique; Alonso, Mar; Álvarez, Felipe</i>	514
8	PERFORMANCE OF POZZOLANIC ADDITIONS TO CONTROL ALKALI-SILICA REACTION (ASR) PROMOTED BY AGGREGATES WITH DIFFERENT REACTION RATES <i>Menéndez, Esperanza; Sanjuán, Miguel Ángel; García-Roves, Ricardo; Argiz, Cristina; Recino, Hairon</i>	522
9	PATHOLOGICAL MANIFESTATIONS IN SANDWICH VERTICAL PANELS: CASE STUDY <i>Lordsleem Jr., Alberto Casado; Lira, Virginia Queiroz</i>	531
23	ANALYSIS OF RECURRENCE OF PATHOLOGICAL LESIONS IN LOW-RISE RESIDENTIAL BUILDINGS IN THE CITY OF MEDELLÍN <i>Cañola, Hernán-Darío; Urrego, Andrés; Granda-Ramírez Fidel; Venegas, Karen ; Arroyave, Joan</i>	539
30	PARAMETERISATION OF THE DEGRADATION PROCESSES IN COATED FAÇADES WITH ONE COAT MORTAR RENDERS <i>Carretero-Ayuso, Manuel J.; Pinheiro-Alves, M<sup>a</sup> Teresa; Sáez-Pérez, M<sup>a</sup> Paz</i>	548
53	THE USE OF MACROPOROUS MORTAR IN THE REHABILITATION OF HANDMADE BRICK WALLS WITH RISING DAMP <i>Camino-Olea, M<sup>a</sup> Soledad; Llorente-Álvarez, Alfredo; Cabeza-Prieto, Alejandro; Martín-Aldudo, Ernesto; M<sup>a</sup> Paz Sáez-Pérez; Rodríguez-Esteban, M<sup>a</sup> Ascensión</i>	556
59	INFRARED THERMOGRAPHY AS A TOOL FOR INSPECTION OF BUILDING DEFECTS IN COATINGS - A SYSTEMATIC REVIEW <i>Lima, Wanessa; Cavalcanti, Lucas, Arruda, Vaness, Figueira, Amanda, Bentzen, Mariana, Póvoas, Yêda, Lordsleem Jr., Alberto</i>	564
62	CONSTRUCTIVE STUDY OF THE SHIPWRECKED HOUSE IN THE PORT OF BILBAO <i>Marcos, Ignacio; Díez, Jesús; Piñero, Ignacio; Egiluz, Ziortza</i>	577
84	MONTEVIDEO MUNICIPAL OSSUARY. INTEGRAL STUDY AND MANAGEMENT PLAN <i>Fontana, Juan José; Gambini, Jorge; Méndez, Mary; Tomeo, Fernando; Romay, Carola</i>	587
107	ASSESSING AESTHETIC AND STRUCTURAL DETERIORATION IN HISTORIC BUILDINGS - A CONTRIBUTION <i>Dias, L.; Rosado, T.; Bhattacharya, S.; Candeias, A.; Caldeira, A.T.; Mirão, J.</i>	596
128	ANALYSIS OF DOCUMENTAL AND EXECUTIVE PROCESSES OF CONSERVATION OF BUILDINGS TAKEN AS HISTORICAL HERITAGE <i>Andrade, Ana Paula Cintra</i>	606

132	STUDY OF THE HERITAGE BUILDING COMPLEX OF THE NATIONAL MUSEUM OF COSTA RICA FROM A HISTORICAL, ARCHITECTURAL AND PATHOLOGICAL PERSPECTIVE <i>Porras-Alfaro, David; García-Baltodano, Kenia; Méndez-Álvarez, Dawa</i>	615
162	FACADE DAMAGE MAPS: A LITERATURE REVIEW <i>Lopes, Melissa L. F.; Silva, Maykon V.; Bauer, Elton</i>	624
174	RADON EXHALATION FROM THE STRUCTURE OF HISTORIC BUILDINGS. A PROBLEM DETECTED AT THE TOWER OF HERCULES, CORUÑA <i>Frutos, Borja; Alonso, Carmen; Martín-Consuegra, Fernando; Sicilia, Isabel; de Frutos, Fernando; Perez, Gloria</i>	634
183	CLASSIFICATION OF BUILDING FACADES BY MEANS OF THE LEVEL OF PROTECTION CRITERIA <i>Souza, Ana Luíza Rocha de; Andrade, Daiane Teodoro de; Bauer, Elton; Souza, Jéssica Siqueira de</i>	643
196	PATHOLOGIES IN THE ORNAMENTATION OF FAÇADES IN THE ARCHITECTURE OF HISTORICIST ECLECTICISM - THE CASE OF MANIZALES (COLOMBIA) <i>Sarmiento, Juan Manuel; Bedoya, Lina Clemencia; Betancur, Angélica; Ramírez, Esteban</i>	655
203	THERMAL ANALYSIS OF SODIUM SULFATE CRYSTALLIZATION WITHIN POROUS BUILDING MATERIALS <i>Bednarska, Dalia; Koniorczyk, Marcin</i>	665
207	REALITY-BASED MODEL AND 3D INFORMATION SYSTEMS: A GIS 3D TO MAPPING THE CRACK PANEL OF THE CHURCH OF SANTA MARIA DEGLI ANGELI IN PIZZOFALCONE IN NAPLES <i>Acquaviva, Sabrina; Pulcrano, Margherita; Scandurra, Simona; Palomba, Daniela; di Luggo, Antonella</i>	673
216	BUILDINGS INVESTIGATION OF DEGRADATION VARIABILITY IN BRASÍLIA-BRAZIL CITY <i>Rodrigues Neto, Eduardo; Bauer, Elton</i>	682
226	THE WOOD MOISTURE FACTOR ON THE BIOLOGICAL DETERIORATION OF WOODEN STRUCTURES <i>Lima, Daniel F.; Tenório, Marina; Branco, Jorge M.; Nunes, Lina</i>	690
241	DEEP DETECTING FOR DETECTING CRACKS IN PAINTED BUILDING FAÇADES <i>Pereira, Sandra; Pires, João; Silva, João; Ferreira, Tomás; Neto, Alexandre; Cunha, António</i>	698
265	IDENTIFICATION OF HERITAGE STONE BUILDING DEGRADATION PATTERNS BASED ON DIGITAL PHOTOGRAMMETRY DATA <i>Jalón, María L.; Chiachío, Juan; Gil-Martín, Luisa María; Hernández-Montes, Enrique</i>	708
266	CASE OF STUDY: DIAGNOSIS OF 100 YEARS OLD ABANDONED MILL <i>Cetrangolo, Gonzalo; Romay, Carola; Mussio, Gianella; Spalvier, Agustin</i>	715
274	RECURRING DAMAGES IN THE EXECUTION OF CONCRETE SLABS ON LARGE SURFACES <i>Martínez Martínez, José Antonio; Manso Villalaín, Juan Manuel; García Castillo, Luis María; Aragón Torre, Ángel</i>	725
324	PATOLOGY AND NUMERICAL MODEL OF THE TEMPLE OF SAN FRANCISCO TZINTZUNTZAN <i>Márquez, Alberto; Olmos, Bertha; Jara, José Manuel; Martínez, Guillermo</i>	734
349	CONSOLIDATION OF A POROUS SANDSTONE USED IN ANCIENT CONSTRUCTIONS <i>Lamas, Pedro; Pinho, Fernando</i>	744

**1.7.- Diagnostic techniques and structural assessment (no destructive testing, monitoring and numerical modeling).**

18	CHARACTERIZATION OF PIGMENTS USED AS PROTECTION AND DECORATION ON EXTERIOR FACADES OF HISTORIC BUILDINGS <i>Martínez-Ramírez, Sagrario; Flores Sasso, Virginia; Ruiz-Valero, Letzai; Pérez, Gloria; Guerrero, Ana; Prieto Vicioso, Esteban; Vučetić, Snežana</i>	752
26	VALIDATION OF ULTRASONIC PULSE TO QUALITY CONTROL OF RECYCLED AGGREGATE SELF-COMPACTING CONCRETE <i>Revilla-Cuesta, Víctor; Santamaría, Amaia; Espinosa, Ana B.; Chica, José A.; Manso, Juan M.; Ortega-López, Vanesa</i>	761
44	NUMERICAL APPROCHES FOR SOIL-STRUCTURE INTERACTION IN A HISTORICAL INDUSTRIAL MASONRY BUILDING <i>Longarini, Nicola; Crespi, Pietro; Zucca, Marco; Scamardo, Manuela</i>	770
46	ENGINEERING SKILLS AIDED BY THERMOGRAPHY AND BIM <i>Ribeiro Antunes, Maria Luisa; Cabaleiro Cortizo, Eduardo; Magalhães Lenz, César Júnior, Kleos</i>	779
60	SEISMIC VULNERABILITY AND RETROFITTING OF A HISTORICAL MASONRY BUILDING <i>Scamardo, Manuela; Crespi, Pietro; Longarini, Nicola; Zucca, Marco</i>	787



64	THE FOURTH ARCH OF THE AUGUSTUS BRIDGE AT NARNI (ITALY): A CASE STUDY OF ROMAN ARCH WITH RIBS <i>Custodi, Alberto; Scaia, Flora</i>	795
78	ANALYSIS OF VARIABILITY AND RELIABILITY OF STRESS WAVE MEASUREMENTS ON STRUCTURAL TIMBER ELEMENTS IN SITU <i>Osuna-Sequera, Carlos; Luengo, Emilio; Cabrero, Juan Carlos; Hermoso, Eva</i>	803
90	A NEW METHODOLOGY BASED ON NON-DESTRUCTIVE TECHNIQUES FOR OLD STRUCTURAL TIMBER <i>Peñalver Oltra, Manuel; Abián Pérez, Miguel Ángel; Segura Orenga, Guillem; Martínez Ruiz, Guillermo Vicente; Redón Santafé, Miguel</i>	813
129	STRUCTURAL ASSESSMENT UNDER LATERAL ACCELERATIONS OF A CONCRETE VAULTED MAYA BUILDING OF BONAMPAK, CHIAPAS, MEXICO <i>Hamad, Omar; Sennyondo, Justin; Kimanya, Humfrey; Nguyen, Dung; Tezcan, Selman; Perucchio, Renato</i>	822
158	FUNICULAR ANALYSIS OF MASONRY VAULTS UNDER GENERAL LOADING CONDITIONS THROUGH A CONSTRAINED FORCE DENSITY METHOD <i>Bruggi, Matteo; Taliercio, Alberto</i>	830
159	EL HÓRREO, ARCHITECTURAL HERITAGE ELEMENT OF THE PRINCIPALITY OF ASTURIAS. METHODOLOGY FOR THE INSPECTION AND DIAGNOSYS FOR ITS CONSERVATION <i>Vega, Abel; Rodríguez, Soledad</i>	838
173	SHAKING TABLE TEST DESIGN OF A TYPICAL CHURCH OF MORELOS STATE <i>Chávez, Marcos M.; Durán, Daniel</i>	845
179	DISPLACEMENT ANALYSIS OF WOODEN TRUSSES THROUGH DIGITAL SURVEY AND VISUAL PROGRAMMING TOOLS. THE BASILICA OF SAN PETRONIO IN BOLOGNA <i>Massafra, Angelo; Prati, Davide; Predari, Giorgia</i>	854
205	CONDITION ASSESSMENT OF SIDE CORRIDORS WITH THE USE OF AGGREGATIONS BASED ON FUZZY INFERENCE METHOD <i>Bukovics, Ádám; Lilik, Ferenc; Kóczy, László T.; Liszi, Máté</i>	864
237	THE ROLE OF THE EARTHQUAKE VERTICAL COMPONENT ON THE SEISMIC BEHAVIOUR OF MASONRY WALLS <i>Camata, Guido; Di Primio, Alice; Sepe, Vincenzo</i>	873
243	EXPERIMENTAL STUDY ON CALIBRATION FACTOR OF FLAT - JACKS <i>Blanco, Haydee; Boffill, Yosbel; Lombillo, Ignacio; Renedo, Carlos; Sosa, Israel; Carrasco, Cesar</i>	882
256	INSPECTION AND STRUCTURAL EVALUATION OF A MASONRY ARCH FOOTBRIDGE, BAIRRO DOS ANJOS BRIDGE - LEIRIA <i>Christo, Guilherme; Veludo, João; Gaspar, Florindo</i>	892
258	INVESTIGATION OF MASONRY DEFORMABILITY THROUGH FLAT-JACK TESTING: A NUMERICAL STUDY <i>Alecci, Valerio; De Stefano, Mario; Marra, Antonino Maria; Stipo, Gianfranco</i>	900
264	AMBIENT VIBRATION TESTING, DYNAMIC IDENTIFICATION, AND MODEL UPDATING OF A CULTURAL HERITAGE BUILDING. THE CHURCH OF THE ROYAL MONASTERY OF SAN JERÓNIMO (GRANADA, SPAIN). <i>Rodríguez, Rubén; Pachón, Pablo; Sáez, Andrés; Aguilar, Jaime; Compán, Víctor</i>	909
268	METHODOLOGY TO MONITORING THE STATE OF CONSERVATION OF BUILDINGS' ROOFS USING MULTISPECTRAL IMAGES: CASE STUDY OF LEIRIA DOWNTOWN HISTORICAL CENTRE <i>Gonçalves, Luisa M.S.; Gaspar, Florindo; Veludo, João</i>	919
281	DIAGNOSIS OF MONUMENTAL STRUCTURES CONSIDERING HISTORY RELATED-PHENOMENA: A SYSTEMATIC OPERATING METHOD APPLIED TO THE BAPTISTERY OF PISA <i>Bartolini, Giada; De Falco, Anna; Giuliani, Francesca</i>	928
282	GEOMETRIC APPROACH AND STRUCTURAL ANALYSIS OF THE TERCELETE VAULTS OF THE CAPTAIN MONTE BERNARDO CHAPEL OF THE SANTA DE SEVILLA CHURCH BY USING PHOTOGRAMETRY TECHNIQUES AND THE FINITE ELEMENTS METHOD <i>Valseca, J.A.; Tarín, María; Rodríguez, Rubén; Compán Cardiel, Víctor Jesús; Cámara, Margarita</i>	937
302	SEISMIC VULNERABILITY ASSESSMENT AND RETROFIT MEASURES FOR MEDIEVAL STONE MASONRY MINARETS IN EGYPT <i>Hamdy, Gehan</i>	950
303	MANAGING DIAGNOSTIC DATA FOR SEISMIC VULNERABILITY ASSESSMENT OF BUILDING STOCKS BY AN INTEGRATE GIS/VR APPROACH <i>De Fino, Mariella; Lasorella, Margherita; Fatiguso, Fabio</i>	960
321	FROM SURVEY TO ANALYSIS OF THE DAMAGE MECHANISMS IN STONE WALLS: DIAGNOSTIC INVESTIGATIONS ON A BASTION OF THE VENETIAN FORTRESS IN BERGAMO <i>Nannei, Virna Maria; Azzola, Pietro; Mirabella Roberti, Giulio</i>	971

325	STRUCTURAL ANALYSIS BY IN-SITU EXPERIMENTAL CAMPAIGN AT THE “TORRE DE LA VELA” OF THE ALHAMBRA DE GRANADA (SPAIN) <i>Suárez, Fco. Javier; Ortega, Javier; Vuoto, Annalaura; Lourenço, Paulo B.</i>	981
326	HOMOGENIZED NONLINEAR PROPERTIES OF URM STRUCTURES <i>Valadao, Ryan Manuel; Pantazopoulou, S.J.</i>	993
355	NON-DESTRUCTIVE TECHNIQUES USED IN THE DIAGNOSIS OF THE MANSARD ROOF STRUCTURE OF THE URIARTE DE HEBER PALACE <i>Torán, Susana</i>	1001
359	EVALUATION OF HISTORICAL STONE STRUCTURES UNDER EXTREME ACTIONS USING RIGID SOLID DYNAMICS METHODS. CASE STUDY: THE ALCÁNTARA BRIDGE, SPAIN <i>Suárez, Diana; Goicolea, José María; Tarque, Nicola</i>	1009
380	APPLICABILITY OF THE GROUND PENETRATING RADAR TO DETECT BUILDING SETTLEMENTS: THE SINGULAR CASE OF AN INDIANA HOUSE <i>Solla, Mercedes; López-Leira, José Manuel; Fernández, Norberto; Rodríguez, Juan Luis</i>	1020
385	ANALYSIS OF THE SHEAR STRENGTH OF MASONRY WALLS ACCORDING TO THE DISTRIBUTION OF THE BRICK AND MORTAR <i>Reynau, Ricardo; Ivorra, Salvador; Bru, David; Estevan, Luis</i>	1028
387	FROM PRELIMINARY STUDIES TO RESTAURO OF CASA BATLLÓ BY ANTONI GAUDÍ <i>Olona, Joan; Bosch, Mireia; Villanueva, Xavier; Villanueva, Ignasi</i>	1036
390	VULNERABILITY ANALYSIS OF HISTORIC MASONRY TANK-TOWER USING THE PHOTOGRAMMETRIC SURVEY: A CASE STUDY <i>Hyseni, Alba; Cascardi, Alessio; Micelli, Francesco; Aiello, Maria Antonietta</i>	1047
399	PETROGRAPHIC STUDY OF THE MURAL PAINTING COATINGS OF THE SAN JORGE CHURCH (LEDANTES, CANTABRIA) <i>Sánchez Carro, Miguel A.; Quevedo González, Lydia</i>	1055
400	NDT MORPHOLOGICAL AND SPECTROSCOPIC ASSESMENT OF NANO CONSOLIDATION OF THE LIMESTONE, THEBAN TOMB 109 OF WEST BANK, LUXOR, EGYPT <i>Ahmed Sallam; Sayed Hemeda ; Haitham Eid; Moustapha Hassan; Mona Khalil</i>	1063

### 1.8.- Vulnerability studies and risk management.

14	CONSISTENCY ANALYSIS IN THE APPLICATION OF THE ANALYTIC HIERARCHY PROCESS METHOD, TO DETERMINE VULNERABILITY CRITERIA OF SOCIAL HOUSING IN VALDIVIA - CHILE, AGAINST SEISMIC EVENTS <i>Alvial, Jorge; Vidal, Luis; Chicuy, Yessenia</i>	1070
42	A CRITICAL ROUTE FOR DOCUMENTING THE SEISMIC VULNERABILITY ON MEXICAN HISTORICAL CITIES ON GIS DATABASES <i>Ramírez Eudave, Rafael; Ferreira, Tiago Miguel; Romeu, Vicente</i>	1078
66	ON THE VULNERABILITY OF ANCIENT TOWN WALLS TO SLOW ONSET EVENTS: FORMULATION OF A SYNTHETIC INDEX <i>De Falco, Anna; Giuliani, Francesca; Gaglio, Francesca; Ladiana, Daniela; Di Sivo, Michele</i>	1088
79	A MULTILEVEL APPROACH FOR THE SEISMIC VULNERABILITY ASSESSMENT OF MASONRY CHURCHES IN CUSCO (PERU) <i>Cocco, Giulia; Di Pietro, Erika; Fusella Stefano; Mazzanti, Claudio; Alfaro, Crayla; Brando, Giuseppe</i>	1097
82	EMERGENCY INTERVENTIONS AND COST ASSESSMENT FOR SEISMIC DAMAGES ON CULTURAL HERITAGE <i>Ferrari, Lia</i>	1106
98	HOW ARE HEAT WAVES PUTTING AT RISK HISTORIC URBAN AREAS? FIRST STEPS FOR DEVELOPING RISK ASSESSMENT METHODOLOGIES <i>Quesada-Ganuza, Laura; Garmendia, Leire; Rojí , Eduardo; Álvarez, Irantzu; Briz, Estibaliz; Gandini, Alessandra</i>	1114
130	SEISMIC PERFORMANCE OF TYPICAL HYBRID BUILDINGS IN THE URBAN CENTRE OF BARCELONA <i>Dimovska, Sara; Saloustrós, Savvas; Pelà, Luca; Roca, Pere</i>	1122
134	THE “ALQUERÍA DE FALCÓ” (VALENCIA): SEISMIC VULNERABILITY ASSESSMENT AND INTERVENTION STRATEGIES <i>Basset-Salom, Luisa; Guardiola-Villora, Arianna</i>	1130
213	RISK MANAGEMENT IN THE CONTEXT OF INTERVENTION WORKS IN HISTORIC BUILDINGS <i>Coelho, Carla; Sá, Bruno; Carcereri, Maria Luiza; Zouain, Rosana</i>	1140
245	CULTURAL HERITAGE BUILDINGS AND RELEVANT USES: SEISMIC RISK ASSESSMENT IN FLORENCE <i>Cardinali, Vieri; Cristofaro, Maria Teresa; De Stefano, Mario; Tanganelli, Marco</i>	1148

278	PASSIVE ENERGY DEVICES FOR RETROFITTING FIRST SOFT-STORY BUILDINGS IN MEXICO <i>García, Carlos; Jara, José; Olmos, Bertha; Martínez, Guillermo</i>	1156
289	TOWARDS AN EXPEDITIOUS METHOD TO ASSESS THE VULNERABILITY OF HISTORICAL MASONRY CHURCHES: PRELIMINARY ANALYSES BASED ON EMILIA (ITALY) 2012 EARTHQUAKES DAMAGE <i>Rosso, Federica; Bernabei, Letizia; Vaiano, Generoso; Quagliarini, Enrico; Mochi, Giovanni</i>	1165
315	RISK COMMUNICATION AND AWARENESS OF THE BUILT ENVIRONMENT THREATENED BY DISASTERS WITH DIGITAL MODELS <i>Fatiguso, Fabio; Bruno, Silvana; Cantatore, Elena; Currà, Edoardo; D'Amico, Alessandro; Russo, Martina; Angelosanti, Marco; Quagliarini, Enrico; Bernardini, Gabriele; Mochi, Giovanni; Salvalai, Graziano</i>	1175
332	OUT-OF-PLANE FAILURE RESISTANCE OF ADOBE FACADES IN CUENCA - ECUADOR FOR DIFFERENT SEISMIC ACCELERATIONS <i>Cárdenas-Haro, Xavier; Tarque, Nicola; Todisco, Leonardo; León, Javier; Pino, Julver</i>	1184
336	EFFECTS OF THE 1755 LISBON EARTHQUAKE ON RIVERS AND CORRESPONDING COMPARATIVE PROPOSAL ON INTENSITY SCALE <i>Tavares, Alice; Costa, Aníbal; S. Oliveira, Carlos</i>	1193

### 1.9.- . Guides and regulations.

48	REGULATION AND STANDARDIZATION ON THE QUALITY OF THE INDOOR ENVIRONMENT APPLICABLE TO KINDERGARTENS AND ELDERLY CARE CENTERS: PORTUGAL - BRAZIL <i>Pinto, Manuel; Lanzinha, João; Silva, Fernando</i>	1202
184	PRESERVO - COMPLEX OF FIOCRUZ COLLECTIONS: PATH OF A CULTURAL HERITAGE PRESERVATION STRATEGY <i>Pinheiro, Marcos José de Araújo; Coelho, Carla</i>	1211
261	DOES THE FINAL FLOOR HEIGHT OF AN EXISTING DOMESTIC BUILDING INFLUENCE THE FATALITY RISK WITH REGARDS A FIRE. A STUDY OF THE LONDON BOROUGH OF LAMBETH <i>Kirk, Mark; Pesce, Giovanni</i>	1222
393	IN-PLANE STRENGTH OF MASONRY PANELS REINFORCED WITH INORGANIC-BASED SYSTEMS: NOVEL DESIGN-ORIENTED FORMULAS <i>Longo, Fabio; Cascardi, Alessio; Aiello, Maria Antonietta</i>	1230

**2.- PROJECT**

**2.1.- Theoretical criteria of the intervention project.**

124	INDICATORS FOR THE PRIORITISATION OF INTERVENTIONS IN HISTORIC ARCHITECTURAL HERITAGE: AN APPROACH USING THE HYBRID DELPHI-AHP METHOD <i>Parra, Jaime; Lombillo, Ignacio; Ribalaygua, Cecilia</i>	1241
165	CARLO SCARPA AT THE QUERINI STAMPALIA PALACE: A STUDY OF THE RELATIONSHIP BETWEEN OLD AND NEW <i>Bosch-Roig, Luis; Marcenac, Valeria; Bosch Reig, I; Ballester-Bordes, M.J.</i>	1254
320	THE EFFECTS OF THE EARTHQUAKE OF SEPTEMBER 19TH, 2017 ON THE RELIGIOUS HERITAGE IN MORELOS AND PUEBLA: DAMAGES AND INTERVENTIONS <i>Tepox, Nayde</i>	1262
375	TRADITIONAL ANDALUSIAN ARCHITECTURE. ACTIVE PRESERVATION OF THE PATIO HOUSE: TYPE, TECHNIQUE AND PROJECT <i>Bellicoso, Alessandra; Berti, Krizia; Albarreal Nuñez, María Jesús; Tosone, Alessandra</i>	1270
398	RESTORATION AS AN ARCHITECTURAL DISCIPLINE AND ENGINE OF A NEW ELEMENT OF LIFE. THE TOWER OF ST. MARÍA MAGDALENA'S CHURCH <i>Rodríguez Cantalapiedra, Pedro</i>	1283

**2.2.- Traditional materials and construction methods.**

29	BUILDING CONSTRUCTION AVANT-GARDE IN ITALIAN IMPERIALISM: AN ARCHITECTURE AND TECHNICAL LABORATORY <i>Pagliuca, Antonello; Trausi, Pier Pasquale; Gallo, Donato</i>	1291
43	DECIMONONIC WOODEN BRIDGES IN THE CENTRAL REGION OF COLOMBIAN ANDES <i>Galindo-Díaz, Jorge; Escobar-García, Diego; Flórez, Gilberto</i>	1299
94	EXPERIMENTAL STUDY OF THERMAL AND ACOUSTIC PERFORMANCE OF RAMMED EARTH PANELS LIGHTENED WITH ANGUSTIFOLIA KUNTH BAMBOO TUBES <i>Aguirre-Maldonado, Eduardo; Guzmán Rojas, Jonathan; Balcázar-Arciniega, Cristian</i>	1307
105	USE OF CHALCEDONITE POWDER AS A SUPPLEMENTARY MATERIAL IN LIME MORTARS <i>Vyšvařil, Martin; Krebs, Martin; Bayer, Patrik</i>	1314
112	USE OF FINE-GROUND LAVA SAND AS A POZZOLANIC ADDITIVE IN AERIAL LIME-BASED MORTARS <i>Žižlavský, Tomáš; Vyšvařil, Martin</i>	1321
123	CONSTRUCTIVE TYPOLOGIES ON PREHISPANIC STONE WALLS IN THE REGION OF PUNO, PERU <i>Tarque, Nicola; Lipa Cusi, Leonel</i>	1327
167	ADVANCED TECHNOLOGIES FOR NATURAL STONE   INOVSTONE 4.0 - IMPORTANT RESULTS FROM A RESEARCH PROJECT ON NATURAL STONE CONSTRUCTION MATERIALS SELECTION AND PERFORMANCE ANALYSIS <i>Pires, Vera; Mirão, José; Sitzia, Fabio; Lisci, Carla; Duarte, José; Dias, Luis; Alves, Tiago; Lopes, Luís; Martins, Ruben</i>	1337
185	HISTORICAL HOSPITALS IN NAPLES: ENHANCING CONSTRUCTION TECHNIQUES AS A STRATEGY FOR POTENTIAL URBAN REGENERATION INTERVENTIONS <i>Sicignano, Claudia; Diana, Lorenzo; Marmo, Rossella; Polverino, Francesco</i>	1351
193	STRUCTURAL ANALYSIS FOR CONSTRUCTIVE HYPOTHESIS OF THE ANNULAR VAULT OF CARLOS V PALACE IN GRANADA (SPAIN) <i>Puertas, Esther; Gallego, Rafael</i>	1360
224	THE "ORO NERO" IN THE ARCHITECTURE OF THE THIRTIES IN SOUTHEASTERN SICILY. MEANINGS AND IMITATIONS OF A LOCAL MATERIAL <i>Cavallo, Alessandro</i>	1368
287	CONTRIBUTIONS TO THE IDENTIFICATION OF THE SYSTEMS USED TO CREATE ISLAMIC PLASTERWORK BASED ON THE STUDY OF DECORATIVE ELEMENTS AT THE ROYAL ALCAZAR OF SEVILLE <i>Alejandro, Francisco J.; Torres-González, Marta; Blasco-López, Francisco J.; Flores-Alés, Vicente</i>	1376
337	REHABILITATION OF EARTHEN ARCHITECTURE, FROM COURTYARD HOUSES TO BRAZILIAN HOUSES IN THE CENTER OF PORTUGAL <i>Tavares, Alice; Costa, Aníbal</i>	1384
353	METHODOLOGY OF EVALUATION OF TECHNOLOGIES. PROPOSAL APPLIED TO BUILDING INTERVENTIONS <i>Bozzo, Laura</i>	1393



362	PORTUGUESE VERNACULAR CONSTRUCTION AND ITS SUSTAINABLE REHABILITATION CHALLENGES: THE SCHIST VILLAGES, LOUSÃ <i>Mouraz, Catarina P.; Silva, J. Mendes; Ferreira, Tiago Miguel</i>	1402
363	INFLUENCE OF REGIONAL GEOLOGICAL CHARACTERISTICS ON PORTUGUESE VERNACULAR CONSTRUCTION: CASE STUDIES <i>Silva, J. Mendes; Mouraz, Catarina; Ferreira, Tiago Miguel; Catarino, Lúcia; Almeida, Vanessa</i>	1411
371	EARTH BUILDINGS IN CRETE: BUILDING CONSTRUCTION KNOWLEDGE THROUGH THE DOCUMENTATION AND PRESERVATION OF EARTHEN ARCHITECTURAL HERITAGE <i>Kada, Dimitra; Mandalaki, Maria</i>	1419

### 2.3.- Novelty products applicable and new technologies.

41	SERVICE LIFE AND EARLY AGE DURABILITY ENHANCEMENT DUE TO COMBINED METAKAOLIN AND NANOSILICA IN MORTARS FOR MARINE APPLICATIONS <i>García, Ramiro; Reyes, Encarnación; Villanueva, Paula; De La Rubia, Miguel Angel; Fernández, Jaime; Moragues, Amparo</i>	1427
70	SIDERURGICAL MORTARS IN SPAIN: REHABILITATION OPPORTUNITIES AND AN OVERVIEW OF PROGRESS <i>Santamaría, Amaia; Esteban, Alberto; Skaf, Marta; García-Cortés, Verónica; González, Javier Jesús</i>	1436
71	EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF MICROCEMENT-BASED GROUTS <i>Hortigon, Beatriz; Ancio, Fernando; Espinal, Jose Santiago; Rodriguez-Mayorga, Esperanza</i>	1444
72	LIGHTWEIGHT CEMENT COBBLE MADE WITH RECYCLED ROOF WASTES <i>Alonso Díez, Álvaro; Arroyo Sanz, Raquel; Alameda Cuenca-Romero, Lourdes; Gutiérrez-González, Sara; Calderón Carpintero, Verónica; Rodríguez Sáiz, Ángel</i>	1452
91	CLIMATIC PERFORMANCE INDICATOR BASED ON FUZZY LOGIC: APPLICABILITY TO THE ARCHITECTURE, ENGINEERING AND CONSTRUCTION SECTOR <i>Prieto, Andrés J.; Carpio, Manuel</i>	1460
125	FEASIBILITY OF DEFECT DETECTION IN CONCRETE CYLINDERS BY MEANS OF MUON SCATTERING RADIOGRAPHY (MSR) <i>Orio, Aitor; Martínez, Pablo; Díez, Carlos; Gómez, Pablo</i>	1468
157	THE BUILDING STOCK REHABILITATION: THE CONTRIBUTION OF VERTICAL GREENERY SYSTEMS (VGS) <i>Lo Faro, Alessandro; Moschella, Angela; Lombardo, Grazia; Salemi, Angelo; Sciuto, Gaetano; Nocera, Francesco; Costanzo, Vincenzo</i>	1476
166	PRELIMINARY STUDIES TO IDENTIFY SUITABLE DEMONSTRATORS FOR RADON REMOVAL WITH INNOVATIVE PAVEMENTS <i>Alonso, Carmen; Frutos, Borja; Manglano, Libertad; Castaño, Enrique; Sicilia, Isabel; Baño, Antonio; Martín-Consuegra, Fernando</i>	1485
239	EXPERIMENTATION OF NEW PRODUCTS AND SOLUTIONS AT FULL SCALE IN KUBIK. ITS EVOLUTION AND TRANSFORMATION IN 10 YEARS OF OPERATION <i>San Mateos Carretón, Rosa; Garay-Martinez, Roberto; Egiluz, Ziortza</i>	1493
247	REUSE OF RESIDUAL DIATOMACEOUS EARTH FOR THE PRODUCTION OF GEOPOLYMERS – A REVIEW <i>Magalhães, Leandro; Ferreira, Débora; Luso, Eduarda; Lima, Óscar</i>	1504
252	NUMERICAL EVALUATION OF THE STRUCTURAL CONTRIBUTION OF STRENGTHENING FOR PERPENDICULAR TENSILE AND FOR SHEAR IN REINFORCED CONCRETE JOINTS FOR TIMBER FRAMES <i>Ribeiro, Aléxia; Negrão, João; Dias, Alfredo</i>	1511
257	GRAPHENE OXIDE AS ADDITIVE FOR INCREASING THE STRENGTH AND DURABILITY PERFORMANCE OF EXISTING CONCRETE STRUCTURES <i>Longarini, Nicola; Cabras Luigi</i>	1519
260	USE OF REMOTELY PILOTED AIRCRAFT (DRONES) FOR THE INSPECTION OF ARCHITECTURAL HERITAGE AND ANCIENT STRUCTURES <i>Rodríguez Elizalde, Rubén</i>	1528
269	USE OF BIOCEMENTATION FOR SEALING STONE JOINTS <i>Cardoso, Rafaela; Barroso, Ana Catarina; Borges, Inês; Fernández Rodríguez, Román; Flores-Colen, Inês</i>	1543
277	APPLICATION OF NANOTECHNOLOGY TO OBTAIN SUSTAINABLE CEMENT-BASED MATERIALS WITH HIGH DURABILITY <i>Ruiz, Alberto; De la Rubia, Miguel Ángel; Reyes, Encarnación; Moragues, Amparo</i>	1551
306	POSSIBILITIES OF USING CALCIUM HYDROXIDE-BASED NANOMATERIALS IN THE CARE OF HISTORICAL SURFACES <i>Kroftova, Klara; Witzany, Jiri; Zigler, Radek; Cejka, Tomas</i>	1560

351	GEOPOLYMER CEMENTITIOUS SOLUTIONS WITH INTEGRAL SUSTAINABILITY AND HIGH ADDED VALUE BASED ON CONSTRUCTION WASTES. KEOPS PROJECT: PRELIMINARY FINDINGS <i>Prego Martínez, Francisco Javier; García Carrillo, Pablo; Miguéns Blanco, Alberto; Martínez García, Carolina</i>	1569
383	HEAT AND PRESSURE DEVELOPMENTS IN CHEMICAL DEMOLITION AGENTS <i>Atteyeh, S. Natanzi; Laefer, Debra F.</i>	1584
<b>2.4.- Sustainable design and energy efficiency.</b>		
6	ASSESSING THE THERMAL ENVIRONMENT OF SOUTH INDIAN HISTORIC TEMPLE TOWNS BY USING CFD MODELLING <i>Kiruthiga, K.; Thirumaran, K.</i>	1592
19	EXPERIMENTAL STUDY OF THE THERMAL AND MECHANICAL PROPERTIES OF ECO-FRIENDLY CEMENT MORTAR INCORPORATING RECYCLED PET AND PP <i>Bourzik, Oumaima; Akkouri, Nacer; Baba, Khadija; Simou, Sana; Nounah, Abderrahman</i>	1600
38	PROPOSITION FOR HEALING MECHANICAL VENTILATION SYSTEMS WITH RESONANT KEPPE MOTOR TECHNOLOGY: ANALYSIS IN A BRAZILIAN PRIVATE SCHOOL <i>Koivukangas, Sari Hannele</i>	1609
52	BIOCLIMATIC STUDY OF ARCHITECTURE IN EASTERN ALMERÍA (SPAIN) <i>García-Ruiz, Luisa-María; García-Ruiz, Almudena; Sáez-Pérez, María-Paz</i>	1618
54	PORTUGUESE PUBLIC SOCIAL HOUSING IN COVILHÃ, PORTUGAL. A CASE STUDY ON INDOOR THERMAL CONDITIONS DURING SUMMER SEASON <i>Brandão, Pedro; Lanzinha, João C. G.</i>	1626
67	AN OVERVIEW OF SUSTAINABLE CONCRETES WITH MAXIMIZED AGGREGATE CONTENT: NATURAL LIMESTONE VERSUS STEEL-MAKING SLAGS <i>García-Cortés, Verónica; García, David; Revilla-Cuesta, Victor; Romera, Jesús-María; San-José, José-Tomás</i>	1634
108	THE POLYFUNCTIONALITY IN THE SINGULAR ARCHITECTURES: KEY OF PERMANENCE AND KEY OF SUSTAINABILITY <i>Agudo Martínez, Andrés; Vázquez Sánchez, Gloria; Lucas Ruiz, Rafael</i>	1643
114	SEISMIC AND ENERGY RETROFIT OF HISTORIC BUILDINGS: A MODEL TO SUPPORT INTEGRATED DESIGN <i>Roncaccia, Elisa; Losco, Giuseppe</i>	1652
116	ANALYSIS OF PASSIVE AIR-CONDITIONING SOLUTIONS IN THE RENOVATION OF COURTYARDS IN A MEDITERRANEAN CLIMATE. <i>Rivera-Gómez, Carlos; Diz-Mellado, Eduardo; López-Cabeza, Victoria; Roa-Fernández, Jorge; Galán-Marín, Carmen</i>	1663
120	BUILDING RETROFITTING IN VULNERABLE CONTEXTS USING END-OF-LIFE HOUSEHOLD MATERIALS AS SUSTAINABLE AND LOW-COST INSULATING SOLUTIONS: THERMAL AND ACOUSTIC ANALYSIS <i>Neri, Manuela; Pilotelli, Mariagrazia; Traversi, Marco; Levi, Elisa; Piana, Edoardo Alessio; Bannó, Mariasole; Pardo-Bosch, Francesc; Cuerva, Eva; Guardo, Alfredo; Pujadas, Pablo</i>	1671
153	INSTALLATION OF DIFFERENT PHOTOVOLTAIC SYSTEMS IN A BUILDING FOR EDUCATIONAL USE <i>Zurro, Belén; González, Sara; González, José Manuel; Rodríguez, Ángel</i>	1680
154	CHECKING THE TECHNICAL SUITABILITY OF THE VENTILATED FAÇADE SOLUTION <i>Zurro, Belén; González, Sara; González, José Manuel; Rodríguez, Ángel</i>	1689
155	CATALOGING ROOFS FOR THE APPLICATION OF NBS IN EDUCATIONAL BUILDINGS <i>Alonso, Carmen; de Frutos, Fernando; Martínez, Arturo; Torres, Salustiano; Frutos, Borja; Martín-Consuegra, Fernando</i>	1698
163	APPLICATION OF EE-HBIM METHODOLOGY TO THE ENERGY RETROFITTING OF A HERITAGE PUBLIC BUILDING IN VALENCIA <i>Carnero Melero, Pablo; Ramírez Pareja, Lucía; Lázaro Moreno, Cecilia; Navarro Escudero, Miriam</i>	1706
171	SIMULATION ANALYSIS AND THE ROLE OF OCCUPANCY MEASUREMENTS ADDRESSING THE ENERGY PERFORMANCE GAP. STUDY OF AN OFFICE BUILDING IN ALMERÍA <i>Soutullo, Silvia; Giancola, Emanuela; Sánchez, María Nuria; Díaz-Hernandez, Heidi Paola; Jiménez, María José</i>	1714
177	HYBRID SOLUTION FOR ELECTRIC AND COLD-WATER PRODUCTION WITH A DUAL DAY-NIGHT BEHAVIOR AS A NATURAL AIR CONDITIONING TECHNIQUE <i>Castro Medina, Daniel; Guerrero Delgado, María del Carmen; Palomo Amores, Teresa Rocío; Cerezo Narváez, Alberto; Sánchez Ramos, José; Álvarez Domínguez, Servando</i>	1722
180	INNOVATIVE INTEGRATION OF ACTIVE ROOF ON 140 SOCIAL HOUSING <i>Castro Medina, Daniel; Guerrero Delgado, MCarmen; Palomo Amores, Teresa; Molina Félix, José Luis; Sánchez Ramos, José; Álvarez Domínguez, Servando</i>	1731

191	INTEGRATED REDEVELOPMENT OF INDUSTRIAL BUILDINGS: A CASE STUDY IN CENTRAL ITALY <i>Banti, Neri; Di Naso, Vincenzo; Ciacci, Cecilia; Bazzocchi, Frida</i>	1740
212	ENERGY EFFICIENCY AND PRESERVATION OF DIFFUSE HISTORIC BUILDINGS: OPPORTUNITIES AND OPEN QUESTIONS <i>Pizzoli, Rolando; Cardani, Giuliana; Bassani, Paola</i>	1752
323	ENERGY EFFICIENCY AND COST OF ENERGY (POSSIBLE SCENARIOS) <i>Balbás, Francisco Javier; Aranda, José Ramón; Carrasco, César; Ceña, Alberto; García, Javier</i>	1760
346	THE IMPACT OF SEISMIC RETROFIT ON THE THERMAL PERFORMANCE OF TRADITIONAL MASONRY WALLS <i>Barreira, Eva; Almeida, Ricardo; Ferreira, Tiago Miguel; Vicente, Romeu; Alves, Pedro</i>	1768
377	NEW MATERIALS IN THE RESIDENTIAL THERMAL CONDITIONING. APPLICATION IN A HOUSE IN THE CITY OF LOJA, ECUADOR. <i>Correa-Jaramillo, Ramiro; Ojeda-Espinosa, Analía; Zúñiga-Torres, Berenice; Torres-Gutiérrez, Mercedes</i>	1776
382	PRELIMINARY THERMAL ANALYSIS OF A CONTAINER HOUSE IN THE NORTHERN REGION OF PORTUGAL <i>Kuninari, Thomas; Pinto, Jorge; Reis, Cristina; Pereira, Sandra; Pappalardo, Alfonso</i>	1784
396	USING DIGITAL MODELS OF BUILT ENVIRONMENT ARCHETYPES TO ANALYZE AND COMMUNICATE CLIMATE RELATED RISK OUTDOORS <i>Blanco Cadena, Juan Diego; Caramia, Martha; Salvalai, Graziano; Quagliarini, Enrico</i>	1793

### 3.- BUILDING INTERVENTION

#### 3.1.- Intervention plans.

186	SPECIAL PROTECTION PLANS OF HISTORICAL SETS IN SEISMIC AREAS: THE PEPRICH OF LORCA <i>García Martínez, María del Sagrado Corazón; Martínez Ríos, Carmen</i>	1804
214	DIGITAL SURVEY FOR BUILT HERITAGE PRESERVATION. AN ADAPTIVE REUSE PROPOSAL OF THE COMPLEX OF SANTA MARIA NASCENTE <i>Costantino, Carlo; Ruocco, Sara; Predari, Giorgia; Ferrante, Annarita</i>	1813
360	CHALLENGES OF THE PRESERVATION OF HERITAGE BUILT IN STONE AND ARMED CONCRETE ON THE ISLAND OF MOZAMBIQUE <i>Alcolete, Isequiel; Silva, J. Mendes; Lage, Luís; Mouraz, Catarina</i>	1822

#### 3.2.- Rehabilitation and durability.

104	HOW A REFURBISHMENT CAN BLATANTLY MISS ITS GOALS: THE PALAZZO STABILE IN POLLA (SALERNO, ITALY) <i>Marino, Francesco Paolo R.; Lembo, Filiberto; Bruno, Pierluigi</i>	1831
137	CONCRETE CRACK REPAIR WITH EXPANSIVE GROUTS: CHLORIDE PENETRATION RESISTANCE <i>Pedrosa, Filipe; García Calvo, José Luis; Carballosa, Pedro; Revuelta, David</i>	1844
143	EFFECTS OF THE APPLICATION OF ORGANIC PLASTERS WITH ADDITIONS OF BEESWAX ON THE DURABLE CHARACTERISTICS OF EARTH-BASED MORTARS IN RURAL ARCHITECTURE <i>Encalada, Luz; Balcázar, Cristian; Aguirre-Maldonado, Eduardo</i>	1854
189	DIAGONAL COMPRESSION TESTING OF TUFF MASONRY PANELS STRENGTHENED WITH INORGANIC-BASED SYSTEM: AN EXPERIMENTAL INVESTIGATION <i>Verre, Salvatore; Cascardi, Alessio; Gallo, Fiorella</i>	1862
206	NEW GENERATION ETICS COATINGS: AN INNOVATIVE AND HIGH-PERFORMANCE CASE STUDY <i>Curado, António; Figueiras, Ricardo; Gonçalves, Hélder; Sambento, Filipe</i>	1871
232	REINFORCEMENT TECHNIQUES FOR REINFORCED CONCRETE STRUCTURES <i>Guimarães, Marcos B.; Prola, Luis C.; Rodrigues, Paulo C.</i>	1879
295	INFLUENCE OF THE POLARIZATION RESISTANCE MEASUREMENT PROCEDURE WHEN MADE POTENTIODYNAMIC ON THE EVALUATION OF THE POWER OF CORROSION INHIBITORS <i>Argiz, Cristina; de la Fuente, Diego; Moragues, Amparo; Andrade, Carmen</i>	1887
301	EXPERIMENTAL STUDY ON BOND BETWEEN BASALT FRM REINFORCEMENT AND CALCAREOUS STONE <i>Bramato, Giuseppe; Leone, Marianovella; Perrone, Daniele; Aiello, Maria Antonietta</i>	1895
354	THE IMPORTANCE OF THE "IN SITU" BEHAVIOR OF MORTARS IN THE REHABILITATION OF BUILDINGS <i>Torres, Isabel; Flores-Colen, Inês</i>	1903
361	CHALLENGES OF SALVAGUARD AND REHABILITATION OF THE RELIGIOUS HERITAGE BUILT OF VILA VIÇOSA <i>Silva, J. Mendes; Ganito, Jorge</i>	1911
389	BEHAVIOR OF SUPPLEMENTARY CEMENTITIOUS MATERIALS IN ELECTRO REMEDIATION PROCESSES APPLIED TO CONCRETE STRUCTURES <i>Martinez, Isabel; Castellote, Marta</i>	1920
403	DIFFICULTIES IN INTERVENING ON PROTECTED HERITAGE ACCORDING TO PREFERRED STANDARDS OF REFURBISHMENT <i>Calderon Bello, Enrique</i>	1927

#### 3.3.- Reinforcement technologies.

61	COMPARATIVE STUDY OF TECHNIQUES IN REINFORCED ADOBE FOR THE SUSTAINABLE RECONSTRUCTION OF THE COLCA VALLEY AFTER THE 2016 EARTHQUAKE <i>Cárdenas Gómez, José Carlos; Bosch González, Montserrat; Damiani Lazo, Carlos</i>	1936
99	STRENGTHENING OF FLAT SLABS WITH FIBRE REINFORCED POLYMERS USING THE EXTERNALLY BONDED REINFORCEMENT ON GROOVES METHOD: A REVIEW <i>Torabian, Ala; Isufi, Brisid; Mostofinejad, Davood; Ramos, António Pinho.</i>	1946
100	MECHANICAL CHARACTERISATION OF VEGETAL FRM COMPOSITES: EXPERIMENTAL AND ANALYTICAL APPROACH <i>Mendizabal, Virginia; Bernat-Maso, Ernest; Mercedes, Luís; Gil, Lluís</i>	1954



152	EXPERIMENTAL AND NUMERICAL ANALYSIS OF THE CYCLIC IN-PLANE BEHAVIOUR OF RETROFITTED MASONRY WALLS <i>Garcia-Ramonda, Larisa; Pelà, Luca; Roca, Pere; Camata, Guido</i>	1962
160	DESIGN AND DETAILING OF ANCHORS FOR SEISMIC ACTIONS <i>Gramaxo, Jorge; Cardo Fernández, Antonio</i>	1971
164	STEEL MESH REINFORCED COATING CHARACTERIZATION FOR MASONRY UPGRADING <i>Crespi, Pietro; Cattaneo, Sara; Scamardo, Manuela; Vafa, Navid</i>	1980
172	PUNCHING POST-INSTALLED REINFORCEMENT OF FLAT SLABS <i>Kunz, Jakob; Cardo Fernández, Antonio</i>	1989
192	BILINEAR EXPERIMENTAL CURVE OF MASONRY WALLS MADE WITH HORIZONTAL HOLLOW BRICK UNITS <i>Díaz, Christian; Tarque, Nicola</i>	1999
202	COMPARISON OF IN-PLANE BEHAVIOR OF UNREINFORCED MASONRY WALLS STRENGTHENED WITH FABRIC-REINFORCED CEMENTITIOUS MATRIX (FRCM)/ FIBER REINFORCED POLYMERS (FRP) SYSTEMS SUBJECTED TO DIAGONAL COMPRESSION <i>Kaddouri, Hajar; Cherradi, Toufik; Kourdou, Ibtissam</i>	2008
350	ON-SITE REHABILITATION OF DECAYED TIMBER FLOORS WITH EPOXY-RESIN COMPOSITES <i>Bender, Tom; Schober, Kay-Uwe; Ihle, Robin</i>	2022

### 3.4.- Restoration of artworks.

63	ARTISTIC BLACKSMITHING IN THE URUGUAYAN BUILT HERITAGE <i>Aguiar, Sofía; Beretta, Ernesto; Hojman, Miriam; Marchese, Valentina; Mussio, Gianella; Olivera, Leticia; Rimbaud, Tatiana; Romay, Carola; Ulfe, Veronica</i>	2030
195	RECOVERY OF A HISTORIC STAINED-GLASS WINDOW OF THE HOUSE MAUMEJEAN IN SAN MARCOS 43 ST. MADRID <i>Pinilla Melo, Javier; Castrillo Sevilla, Elena; Moreno Fernández, Esther., Lasheras Salgado, Raquel</i>	2038

### 3.5.- Conservation of industrial heritage.

81	PROPOSAL OF SUSTAINABLE REHABILITATION OF INDUSTRIAL BUILDING FOR INTERNSHIP AND TRAINING SPORTS CENTER <i>Lopes, Vera; Iñigo, Miriam; Lanzinha, João</i>	2048
267	EXAMINING THE DEFECTS AND INTERVENTIONS IN THE COMPONENTS OF REUSED INDUSTRIAL BUILDINGS-CASE OF TURKEY <i>Çakar, H. Yasemin; Edis, Ecem</i>	2056
279	ANALYSIS OF THE FRENCH TRAIN SYSTEM IN A SUGAR MILL OF THE 18TH CENTURY ON THE ISLAND OF SANTO DOMINGO AND RESTORATION CRITERIAS <i>Prieto-Vicioso, Esteban; Flores-Sasso, Virginia</i>	2067

### 3.6.- Examples of intervention.

17	REHABILITATION OF THE ACCESS TO THE SAN JUAN DE GAZTELUGATXE HERMITAGE <i>Baraibar, José Manuel; Escobal Marcos, Iñigo</i>	2076
24	INTEGRAL RECOVERY OF THE HERMITAGE OF SAN BLAS IN BROTO-HUESCA <i>Febas Borra, José Luís; Díez Hernández, Jesús; Rojí, Eduardo</i>	2084
80	MODEST HERITAGE PRESERVATION IN SAN SALVADOR HISTORIC CENTER. THE GREEN HOUSE REHABILITATION CASE <i>Avendaño, Ayansi</i>	2096
83	LIGHT AND SPACE - TRANSFORMING A VILLA INTO THE CHRISTIAN YOUTH CENTRE TIMISOARA <i>Andreescu, Ioan; Dinu, Dan – Răzvan</i>	2106
110	ARCHITECTURAL REHABILITATION OF THE ROOF OF THE CENTRAL COURTYARD OF THE FACULTY OF ECONOMICS AND BUSINESS SCIENCES OF THE UNIVERSITY OF SEVILLE. A CASE OF ARCHITECTURAL INTERVENTION IN MODERN HERITAGE PROPERTIES <i>Agudo Martínez, Andrés; Basallote Neto, Francisco</i>	2115
115	TECHNOLOGICAL REFURBISHMENT AND ENERGY RETROFIT OF LARGE, FLAT ROOFS BY USING METAL SHEET SYSTEMS: THE CASE STUDY OF A MULTIFUNCTIONAL BUILDING <i>Scrinzi, Giacomo; Mazzucchelli, Enrico Sergio; Stefanazzi, Alberto; Lucchini, Angelo</i>	2129

118	REHABILITATION OF THE TXATXARRAMENDI BRIDGE IN BUSTURIA-SUKARRIETA (BIZKAIA) <i>Pérez Salazar, Laura; Barroso Prados, Fran; Piñero Santiago, Ignacio; Orbe Mateo, Aimar; Ezquerro Andreu, Mikel</i>	.....	2139
175	MEMORIES OF IMMIGRATION - THE RESTORATION OF THE HOTEL LANFREDI <i>Betemps Vaz Da Silva, Juliana; Rauber Motter, Cristiane; Werner, Priscila; Lorscheiter, Aline; Matozo da Silva, Luana; Herpich, Bruna</i>	.....	2148
178	THE RESTORATION OF SANTA CRUZ CHURCH IN ECIJA (SEVILLE): THE BUILDING AS PLOT <i>Rincón-Calderón, José María; de Sola-Caraballo, Javier; Galán-Marín, Carmen; Rivera-Gómez, Carlos</i>	.....	2156
223	ANALYSIS OF LEAN CONSTRUCTION INFLUENCE IN BUILDING PROCESSES USING BIM 4D: CASE STUDY <i>Ferrer, Pedro A. M.; Ribeiro, Rodrigo S.; Oliveira, Rui A. F.</i>	.....	2165
225	PLANNING AND MANAGEMENT OF AGRICULTURE WAREHOUSE CONVERSION PROJECT: A CASE STUDY <i>Oliveira, Rui A. F.; Abreu, Maria Isabel; Lopes, Jorge</i>	.....	2174
228	THE ROOF OF THE SANTA LUCIA CHURCH - FERREÑAFE: INTERVENTIONS FOR THE MAINTENANCE OF THEIR STRUCTURAL AND FUNCTIONAL INTEGRITY <i>Chirinos, Haydeé; Zárate, Eduardo; Beltrán, Freddy</i>	.....	2184
229	INCORPORATION OF HIGH ENERGY PERFORMANCE AND SUSTAINABILITY CRITERIA IN THE ARCHITECTONIC AND STRUCTURAL RETROFIT OF INDUSTRIAL HERITAGE BUILDINGS: THE CASE OF THE NEW COURTS IN SERENA, CHILE <i>Videla, José Tomás; Huenchuñir, Marcelo; Bustamante, Fermín; Martínez, Patricia</i>	.....	2192
259	THE GOTHIC OF THE TWENTIETH CENTURY IN COLOMBIA. RESTORATION PROJECT OF THE CHURCH OF THE INMACULADA CONCEPCIÓN IN CARAMANTA, ANTIOQUIA <i>Carvajal Jaramillo, Henry H.; Ochoa Botero, Juan C.</i>	.....	2200

**4.- MAINTENANCE**
**4.1.- Construction maintenance and infrastructures.**

21	COVID-19 LESSON ON FACILITY MANAGEMENT OF PUBLIC BUILDINGS <i>D’Orazio, Marco; Bernardini, Gabriele; Di Giuseppe, Elisa</i>	2212
32	INFLUENCE OF THE USERS’ PERFORMANCE CRITERIA ON THE IMPACT OF MAINTENANCE OF CERAMIC CLADDINGS <i>Ferreira, Cláudia; Silva, Ana; de Brito, Jorge</i>	2220
51	METHODOLOGY FOR IMPROVING THE EFFICIENCY OF INVESTMENTS OF THE INDUSTRIAL INFRASTRUCTURES OF THE FORMER PORT AREA IN THE BAY OF HAVANA <i>Piñero, Ignacio; de la Cruz, Raimundo; Bresó, Juan Carlos, Cuadrado, Jesús; Ezquerro, Mikel</i>	2226
69	A NEW METHODOLOGY FOR RAILWAY BRIDGE INSPECTION FROM OPTICAL IMAGES AND HD VIDEOS OBTAINED BY RPAS <i>Cano, Miguel; Pastor, José Luis; Tomás, Roberto; Riquelme, Adrián; Asensio, José Luis; Pagán, José Ignacio</i>	2235
85	FEASIBILITY ASSESSMENT OF HEIGHT WORKING EQUIPMENT, IN SOUTH-ITALIAN RESIDENTIAL BUILDINGS MAINTENANCE <i>Di Ruocco, Giacomo; Melella, Roberta</i>	2245
176	PUBLIC BUILDINGS MAINTENANCE MANAGEMENT <i>Ferreira, Lélia; Paiva, Anabela; Silva, J. Mendes</i>	2254
352	THE REHABILITATION THROUGH EXTERNAL PRESTRESSING OF HISTORICAL REINFORCED CONCRETE BRIDGES WITH REDUCED PERFORMANCE: A CASE STUDY <i>Granata, Michele Fabio; Messina, Davide; Colajanni, Piero; La Mendola, Lidia; Recupero, Antonino; Lo Giudice, Elio</i>	2262
378	DIAGNOSIS OF A MODERNIST WORK: THE “PARADOR ARISTON” <i>Valcarce, María Beatriz; Vázquez, Marcela</i>	2272
388	REMOTE INSPECTION OF THE INTERIOR OF CHANNELS AND TANKS OF THE WATER SUPPLY AND SANITATION NETWORK <i>Tárrago Garay, Nerea; Barroso Prados, Francisco Javier; Espada, Fran; Borrás Morrison, Mikel</i>	2280

**4.2.- Preventive conservation of built heritage.**

15	MANUAL OF GOOD PRACTICES IN THE TRADITIONAL RURAL ARCHITECTURE OF GRAN CANARIA: THE DWELLING-CAVE <i>Delgado Quintana, Guacimara; Lozano Más, María Yazmina; Cabrera Librada, Javier; Medina Arias, Aarón; González Navarro, José</i>	2290
36	PREVENTIVE MAINTENANCE OF EXISTING BUILDINGS USING BIM TECHNOLOGY FOR THE OPTIMISATION OF RETROFITTING PROCESSES <i>Sagarna, Maialen; Otaduy, Juan Pedro; Mora, Fernando; Leon, Iñigo</i>	2299
50	PRESERVING THE 20TH CENTURY INDUSTRIALIZED BUILDING HERITAGE IN ITALY: COMBINING HISTORICAL SURVEYS AND PHILOLOGICAL BIM <i>Mornati, Stefania; Giannetti, Ilaria</i>	2308
86	MICROCLIMATE FOR PRESERVATION IN A LIBRARY: ASSESSMENT OF TEMPERATURE AND RELATIVE HUMIDITY PRE AND POST CONFINEMENT <i>Diulio, María de la Paz; Gómez, Analía Fernanda</i>	2317
92	APPLICATION OF A FUZZY LOGIC SYSTEM WITH EMPHASIS ON CLIMATE CONDITIONS IN THE BUILDING SECTOR IN CHILE <i>Carpio, Manuel; Prieto, Andrés J.</i>	2325
136	ANALYSIS OF ANTHROPIC AND SOCIAL THREATS OF THE ARAB WALL OF ALZIRA <i>Guardiola-Villora, Arianna; Basset-Salom, Luisa</i>	2332
138	SLOPE STABILIZATION BY ROAD ROTATIONAL SLIDE IN THE JUNGLE OF PERU <i>Soplopuco Quiroga, Serbando; Soplopuco Torres, Rubén Ronald; Martínez Quiroz, Enrique Napoleón; Alarcón Zamora, José Evergisto</i>	2343
151	CHARACTERISTICS OF THE CULTURAL HERITAGE PREVENTIVE CONSERVATION SYSTEM OF SOUTH KOREA <i>Hwang, Minhye</i>	2353
238	SAN JUAN DE GAZTELUGATXE, HOW TO MANAGE THE RESILIENCE OF A UNIQUE LOCATION ON THE COAST OF THE BASQUE COUNTRY <i>San Mateos Carretón, Rosa; Ezquerro Andreu, Mikel; Eppich, Rand; Quesada, Laura</i>	2359
357	THE CONTRIBUTION OF DECONSTRUCTION TO THE PRESERVATION OF PORTUGUESE OLD BUILDINGS <i>Ranna, Gabriela; Torres, Isabel; Silva, José</i>	2369

**5.- DIFFUSION AND PROMOTION**

**5.1.- Heritage and cultural tourism.**

35	DISUSED RAILWAY STATIONS AND BUILDING AND ENVIRONMENTAL RECOVERY STRATEGIES <i>Radogna, Donatella</i>	2378
47	INDUSTRIAL HERITAGE IN THE PROVINCE OF ALMERÍA. ANALYSIS AND REUSE FOR A SUSTAINABLE TOURISM <i>García-Ruiz, Almudena; García-Ruiz, Luisa-María; Sáez-Pérez, María-Paz</i>	2387
49	EVOLUTIONARY, MORPHOLOGICAL AND ACOUSTIC ANALYSIS OF CLASSICAL GREEK THEATRES. PARAMETERS FOR PRE-DIMENSIONING AND REHABILITATION <i>Mesto, Suleiman; Rubio, María Jesús</i>	2396
87	AN EXAMPLE OF THE ANALYSIS OF RURAL SETTLEMENTS: ASAGI BELEMEDIK VILLAGE <i>Ortakaya, Esra Nur; Umar, Nur</i>	2404
109	PROPOSAL FOR INTERVENTION IN ABANDONED ARCHITECTURE: THE ROMAN TEMPLE OF VIÑEROS OF THE CITY OF MERIDA <i>Agudo Martínez, Andrés; Fernández Castelló, Francisco; Vázquez Sánchez, Gloria</i>	2414

**5.2.- Teaching and training.**

188	ADVANTAGES OF FLIP TEACHING ACTIVE METHODOLOGY DURING THE COVID-19 PANDEMIC <i>Tuesta Durango, Nelson; Villanueva Valentín-Gamazo, David; Mansilla Blanco, M<sup>a</sup> Isabel; Rey de las Moras, M<sup>a</sup> Cruz; Cantalapiedra Cantalapiedra, Ángel; Martínez Iranzo, Fco. Javier</i>	2424
-----	--	------

**5.3.- New technologies applied to the heritage diffusion.**

12	INVENTORIES FOR THE PRESERVATION AND DISSEMINATION OF THE ARCHITECTURAL HERITAGE <i>Quintilla, Marta; Agustín, Luis</i>	2433
27	THE GEOMETRIC APPEARANCE OF COLUMNS AND FRAMES IN THE PALATIAL OTTOMAN ARCHITECTURE OF THE ALGIERS CASBAH: WHAT PROCESS TO CREATE? <i>Aïcha, Bibimoune; Samia, Chergui</i>	2441
75	PLANIMETRIC SURVEY, 3D PRINTING AND VIRTUAL RECREATION FOR THE MUSEALIZATION OF THE HOYA DE LOS MOLINOS SITE, IN CARAVACA DE LA CRUZ (REGIÓN DE MURCIA, SPAIN) <i>Collado-Espejo, Pedro-Enrique; García-León, Josefina; González-García, Jesús Ángel</i>	2450
113	3D MODELING AS A VALIDATION SYSTEM FOR THE RECONSTRUCTION OF THE DISAPPEARED HISTORICAL ARCHITECTURAL HERITAGE: THE OCTOGON OF VALLADOLID <i>Villanueva-Valentín-Gamazo, David; Arcones-Pascual, Gustavo; Bellido-Blanco, Santiago</i>	2458
286	MIXED VIRTUAL TOUR FOR THE DISSEMINATION OF THE DECONTEXTUALIZED HERITAGE. THE OVIEDO CATHEDRAL CHOIR STALLS <i>Sanchez Riera, Alberto; Pàmies Sauret, Carles; Navarro Delgado, Isidro</i>	2467
291	DEFENSIVE ARCHITECTURE, DIFFUSION AND NEW TECHNOLOGIES. ANALYSYS OF THE NATIONAL PARK SERVICE AND PARKS CANADA STRATEGIES <i>Mira Rico, Juan A.</i>	2476
304	MALAKA.NET AS A COMPREHENSIVE WEBGIS PLATFORM TO MANAGE CULTURAL HERITAGE. A COMPARATIVE CASE STUDIES <i>Conejo-Arrabal, Francisco; Chamizo-Nieto, Francisco José; Rosa-Jiménez, Carlos; Nebot-Gómez de Salazar, Nuria</i>	2484
312	A COMPARATIVE STUDY BETWEEN A STATIC AND A MOBILE LASER SCANNER FOR THE DIGITALIZATION OF INNER SPACES IN HISTORICAL CONSTRUCTIONS <i>Villanueva Llauradó, Paula; Maté González, Miguel Ángel; Sánchez Aparicio, Luis Javier; Benito Pradillo, María Ángeles; González Aguilera, Diego; García Palomo, Luis Carlos</i>	2492
317	THE INTANGIBLE CULTURAL HERITAGE THROUGH DIGITAL INVENTORIES. CASE STUDY IN MÁLAGA, SPAIN <i>Nebot-Gomez de Salazar, Nuria; Chamizo-Nieto, Francisco José; Conejo-Arrabal, Francisco; Rosa-Jiménez, Carlos</i>	2499

**5.4.- Accessibility to cultural heritage.**

187	ACCESSIBILITY AND CULTURAL HERITAGE: THE CASE STUDY OF THE BRAZILIAN FEDERAL SUPREME COURT PALACE USING THE MATRIX OF AUTHENTICITY AND ACCESSIBILITY <i>Máximo, Marco Aurélio da Silva; Ferreira, Oscar Luís</i>	2508
-----	---	------



**5.5.- Built heritage management.**

40	HBIM & GIS INTEGRATION FOR THE 3D VISUALISATION OF VIRTUAL LIBRARIES IN EXISTING BUILDINGS: A CASE STUDY <i>Carrasco, César A.; Lombillo, Ignacio; Blanco, Haydee; Boffill, Yosbel; Sánchez-Haro, Javier</i>	.....	2518
209	THE RESILIENT CONSTRUCTION SITE OF THE HISTORICAL CENTERS. A CASE STUDY <i>Rotilio, Marianna; Laurini, Eleonora; De Berardinis, Pierluigi</i>	.....	2527
210	GUNPOWDER HOUSE – VALPARAÍSO. AN URBAN ARCHAEOLOGICAL SITE AND ITS HERITAGE RECOVERY <i>Kaplan, Paulina</i>	.....	2536
215	REVIEW OF THE MANAGEMENT OBJECTIVES OF THE WORLD HERITAGE DECLARATION OF ÚBEDA AND BAEZA <i>Hervás-Molina, María; Loren-Méndez, Mar</i>	.....	2542

**KEYNOTE LECTURES**

**CODE 67****AN OVERVIEW OF SUSTAINABLE CONCRETES WITH MAXIMIZED AGGREGATE CONTENT: NATURAL LIMESTONE VERSUS STEEL-MAKING SLAGS**

**García-Cortés, Verónica<sup>1</sup>; Garcia, David<sup>2</sup>; Revilla-Cuesta, Victor<sup>3</sup>;  
Romera, Jesús-María<sup>4</sup>; San-José, José-Tomás<sup>5</sup>\***

1: Basque Research and Technology Alliance (BRTA), TECNALIA  
e-mail: [veronica.garcia@tecnalia.com](mailto:veronica.garcia@tecnalia.com), web: <https://www.tecnalia.com>

2: Basque Research and Technology Alliance (BRTA), TECNALIA  
e-mail: [david.garcia@tecnalia.com](mailto:david.garcia@tecnalia.com), web: <https://www.tecnalia.com>

3: University of Burgos, Department of civil Engineering  
e-mail: [yrevilla@ubu.es](mailto:yrevilla@ubu.es), web: <https://investigacion.ubu.es/grupos/1820/detalle>

4: University of the Basque Country, Department of Mechanical Engineering  
e-mail: [jesusmaria.romera@ehu.es](mailto:jesusmaria.romera@ehu.es), web: <https://www.ehu.es/es/web/ingenieria-mecanica/home>

5: University of the Basque Country, Department of Mining, Metallurgical and Materials Science.  
e-mail: [josetomas.sanjose@ehu.es](mailto:josetomas.sanjose@ehu.es), web: <https://www.ehu.es/en/web/im3/>

**ABSTRACT**

The conversion of various industrial by-products from Spanish factories into co-products used in partial substitution of cement and concrete aggregate has been extensively studied since the 1990s. Building on that research effort, the present investigation is focused on improving the packing density of concrete aggregates, with special emphasis on two central objectives: firstly, the reduction of cement and natural aggregate content within concrete; secondly, the validation of their substitution by Electric Arc Furnace Slag (black-slag) aggregate. To do so, several experimental campaigns were conducted, in which 4 compaction procedures were applied under dry conditions to: 4 sieved fractions of natural limestone and 3 sieved fractions of black-slag aggregates. The physical properties of the 7 sieved fractions had previously been characterized and compared with theoretical models, in order to validate their dosing in the experimental tests: Fuller curve, Funk and Dinger curve, Compressible Packing Model, and the 3-Parameter Packing model. The aggregate-packing densities were experimentally and theoretically studied with dry methods. Our findings showed that, unlike natural aggregates, other methods based on aggregate shape are preferable for black-slag mixtures, due to the specific textures and their abrupt particle contours. The conclusions from the investigations were that both the Compressible Packing Model and the 3-Parameter Packing models produced valuable packing-density predictions for the binary mixes.

**KEYWORDS:** Compressible Packing Model (CPM); 3-Parameter Packing Density Model (3-PM); Electric Arc Furnace Slag (ES); Natural (limestone) Aggregate (NA); Concrete design.

**1. INTRODUCTION**

Concrete is among the materials that humankind has processed in ever greater quantities and yet its negative environmental effects have only recently raised great alarm: CO<sub>2</sub> emissions, high (non-renewable) resource consumption, and raw-material extraction. Since the 1990s, the properties of

various industrial by-products from Spanish factories have been studied for their partial substitution of cement and concrete aggregates. Building on that research effort, the present investigation is focused on improving the Packing Density (PD) of concrete aggregates, with emphasis on two central objectives. Firstly, the reduction of cement (the more compact the aggregate structure, the less the need for cement paste) and natural aggregate (NA, 70% by mass of concrete) content within concrete. Secondly, the validation of Electric Arc Furnace Slag (ES, black-slag recovered from the primary steel-making process) aggregate used in substitution of concrete aggregate (as an example, 0.4 Mt/year alone is produced in the Basque country), in order to reduce these wastes through their reuse in the manufacture of sustainable concretes [1-2].

One of the earliest pioneers [3] recognized that concrete strength is affected by aggregate gradation. Among others, there is the research work of Funk and Dinger on a set of ideal grading curves [4]. On the one hand, discrete methods were applied to concrete mixes that incorporated NA and recycled concrete aggregates [5]; however, their applicability to ES aggregates and PD prediction has still to be demonstrated. On the other hand, the Compressive Packing Model (CPM), of demonstrated accuracy at predicting PD [7], was extensively used [6] and, the 3-parameter packing model (3-PM) that first included the wedging effect over 8 years ago, has presented new theories based, respectively, on the wall effect and the loosening effect [8].

Aggregate PD was experimentally and theoretically studied (with dry methodologies), after which the NA and ES aggregates were compared with 4 theoretical models, in order to validate the experimental results for their dosing: Fuller curve, Funk and Dinger curve, CPM, and 3-PM. Our findings showed that, unlike NA aggregates, other methods based on aggregate contours should be preferred for ES mixtures, due to the specific shape and textural variability of these co-products. In conclusion, the investigations showed that both the CPM and the 3-PM models produced valuable packing density predictions for binary mixes, although the superior performance of the 3-PM model was evident in relation to both the ternary and the quaternary mixes.

## 2. MATERIALS AND METHODS

### 2.1 Materials: aggregates, cement and water

Two aggregate types from Northern Spain (Basque Country) were mixed (see figure 1). Firstly, natural aggregate (NA) from limestone quarries in 4 fraction sizes: 11/22, 4/11, 0/4, and 0/2 millimeters, respectively. Secondly, Electric Arc Furnace Slag (ES) aggregate in 3 fraction sizes: 11/22, 4/11 and 0/5, after crushing and spontaneously weathered outdoors for three months, until their volumetric stabilization (a process that creates surfaces with an angular morphology).

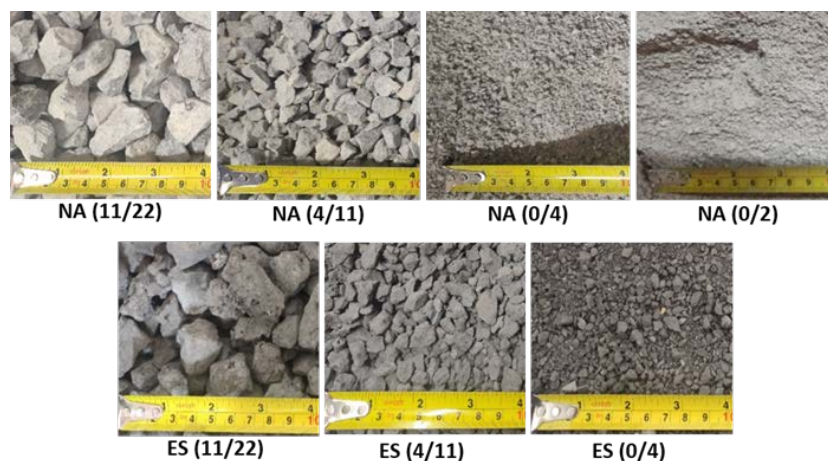


Figure 1: Aggregates under study.

Some physical properties from NA and ES aggregates are presented in Table 1. The average-size particle aggregate fraction is a key point in the discrete packing model. However, there is no a clear agreement on its calculation. Some authors [9] calculated the main aggregate diameter according to specific distributions, others [6] defined it as a geometric mean, and yet others established that mean diameter represented 50% of all retained particles, etc. In the present research, the mean size of each fraction was calculated from the particle-size distribution [10].

Table 1: Properties of aggregates.

Aggregates	Saturated surface dry gravity (kg/dm <sup>3</sup> )	Specific dry gravity (kg/dm <sup>3</sup> )	Bulk density (kg/dm <sup>3</sup> )	Absorption (%)	Fineness modulus	Mean size aggregate fraction (mm)
NA (0/2)	2.7	2.7	1.6	1.8	2.8	1.0
NA (0/4)	2.7	2.7	1.6	0.9	3.0	1.2
NA (4/11)	2.6	2.6	1.4	1.1	6.2	7.6
NA (11/22)	2.7	2.7	1.3	0.4	7.7	18.1
ES (0/5)	3.6	3.5	2.1	1.8	4.0	2.3
ES (4/11)	3.5	3.4	1.8	2.2	6.2	7.4
ES (11/22)	3.57	3.4	1.7	1.7	7.5	16.8

The NA consisted of a commercial natural limestone (calcite fraction >95%) and, as detailed by the authors [1], some limestone fine fraction (0/2) was added to improve concrete workability by avoiding segregation and to compensate for the spontaneous presence of fewer fine particles within the smaller size fraction (0-5) of ES (siderurgical aggregates).

ES aggregates are a by-product of steel processing where, in the primary steel-making process, ferrous scrap is smelted in electric arc furnaces. These black slags are gravelling products (stony materials) with a higher density than NA, and an interesting mechanical performance [1-2], but their superficial roughness, in general, hinders adequate in-fresh workability. The main chemical components of the ES were: Fe<sub>2</sub>O<sub>3</sub> (22.3%), CaO (33.0%), SiO<sub>2</sub> (20.2%), Al<sub>2</sub>O<sub>3</sub> (12.2), MnO (5.0%), MgO (3.0%), Cr<sub>2</sub>O<sub>3</sub> (2.0%), TiO<sub>2</sub> (0.8%), P<sub>2</sub>O<sub>5</sub> (0.5%), SO<sub>3</sub> (0.4%), and others (0.6%); XRD analysis revealed Wüstite, Ghelenite, and Kirshteinite.

In the present research, a CEM II/A-M (V-L) 42.5R containing Portland clinker (80%) was mixed with active additions: fly ash (9%), limestone (9%) and others (2%). This cement had a specific density of 2.99 kg/dm<sup>3</sup> and a specific Blaine surface of 4130 cm<sup>2</sup>/g.

The mix water source from the urban mains supply of the city of Derio (Spain) contained no compounds with adverse effects on hydraulic mixes. Besides, no admixtures were added, in order to avoid undesirable effects of the aggregate proportion on mix properties (the admixtures increased the complexity of particle packing).

## 2.2 Testing the aggregates compactness

The maximum packing densities of NA and ES aggregate mixes were tested under dry methods (packing density measure), which is highly sensitive to the compacting energy. This compacting energy was measured with 4 methods: loose (L), compacted by tamping rod (C), compacted on a vibration table at a frequency of 26 Hz under 10 kPa compression (C26) and, finally, compacted on a vibration table at 33 Hz and 10 kPa (C33), respectively. L and C methods follow UNE-EN 1097-3 (1999) and C26, while C33 follows the [6] research indicated in Figure 2: a pre-set amount of 5.3 kg NA plus 7 kg of ES poured into a cylindrical container and then pressurized at 10 kPa and vibrated for 3 min.



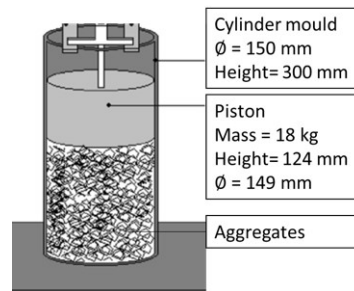


Figure 2: C26 and C33 compaction device described in the procedure [2].

### 2.3 Particle packing models

The experimental results of dosing NA and ES aggregates were compared with the results of 4 theoretical models:

- Fuller curve (optimized curve). This method requires a particle-size distribution and its output is the aggregate proportion according to the best fit with the curve.
- Funk and Dinger curve (optimized curve) [4]. This method requires a particle-size distribution and its output is the aggregate proportion according to the best fit with the curve.
- CPM (discrete model). This method requires a characteristic diameter of each granular fraction, a particle-size distribution of each granular size and a compaction index. Its output is a prediction of the packing density at different proportions.
- 3-PM (discrete model). This method requires a characteristic diameter and a particle-size distribution of each granular fraction. Its output is the prediction of packing density proportions.

#### OPTIMIZED CURVES: FULLER (1) AND FUNK & DINGER (2) METHODS

Both curve-equations were applied, to establish an optimal particle-size proportion of NL and ES aggregate in the concrete mixes.

$$P(d) = (d/d_{max})^q \quad (1)$$

$$P(d) = ((d - d_{min}) / (d_{max} - d_{min}))^q \quad (2)$$

These simple and practical procedures require three inputs: the maximum/minimum ( $d_{max}/d_{min}$ ) particle size and the particle-size distribution (P). The optimal packing density can be determined by varying the “q” factor. A “q” value of 0.5 is the most widely used for the Fuller curve and 0.37 for the Funk and Dinger curves (other researchers [11] recommended  $q=0.25\div 0.3$  depending on concrete types). The optimal NA/ES aggregate rate fractions were obtained by minimizing the residual sum of squares.

#### COMPRESSIBLE PACKING MODEL (CPM)

The CPM method was applied under 3 scenarios to calculate the virtual packing density ( $\beta$ ) of each fraction:

- $\beta_m$ . Each aggregate fraction should be mono-size, neglecting the interaction effects between particle sizes.
- $\beta$ . The second scenario considers the interaction between different particles within the same aggregate fraction. In the end, this procedure was excluded, because the virtual packing density was lower than the real one in some fractions of NA (0/4, 4/11 and 0/2) and ES (0/5 and 4/11).

– $\gamma$ . The virtual packing density was determined on the basis of the second scenario, except that  $\beta$  was considered as the maximum virtual density ( $\gamma$ ), defined as the minimum packing density of an aggregate class when the latter is the dominant one in a poly-sized mix.

Once the  $\beta$  factor had been determined in each aggregate fraction, the model was applied to binary mixes. Initially, this method was applied to coarse and medium sizes, grading the volumetric fractions from 0.0 to 1.0 (in 0.1-point increments). It was subsequently applied to the mixing of all NA and ES fractions (in addition to the NA fine fractions).

### 3-PARAMETER PARTICLE PACKING MODEL (3-PM)

The 3-PM model was applied to binary mixes of coarse/medium aggregate sizes of NA plus ES, following previous research [8]. Afterwards, informed of the developments at the University of Hong Kong under Dr. Wong, based on the multi-component particle-mix model, applied to ternary and quaternary mixtures, it was concluded that the loosening effect, the wall effect and the wedging effect were dependent on the aggregate size-ratio and, additionally, that the former were dependent on both the aggregate morphology (whether rounded or not) and the compaction energy.

## 3. RESULTS

### 3.1 Concrete mix design and properties

The 12 concrete mixes presented in Table 2 were prepared. The ES fractions were mixed as needed with 0/2 mm NA, to adjust the siderurgical aggregate grading curves. These mixtures respond to the optimum combinations of aggregates based on experimental packing density results and the 4 theoretical models previously presented.

Table 2: Concrete mixes and their properties.

Materials and properties	Experimental				Funk & Dinger				CPM and 3P			
	NA1	NA2	ES1	ES2	NA3	NA4	ES3	ES4	NA5	NA6	ES5	ES6
NA-0/4 (kg/m <sup>3</sup> )	905	844			996	978			804	751		
NA-4/11 (kg/m <sup>3</sup> )	436	407			579	542			594	555		
NA-11/22 (kg/m <sup>3</sup> )	664	619			403	373			603	563		
NA-0/2 (kg/m <sup>3</sup> )			402	375			335	376			905	844
ES-0/5 (kg/m <sup>3</sup> )			1065	994			919	828			586	547
ES-4/11 (kg/m <sup>3</sup> )			630	588			574	518			433	404
ES-11/22 (kg/m <sup>3</sup> )			416	389			681	594			430	401
CEMII/A-M(V-L)42.5R (kg/m <sup>3</sup> )	260	317	260	317	270	306	267	326	260	317	260	317
q-factor	-				0.31	0.29	0.35	0.33	-			
W/C	0.55 (Spanish Structural Concrete Instruction EHE-08)											
Solids (%)	84.4	82	83.4	81.0	82.7	82.2	83.7	81.4	85.0	82.8	82.8	81.0
Slump (mm)	15	80	0	150	0	40	15	160	15	150	15	40
Bulk density (kg/dm <sup>3</sup> )	2.4	2.4	2.9	2.9	2.4	2.4	2.9	2.9	2.4	2.4	2.7	2.7
Packing density aggregates (%)	71.6	71.5	72	72.1	75.4	75.8	74.9	74.3	71.4	71.6	74	74
P. density aggregates+CEM (%)	75.2	75.8	74.1	75.0	76.0	76.1	76.5	76.3	75.5	75.9	75.4	74.8

Some of the mixes were cast with a reduced % volume paste (23-24%) and others were dosed with a typical content of 27÷29%. Additionally, several q-parameters (more than initially mentioned) were tested until a 260÷300 kg/m<sup>3</sup> cement content. These mixes had been designed regarding be comparable with these three mixing aggregates methods.

According to the ACI 211.1 code, the absolute volume method (2% of air content when the maximum aggregate size is over 20 mm, in a total volume of 1 m<sup>3</sup>) should be applied to the mixes.

### **3.2 Factors that affect the packing density of aggregate fractions**

The packing densities of both aggregate types (natural and siderurgical) differed, despite their similar grain size distributions and despite having followed a similar compaction process, probably because of the differences in their surface texture (roughness of ES vs plain NA) and shape (depending on whether fractions were crushed or crushed/screened).

The packing density of both the NL and the ES aggregates under study decreased as their mean particle size increased, contrary to the findings of other studies (practically mono-size, while wider fractions were tested in this study), due very probably to a higher agglomeration effect between the finer particles (inter-particle forces), which causes these finer particles to fill the voids left by the larger particles and the agglomeration effect is less prevalent. In addition, the authors observed how both aggregate types were sensitive to the compaction method and, specifically, the fine fractions, due to the above-mentioned agglomeration effect.

### **3.3 Assessment of particle packing models: experimental vs predicted**

#### EXPERIMENTAL PACKING DENSITY OF MIXING AGGREGATES

Two different approaches were analyzed close to the maximum packing value scenario. Firstly, a dosage with the highest packing density computed with a 2<sup>nd</sup> degree-polynomial curve in the packing model: 40%(11/22)+60%(4/11) of NA aggregates and 20%(11/22)+80%(4/11) of ES. Secondly, an optimum aggregate packaging proportion for concrete mixes was designed, because coarse aggregates provide the concrete strength and reduced aggregate surface areas will also reduce the water requirement. In this second approach, the desired workability was obtained with a combination of: 60%(11/22)+40%(4/11) of natural aggregates and 40%(11/22)+60%(4/11) of ES aggregates. The packing density of ES aggregates was maximized when the 4/11 fraction was dominant and, as expected, the higher the packing density, the higher the compaction energy.

It should be highlighted that the aggregate proportions with the maximum packing value were independent of the applied compaction method. The fine fractions had a compaction sensitivity greater than all others. Additionally, a maximum packing density will require siderurgical mixes with fewer fillers (ES 0/5 plus NA 0/2) when the coarse aggregate contents are in lower proportions.

#### OPTIMUM MIX DESIGN BASED ON IDEAL CURVES

The comparison between Funk/Dinger and Fuller methods showed that the former required higher amounts of fines and that when the Fuller method was applied, the crushed aggregates were in preferable proportions. Besides, the Fuller method provided preferable NA proportioning of 50%(11/22)+50%(4/11), while, in the Funk/Dinger procedure, the preferred proportions were 40%(11/22)+60%(4/11).

In the present research, the medium aggregate fractions (40%(11/22)+60%(4/11)) dominated the experimental ES combinations with maximum packing densities. Although, when fitted with the ideal curves, the prediction was 60%(11/22)+40%(4/11). In conclusion, the ideal curves for the siderurgical (crushed) aggregates were not in agreement with their experimental counterparts.

#### ASSESSMENT OF DISCRETE MODELS FOR AGGREGATE PACKING DENSITY

The predictions of the CPM and 3-PM models and their applicability were verified and compared with the experimental packing densities throughout the 4-compaction procedures (L, C, C26 and C33):

binary, ternary and quaternary mixtures, respectively. Firstly, we will present the results of the NA-based mixtures.

It was concluded that, in both the binary and the ternary mixtures, the CPM overestimated the packing density and its prediction of the most compacted combinations reached maximum values of aggregate ratios close to 50%(11/22)+50%(4/11). In contrast, the 3-PM model fitted the experimental results of the ternary mixtures better, especially in two compacting methods: C and C26. The 3-PM model appeared to be suitable for predicting the packing density of these natural aggregates, regardless of the compaction method, taking into account the mean diameter in each aggregate fraction.

The results of the siderurgical aggregate mixes are now presented. In ES binary mixtures, the CPM model (coarse and fine sizes dominant) appears valid. On the other hand, the predictions of this model overestimated the packing density when there was no dominant aggregate fraction. However, the 3-PM fit for the intermediate mixes was better, especially for the two compacting methods: C26 and C33.

In the ternary ES mixtures, the CPM model fitted the experimental values and the 3-PM model clearly showed a better fit when C and C26 compacting methods were applied. Besides, CPM overestimated the packing density in the quaternary mixtures (added NA 0/2 fines), although it was underestimated in the 3-PM model. These behaviors could be based on how the 3-PM model accounts for the welding effect between particles or because of the reduction of the packing density when the fine particle layers cannot be formed (gaps between coarse particles).

Model accuracy for ES materials based on the predicted CPM (binary mix) packing densities deviated by around 6%. Furthermore, this error increased when ternary and quaternary mixtures were assessed (overestimation). On the contrary, the 3-PM model fitted a better agreement, showing itself to be a suitable method for predicting the packing density of ES materials.

As an additional study, the CPM and 3-PM models were analyzed to validate aggregate proportioning at the highest packing density (see Table 3). The table below presents 3 results: a wide range of aggregate combinations were close to the maximum packing density when mixing three or more granular fractions, and close enough therefore to the maximum experimental values.

Table 3: Optimal granular (in volume) proportioning and maximum Packing Densities (PD).

Compacting	Model	Natural aggregates (NA)				Siderurgical aggregates (ES)				
		0/4	4/11	11/22	PD	NA-0/2	0/5	4/11	11/22	PD
L	CPM				0.68	0.5	0.2	0.2	0.2	0.75
	3P	0.4	0.3	0.3	0.69	0.4	0.3	0.2	0.1	0.66
C	CPM				0.76	0.5	0.2	0.2	0.2	0.84
	3P	0.5	0.3	0.3	0.75	0.6	0.2	0.1	0.0	0.72
C26	CPM	0.4	0.2	0.4	0.83	0.5	0.2	0.2	0.2	0.91
	3P	0.5	0.3	0.3	0.80	0.4	0.5	0.1	0.0	0.76
C33	CPM	0.4	0.2	0.4	0.84	0.5	0.2	0.2	0.2	0.92
	3P	0.5	0.3	0.3	0.81	0.4	0.4	0.2	0.0	0.78

As can be seen in Table 3, there are differences in aggregate proportioning depending on the compacting procedures. The 3-PM model predictions for the ES mixtures implied that the denser the mix the lower the content of coarse aggregates (11/22), which suggests that the model is not useful for concrete applications. Moreover, taking into account the same criteria in the experimental campaign, to identify the optimum packed aggregate proportioning for concrete mixes, the optimal aggregate proportioning will be: 0.17(11/22):0.25(4/11):0.28(0/5):0.30(0/2-NA), compacted with the C33 method; proportions that were very close to the predictions.

#### 4. CONCLUSIONS

Numerous experimental test campaigns have been conducted, in which 4 compaction procedures (dry conditions) have been applied to four sieved fractions of natural limestone and three others from siderurgical aggregates. Different physical and chemical properties of these aggregates have been characterized. Different aggregate proportioning studies have been compared and the experimental results validated with four theoretical models (Fuller, Funk and Dinger, CPM and 3-PM).

Regardless of the compaction method, the 3-PM model showed higher accuracy for the ternary and the quaternary mixtures when determining the PD of individual fractions. Our conclusion is that, unlike natural aggregates, other methods based on aggregate shape should be preferred for these ES aggregates mixtures, due to the variability of these co-products, their specific textures and contours.

#### 5. ACKNOWLEDGEMENTS

The authors thanks for funding to MCIN/AEI/10.13039/501100011033/FEDER, UE [PID2021-124203OB-I00; PID2020-113837RB-I00; RTI2018-097079-BC31; FPU17/03374]. Our thanks also go to SAREN research group (IT1619-22, Basque Government), the Junta de Castilla y León (Regional Government) and ERDF [UIC-231, BU119P17], the BASKRETE initiative and the Transnational Common Laboratory “Aquitaine-Euskadi Network in Green Concrete and Cement-based Materials”. Also thank you to companies: Morteros y Revocos Bikain, HORMOR, FYM Heilderberg Cement Group and Amantegui Group.

#### 6. BIBLIOGRAPHY

- [1] Santamaría A, Ortega-López V, Skaf M, Chica JA, Manso JM. The study of properties and behavior of self compacting concrete containing EAFS as aggregate. *Ain Shams Eng J.* 2020; 11(1):231-243. <https://doi.org/10.1016/j.asej.2019.10.001>.
- [2] Roslan NH, Ismail M, Khalid NHA, Muhammad B. Properties of concrete containing electric arc furnace steel slag and steel sludge, *J. Build. Eng.* 2020; 28:101060. <https://doi.org/10.1016/j.jobte.2019.101060>.
- [3] Feret R. Sur la compacité des mortiers hydrauliques. *Annales des Ponts Chaussées* 1892; 7(4): 164 p.
- [4] Funk JE, Dinger DR, Funk JEJ. Caol Grinding and Particle Size Distribution Studies for Coal-Water Slurries at High Solids Content. Final Report, Emp State Electr Energy Res Corp. 1980.
- [5] Sunayana S, Barai VS, Barai SV. Recycled aggregate concrete incorporating fly ash: comparative study on particle packing and conventional method. *Constr Build Mater.* 2017; 156:376-386. <https://doi.org/10.1016/j.conbuildmat.2017.08.132>.
- [6] de Larrard F. *Concrete Mixture Proportioning. A Scientific Approach.* London, United Kingdom: CRC Press; 1999 (1<sup>st</sup> Edition): 448 p.
- [7] Moutassem F. Assessment of packing density models and optimizing concrete mixtures. *IJCMES* 2016; 2(4):29-36.
- [8] Kwan AKH, Wong V, Fung WWS. A 3-parameter packing density model for angular rock aggregate particles. *Powder Technol.* 2015; 274:154-162. <https://doi.org/10.1016/j.powtec.2014.12.054>.
- [9] Li Z, Afshinnia K, Rangaraju PR. Effect of alkali content of cement on properties of high performance cementitious mortar. *Constr Build Mater.* 2016; 102:631-639. <https://doi.org/10.1016/j.conbuildmat.2015.10.110>.



- [10] Lim JS, Cheah CB, Ramli MB. The setting behavior, mechanical properties and drying shrinkage of ternary blended concrete containing granite quarry dust and processed steel slag aggregate. *Constr Build Mater.* 2019; 215:447-461. <https://doi.org/10.1016/j.conbuildmat.2019.04.162>.
- [11] Mangulkar MN, Jamkar SS. Review of particle packing theories used for concrete mix proportioning. *IJSER* 2013; 4(5):143-148.

## **CODE 108**

### **THE POLYFUNCTIONALITY IN THE SINGULAR ARCHITECTURES: KEY OF PERMANENCE AND KEY OF SUSTAINABILITY**

### ***LA POLIFUNCIONALIDAD EN LAS ARQUITECTURAS SINGULARES: LLAVE DE PERMANENCIA Y CLAVE DE SOSTENIBILIDAD***

**Agudo Martínez, Andrés <sup>1\*</sup>; Vázquez Sánchez, Gloria <sup>2</sup>; Lucas Ruiz, Rafael <sup>3</sup>**

1: Grupo HUM-1012 Teorías Estéticas Contemporáneas  
Universidad de Cádiz  
e-mail: [andresam@us.es](mailto:andresam@us.es)

2: Universidad de Sevilla  
e-mail: [glovazsan@alum.us.es](mailto:glovazsan@alum.us.es)

3: TEP-172: Arquitectura: Diseño y Técnica (Arditec)  
Universidad de Sevilla  
e-mail: [rlucas@us.es](mailto:rlucas@us.es)

#### **RESUMEN**

Nos venimos preguntando si es posible establecer modelos de gestión que permitan considerar sostenibles los edificios singulares. Partimos de la base de que la concepción de una arquitectura singular implica afrontar una inversión inicial superior a la que pudiera corresponder a cualquier otra de carácter ordinaria.

Sin embargo, este tipo de arquitecturas han sido, es, y se prevé que siga siendo un patrimonio icónico para la sociedad. Se han elaborado modelos a partir de datos reales de los que deduce que el mayor importe del coste global se puede compensar con actitudes basadas en el valor simbólico del edificio y en su propio mercadeo, todo ello contando con el compromiso de los líderes sociales, la difusión adecuada y la explotación comercial de la singularidad del edificio.

Nuestra ponencia pretende aportar un nuevo factor de reflexión que consideramos indispensable para mitigar la diferencia de costes entre un edificio singular y otro carente de esta designación, de forma que pueda alcanzar la máxima sostenibilidad a lo largo de su vida útil: la polifuncionalidad o el multiuso del edificio con la posibilidad de asumir cambios de uso en el tiempo, así como disponer de un modelo de gestión que le permita interactuar con diversos factores sociales.

**PALABRAS CLAVE:** Arquitecturas singulares; Sostenibilidad; Polifuncionalidad; Multiuso del edificio.

#### **1. SOBRE LAS ARQUITECTURAS SINGULARES**

Los edificios singulares son un ejemplo de construcciones no convencionales, y casi todas las arquitecturas que hemos heredado han sido en su mayoría edificios singulares: templos, palacios y castillos, destinadas a todos los usos que los avatares de la historia les ha deparado.

[14] Consejería de Cultura. *Conjuntos monumentales de Úbeda-Baeza: patrimonio mundial: enclave dual del Renacimiento español*. Sevilla. 2003.

[15] Fernández Ruiz, R. Anexo de Gestión en *Conjuntos monumentales de Úbeda-Baeza: patrimonio mundial: enclave dual del Renacimiento español*. Sevilla. 2003



[www.rehabend.unican.es](http://www.rehabend.unican.es)

Coordinator:



Co-Organizers:

